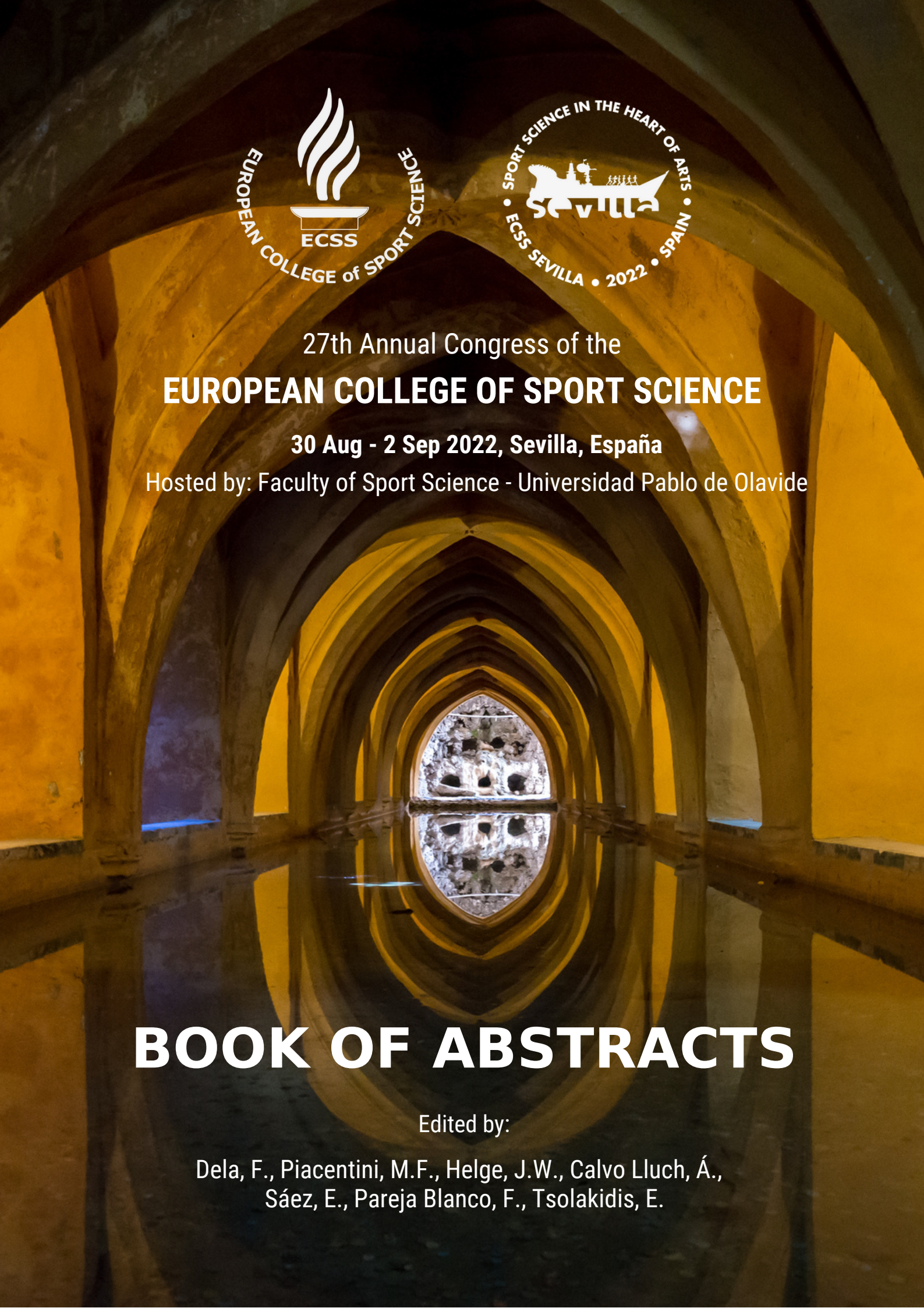


27th Annual Congress of the

# EUROPEAN COLLEGE OF SPORT SCIENCE

**30 Aug - 2 Sep 2022, Sevilla, España**

Hosted by: Faculty of Sport Science - Universidad Pablo de Olavide

# BOOK OF ABSTRACTS

Edited by:

Dela, F., Piacentini, M.F., Helge, J.W., Calvo Lluch, Á.,
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# Welcome

## Welcome to Seville

Dear Friends,

We are honoured to invite you to celebrate the 27th Annual Congress of the European College of Sport Science (ECSS) with us, and in doing so, we offer you a special gift: Sevilla! A melting pot of more than 3,000 years' history, a city full of art, culture, cuisine, leisure and sports. The city looks forward to welcoming sport scientists from all parts of the world, with open arms, to enjoy this unique ECSS congress.

"Sport Science in the Heart of Arts" is the theme for the 2022 ECSS congress in Sevilla. Make the most of your time before or after the congress and admire the Guadalquivir River, various art forms, diverse cultures, the numerous historic quarters and above all, our people. We suggest that you make your travel arrangements to allow for time to explore this wonderful city and this region of Spain known as Andalucía. With affordable accommodation, summer weather and countless activities and sites to visit, you will have a memorable time.

Added to this, the Sevilla Convention Bureau has kindly offered gift vouchers to all congress delegates that include free give-aways, including public transportation tickets, and discounts at restaurants, museums, flamenco shows, recreational parks, cafés, pubs and various shops. We have also engaged with a local tour operator and asked them to provide discounted trips before and after the congress.

The ECSS congress brings about a new congress model, which will see an enhanced programme built with even higher scientific standards and quality measures, which will all take place in the world-class congress venue, FIBES. We have selected an outstanding, international panel of experts, bringing their specialised knowledge to the plenary, and invited sessions. Prior to the congress, there will be a satellite dedicated to football, where the most reputable researchers in the industry will present their topics and experiences.

We are also working hard on inclusion at the congress and for the first time we will have sessions available with interpretation services which will serve our Latin American colleagues. This will be a unique cooperation that aims to brings new partnerships and friends to the ECSS community. Other unique initiatives for the congress includes a congress mascot which you have the opportunity to design and win some fabulous prizes. We also have planned additional activities that will bring the research community closer to the business community. More information on these in due course.

We cordially invite the sport science community to make a wish and come to ECSS Sevilla 2022!

Nos vemos en Sevilla! / See you in Seville!

Your Congress Co-Presidents,

*África Calvo Lluch, General Director of Sports*
*Eduardo Saez de Villareal Saez, Vice Dean*

Faculty of Sport Science
Universidad Pablo de Olavide
Sevilla, España

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# Wednesday, August 31, 2022

## 08:30 - 09:45

### Plenary sessions

#### PL-PS01 Exercise and brain health during growth and aging

**EFFECTS OF EXERCISE ON BRAIN HEALTH IN CHILDREN**

ORTEGA, F.

*UNIVERSITY OF GRANADA*

Pediatric obesity is highly prevalent across the world; and it is related to poorer cognitive and brain development. Exercise is a potential candidate to attenuate these adverse consequences. During this lecture, Dr. Ortega will show results from the ActiveBrains randomized controlled trial. This study aimed to investigate the effects of an exercise program on brain health indicators, including intelligence, executive functions, academic performance and brain outcomes in over 100 children aged 8-11 years with overweight/obesity; as well as to explore potential mediators and moderators of the main exercise effects observed. The main findings show that a 20-week concurrent exercise program (aerobic + resistance training) improves overall and crystallized intelligence, and cognitive flexibility in children with overweight/obesity. Exercise also improves, to a lesser extent, academic performance, which was partially mediated by cognitive flexibility. However, exercise did not influence brain structure (i.e. volume and shapes of hippocampal subregions, global and regional gray and white matter volume, thickness and area of prefrontal cortex subregions, and structural networks) and function (i.e., hippocampal functional connectivity). This intervention increased the performance in a treadmill cardiorespiratory fitness test; and these changes in fitness partially mediated the effects on crystallized intelligence, total academic performance and problem solving. The main results were stratified by sex, chronological and biological age, socioeconomic status and baseline performance, highlighting the larger improvements in intelligence outcomes observed in boys compared to girls. Collectively, exercise can positively affect intelligence and cognitive flexibility, which has important implications. This talk will guide future directions on the field of exercise, brain health and childhood obesity.

**EFFECTS OF EXERCISE ON BRAIN HEALTH DURING AGING**

ERICKSON, K.

*UNIVERSITY OF PITTSBURGH*

Despite the ubiquity of normal age-related cognitive decline there is an absence of effective approaches for improving neurocognitive health. Fortunately, moderate intensity exercise is a promising method for improving brain and cognitive health in late life, but its effectiveness remains a matter of skepticism and debate because of the absence of large and comprehensive clinical trials. In this talk, Dr. Erickson will describe the implementation of the IGNITE randomized clinical trial. This study aimed to examine whether aerobic exercise influences cognitive and brain health in 639 cognitively normal adults between 65 and 80 years of age. Participants are engaging in 3 days/week of supervised exercise and two more days per week of unsupervised exercise for 12 months. All participants have been already randomized to (i) a moderate intensity aerobic exercise condition of 150 min/week, (ii) a moderate intensity aerobic exercise condition at 225 min/week, or (iii) a light intensity stretching-and-toning control condition for 150 min/week. IGNITE is currently ongoing, all baseline assessments are completed, and follow-up assessments are expected to be completed by 2023. Outcome measures includes brain magnetic resonance imaging, positron emission tomography of amyloid deposition, a comprehensive cognitive battery, blood biomarkers, physiological biomarkers, cardiorespiratory fitness, physical function, and a battery of psychosocial questionnaires. While promising findings on the effects of the exercise intervention will come up soon, data on the financial cost associated with a phase III, multi-site exercise intervention trial as well as some baseline findings on the associations between fitness, cognition and brain structure will be presented. Finally, Dr. Erickson will highlight how this trial could transform scientific-based policy and health care recommendations for approaches to improve cognitive function in cognitively normal older adults.

## 10:00 - 11:15

### Invited symposia

#### IS-PN01 Skeletal muscle disuse atrophy: time to 'complicate' uncomplicated disuse?

**UNCOMPLICATED SKELETAL MUSCLE DISUSE ATROPHY: HUMAN IN VIVO INVESTIGATION AND MECHANISTIC BASIS**

DIRKS, M.

*UNIVERSITY OF EXETER*

Skeletal muscle disuse refers to a state of inactivity of one or more muscle groups. This is common during injury, illness or as a characteristic of more sedentary lifestyles. While disuse remains a major contributor to atrophy, its requirement for clinical reasons tends to be accompanied by a multitude of complicating and relevant factors that also influence muscle tissue (e.g. inflammation, cortisolaemia, malnutrition etc.). However, laboratory studies have generally focused on the withdrawal of contractile loading per se in healthy humans, as

controlled means to isolated a single variable; disuse. Such studies have typically utilized bed-rest and/or limb immobilization studies to thoroughly characterize the speed, locality and extent of muscle atrophy, the level of impairment of muscle function and the onset of whole body and local insulin resistance. Moreover, the physiological mechanisms underpinning these aspects of deconditioning have been well-described. This presentation will cover this background, discuss more novel approaches to study disuse (e.g. the arteriovenous-venous forearm balance model) and lay the groundwork for why 'complicating' uncomplicated disuse may be necessary for translation from lab to practice.

**COMPLICATING MUSCLE DISUSE: APPROACHES TO LOOK BEYOND ONLY DISUSE**

WALL, B.

*UNIVERSITY OF EXETER*

Studies isolating muscle disuse (i.e. 'uncomplicated muscle disuse') as a primary variable driving muscle atrophy have yielded important insights into the responsible physiological mechanisms. For instance, a reliable finding is that myofibrillar protein synthesis rates decline rapidly consequent with the onset of disuse, and this decline extends to the response to food intake ('anabolic resistance') and translates to considerably less synthesis of muscle protein over days and weeks explaining the large part of observed atrophy. However, clinical manifestations of muscle disuse typically result in several complicating factors; for example during injury the occurrence of muscle damage (and associated inflammation) or the reduction of energy expenditure and therefore implications for dietary intake. All such aspects also directly affect myofibrillar protein synthesis rates and/or other relevant metabolic processes, and therefore need to be accounted for if we are to properly understand how muscle disuse atrophy may best be understood, and managed, in a variety of clinical situations. This presentation will discuss recent work that has employed strategies to introduce some of these additional variables beyond disuse only, to examine how this can modulate the regulation of muscle mass during disuse.

**NUTRITIONAL REQUIREMENTS AND COUNTERMEASURES DURING MUSCLE DISUSE**

MCGLORY, C.

*QUEENS UNIVERSITY*

Over their lifespan, many individuals experience multiple episodes of skeletal muscle-disuse that arise from illness, injury, or elective surgery requiring bedrest. These periods of muscle-disuse initiate the loss of muscle mass and strength that are associated with several associated negative health effects such as the onset of insulin resistance, a reduction in basal metabolic rate, and the accrual of body fat. In the absence of safe and scalable pharmacological countermeasures, nutrition is considered a primary means by which to combat the negative impact of muscle-disuse. In this regard, there is growing evidence that prophylactic ingestion of amino acids and omega-3 fatty acids may act in concert to attenuate declines in skeletal muscle mass with disuse. However, there is little evidence that such interventions are effective in attenuating declines in muscle strength. Moreover, how amino acid and omega-3 fatty acid ingestion impacts the progression of other clinically relevant processes during muscle-disuse remains largely unknown. The aim of this presentation is to review and critically evaluate the existing literature related to the role of nutrition as a countermeasure to muscle-disuse atrophy with a specific focus on the role of amino acids and omega-3 fatty acids.

## Invited symposia

### IS-BM01 The functional integrity of muscle and connective tissue for locomotor performance

**THE INTERACTION OF ACTIVE AND PASSIVE TISSUE CONTRIBUTIONS TO HUMAN FOOT MECHANICS**

FARRIS, D.

*UNIVERSITY OF EXETER*

Tendons, aponeuroses, and ligaments of the human foot and ankle have long been known to possess spring-like properties that help us recycle bodily energy during walking and running. This provides a metabolically inexpensive contribution to maintaining walking and running mechanics. However, these passive tissues alone cannot support human locomotion, particularly in situations where the external environment and situational demands are constantly changing. In prior work, my colleagues and I have shown that activations of the muscles within the foot (intrinsic foot muscles) are modulated in response to varied mechanical requirements during locomotion [1], and that blocking their activation affects foot and lower limb mechanics [2]. In particular, we have shown that the important push-off phase of walking and running is influenced by intrinsic foot muscles, as is the 'windlass mechanism' that was previously considered to be reliant solely on the plantar aponeurosis [3]. I will begin this presentation by summarising the above work and concluding that contributions from plantar intrinsic foot muscles are important for modulating the mechanics of the human foot in response to external influences.
A highlight of the above work was that running shoes were shown to increase intrinsic foot muscle activation. We proposed that this was due to their midsole functioning as a spring in-series with the foot, and the muscles acting to stiffen the longitudinal arch of the foot. To test this hypothesis we recently conducted a series of experiments where humans hopped on platforms with adjustable stiffness and damping properties. Multi-segment foot mechanics were modelled based on motion capture data, and combined with ground reaction forces to compute joint moments and quasi-stiffness. Fine-wire electromyography techniques were also implemented to record muscle activations from flexor digitorum brevis and abductor hallucis. In response to increased surface compliance, human hoppers adjusted foot and ankle mechanics to maximise the work recycled from the spring-loaded surface, and reduce the active work contribution from foot muscles. Furthermore, the longitudinal arch of the foot was not stiffened in response more compliant surfaces, contradicting our hypothesis from the running-shoe experiment. However, traditional running shoe midsoles are not simply springs, and also dampen impacts. When our platform was set to provide damping of energy, foot muscle activation increased concurrently with foot contributions to mechanical work. Therefore, we suggest that it is the damping of energy by traditional running shoes that results in increased foot muscle activation when wearing them. New generations of highly resilient-elastic running shoes may benefit the wearer by reducing active muscular work within the foot.
1. Kelly et al. Sci Rep, 2018. 8(1): p. 10576

2. Farris et al. PNAS, 2019. 116(5): p. 1645-1650
3. Farris etal. J R Soc Interface, 2020. 17(168): p. 20200208

**LATCH-BASED MUSCLE-TENDON INTERACTIONS ENABLE RECOVERY FROM RAPID, UNEXPECTED PERTURBATIONS**

DICK, T.

*FACULTY OF MEDICINE*

The ability for humans to stay upright in the face of uneven terrain or unpredictable changes in their environment is remarkable, yet we understand little about the mechanisms that enable this. Much of our knowledge regarding movement performance has come from studies conducted under steady-state conditions. During steady movement, the lower limb muscle-tendons store and return energy, and this elastic behaviour is further exploited during activities where humans must rapidly generate energy (e.g., jumping). To date, we know very little about how humans adjust lower-limb joint biomechanics and muscle-tendon function during movements whereby energy must be rapidly dissipated. The aim of this research is to provide fundamental insights into the mechanisms for movement stability during unexpected perturbations.
To study this, we have developed a perturbation paradigm whereby participants perform steady- state hopping at their preferred frequency. An unexpected perturbation, via manual removal of two custom-built platforms (5, 10, or 20 cm height) from directly under the lower limbs, was elicited at a random time between the 10th and 20th hop. During each trial, motion capture (Vicon, UK) was used to measure the 3D positions of the lower limbs. Ground reaction forces were measured during hopping using a static instrumented split belt treadmill (Bertec, USA). MTU lengths and joint moments were computed using a scaled musculoskeletal model, motion capture and force plate data. Surface electromyography was used to record muscle activations in the medial (MG), lateral gastrocnemius (LG), soleus (SOL), and tibialis anterior (Biometrics, UK). MG and SOL fascicle lengths were determined from B-mode ultrasound images (Telemed, Lithuania).
Our results highlight that humans successfully recover from perturbations via an increase in energy absorption in distal lower-limb joints (i.e. the ankle) at small perturbation heights (5-10cm). However, with increased perturbation height (20cm) humans increase their reliance on the proximal lower-limb joints (i.e. the knee and hip) to absorb mechanical energy and stabilize fall recovery. Our investigations into the muscle–tendon interactions that underpin these joint-level responses shows that an unexpected drop in ground height introduces an automatic phase shift in the timing of plantar flexor muscle activity relative to ground contact and an increase in co-activation of the plantar and dorsi-flexor muscles. Together, this enables a latch-based behaviour whereby the plantar flexor fascicles shorten and stretch the series elastic tendon prior to ground contact. This improves the capacity of the plantar flexors to rapidly absorb energy upon ground contact and may also aid in avoiding potentially damaging strains. These data provide insights to guide design of targeted training programs or lower-limb assistive devices that are capable of improving human locomotor performance during energy-dissipation tasks.

**MUSCLE-SPECIFIC ECONOMY OF FORCE GENERATION AND EFFICIENCY OF WORK PRODUCTION DURING HUMAN RUNNING**

BOHM, S.

*HUMBOLDT-UNIVERSITÄT ZU BERLIN*

During locomotion, muscles generate force and perform work in order to support and accelerate the body and the activity of the lower limb muscles accounts for most of the metabolic energy needed. Running is characterized by a spring-like interaction of the body with the ground, where the bodies energy is stored mainly to elastic tendons as strain energy and recovered during the propulsion phase. In addition, the compliance of tendons together with rotation of muscle fibers (changes of pennation angle) decouples the fiber excursions from the muscle-tendon unit, influencing the muscle operating force-length and force-velocity potential (fraction of maximum force according to the force-length and force-velocity curve). For a given muscle force, the metabolic cost depends on the force-length-velocity potential because it determines the active muscle volume. We showed, that during running the vastus lateralis as the main knee extensor contracts almost isometrically and close to optimal length during the stance phase despite a lengthening-shortening of the muscle-tendon unit [1,2]. This indicates favorable muscle operating conditions due to substantial decoupling by tendon compliance that allows to generate force economically. For the soleus muscle as the main plantar flexor during running, our experiments showed, however, that the muscle fascicles actively shorten throughout the stance phase, i.e. generating work for propulsion [3]. The metabolic cost of muscular work then additionally depends on the velocity of shortening. The enthalpy efficiency (or mechanical efficiency) quantifies the fraction of chemical energy that is converted into muscular work, showing a peak at ~20% of the maximum shortening velocity. We found that the soleus shortens at a velocity in a range of high enthalpy efficiency and around optimal length during stance, providing evidence of efficient work generation during running [2]. Effective decoupling by tendon compliance and marginally fascicle rotation regulated the advantageous operating conditions. We then investigated the soleus enthalpy efficiency as a mechanism that could contribute to improvements in running economy after exercise-induced increases of plantar flexor strength and Achilles tendon stiffness [4]. Using a controlled longitudinal study design featuring a specific muscle-tendon training, increases in muscle strength and tendon stiffness and reduced metabolic cost of running were found. Following training, the soleus fascicles operated at higher enthalpy efficiency during the phase of muscle-tendon unit lengthening and in average over stance. Thus, improvements in metabolic cost of running following increases in plantar flexor strength and tendon stiffness seem attributed to increased enthalpy efficiency of the operating soleus muscle.
[1] Bohm et al. 2018, Sci Rep 8:5066
[2] Bohm et al. 2021, eLife 10:e67182
[3] Bohm et al. 2019, Proc. R. Soc. B 286:20192560
[4] Bohm et al. 2021, Proc. R. Soc. B 288:20202784

# Oral presentations

## OP-LAG01 Training and testing

### RAPID WEIGHT LOSS, EMOTIONS, AND HEART RATE VARIABILITY IN FEMALE WRESTLERS

CASTOR-PRAGA, C.1, LOPEZ-WALLE, J.1, GARRIDO-ESQUIVEL, A.1, SANCHEZ-LOPEZ, J.2

*1.UNIVERSIDAD AUTÓNOMA DE NUEVO LEÓN, 2. ESCUELA NACIONAL DE ESTUDIOS SUPERIORES*

INTRODUCTION: Rapid Weight Loss (RWL) consists of immediate weight reduction within 10 days of competition, dehydration being one of the most used strategies. Negative effect has been reported at the mood level, but few studies have evaluated the Heart Rate Variability (HRV), which allows us to know the physiological state of the athlete. The aim of this study was to know the hydration status, emotions and HRV prior to the competition, as well as their correlation and differences between athletes who performed the RWL or not.
METHODS: Method: 15 females wrestlers aged 17.13 ± 2.77 participated. They were evaluated prior to the competition through Urine Specific Gravity (USG), PANAS and Elite HRV.
RESULTS: The average number of days in which strategies were used for RWL were 3.33 ± 4.91 and the number of strategies used was 2.73 ± 2.99. Positive correlations were found between: 1) USG and active emotion (r = . 536*; 2) days using strategies and tense (r = . 540*), guilty (r = . 601*), frightened (r = . 573*); and 3) number of strategies used and guilty (r = . 580*), hostile (r = . 544*), and days using them (r = . 947**). Negative correlations between: 1) USG and RR (r = -.460*) and 2) Ratio (SS/SD1) and emotion of motivation (r = -.520*). Older athletes also felt guilty (r = . 825**). Finally, differences were found between athletes who made RWL and those in the hydration state (p < .05*, p < .01**).
CONCLUSION: The athletes who performed the RWL present greater dehydration and their RR intervals are affected, also those athletes who have greater SS (SS/SD1) feel less motivated. And those who perform the RWL, who perform it for more days and more quantity feels tense, guilty, afraid, and hostile. These results provide a preliminary overview of the consequences of RWL.

### DISTRIBUTION OF GENOTYPE AND ALLELE FREQUENCY OF THE I/D POLYMORPHISM OF THE ACE GENE IN ENDURANCE RUNNERS: A SYSTEMATIC REVIEW

VELANDIA, F., BUITRAGO, J., PRIETO, L., RODRÍGUEZ, A., MÉNDEZ, G., CARDONA, C., ORDOÑEZ, N.

*UNIVERSIDAD DE CIENCIAS APLICADAS Y AMBIENTALES U.D.C.A*

INTRODUCTION: The ACE gene determines the physiological functions in the renin-angiotensin-aldosterone system, it has been related to resistance activities (Sarmento et al., 2020). The objective of this study is to analyze the distribution of the genotype and allelic frequency of the I/D polymorphism of the ACE gene in endurance runners and its relationship with sports performance.
METHODS: Systematic review with PRISMA methodology. Studies that identified the allelic and genotypic frequency of the I/D polymorphism in athletic performance athletes were selected.
RESULTS: 21 articles were included and classified into three categories. 1) Genotype II/ID: nine studies in Caucasian runners show that the genotype I/D occurs with higher percentages in athletes and the allele frequency I of athletes increases compared to the control group, presenting a greater correlation with longer distance races. 2) D/D Genotype: Eight studies in Caucasian and Asian runners determine that the D/D genotype is associated primarily in short-duration or power-race athletes. 3)Absence of relationship of the ACE gene with athletic performance: Four studies in African and Caucasian runners determine that other genetic factors influence performance in endurance runners.
CONCLUSION: The Caucasian and Asian population has the ACE gene with polymorphism I or D, but this polymorphism is not identified in African runners of black ethnicity, because sports performance depends on multiple factors associated with morphological and physiological characteristics, conditions environmental and geographic, to the genetics of populations that generate variability of allelic frequencies of this African population (Scott & Pitsiladis, 2006).
Studies highlight the importance of genotype I/I and allelic frequency I of the ACE gene as one of the main factors responsible for athletic performance in endurance athletes (Woods et al., 2000). The I/D genotype shows superior results compared to the other genotypes, with a predominance of allelic frequency I in long-distance runners. When comparing short- and medium-duration runners versus long-term runners, a relationship between the ACE gene and the duration of activity was identified, with a high frequency of allele I in medium- and long-distance athletes.
The genotype can vary according to the distance of the race, the population and the training, although the two genotypes I/I and D/D were presented in Caucasian and Asian populations, it is inescapable to exclude the influence of the sports preparation and the factors epigenetics in modeling athletic performance (Moir et al., 2019). It is concluded that the II/ID/DD genotypes are related to the physical performance of athletes in 17 (81%) of 21 articles studied. It should be noted that in addition to this ACE gene polymorphism relationship, external factors (training, geographical characteristics, diet, psychological factors) have a great influence on physical performance.

# Invited symposia

## IS-AP01 Mental fatigue: Where are we?

### MENTAL FATIGUE: THE CURRENT STATE-OF-THE-ART

ROELANDS, B.

*VRIJE UNIVERSITEIT BRUSSEL*

MF can be defined as a psychobiological state that emerges during prolonged demanding cognitive activity and results in an acute feeling of tiredness, with potential decrements in physical and/or cognitive performance. Over the last years several high quality systematic review papers have been published that identified significant effect of a condition of mental fatigue on subsequent performance capacity. Given

the abundance of papers on the performance aspect, there is significantly less information available about the mechanisms behind this reduced performance capacity. Interestingly, the reduction in physical performance in a mentally fatigued state is not mediated by an exacerbation of peripheral factors normally associated to physical fatigue. The negative effect of mental fatigue on exercise performance is mainly attributed to a higher-than-normal RPE. During the presentation we will focus on recent findings from lab-based studies looking at the effect of mental fatigue on performance. We will further try to identify potential mechanisms from the literature (as an example the accumulation of adenosine in the anterior cingulate cortex). Finally, some studies have already applied behavioral or nutritional countermeasures in an attempt to negate the negative effects of a mentally fatiguing task. We will explore some of these countermeasures in order to pinpoint their potential.

**MENTAL FATIGUE IN ATHLETIC POPULATIONS**

RUSSELL, S.

*THE UNIVERSITY OF QUEENSLAND*

A plethora of laboratory-based research demonstrates the negative impact of mental fatigue on physical, technical, tactical, and psychological aspects of sporting performance. However, studies have largely failed to translate to impact applied elite sporting practice and are commonly lacking in ecological validity. As such, despite its potential impact, mental fatigue and mental recovery is rarely routinely assessed nor managed in athletic populations. Recent research has advanced the way we understand athletes' perceptions and experiences of mental fatigue in training, competition, and camp. The practical implications of this research and comparison to previous laboratory-based findings will be examined including potential indicators, causes, and management or mitigation strategies. Current practice by those working in high-performance sport will be critically discussed with future suggestions for harnessing mental fatigue and enhancing mental recovery to maximize elite sport training and competition performance. Future directions for translatable research and recommendations for protocols will be discussed.

**CONNECTIONS BETWEEN MENTAL FATIGUE ON THE FIELD, IN THE WORKPLACE, AND IN THE CLINIC.**

BAILEY, S.

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The impact of MF on performance has been explored in athletic settings and in the workplace. Fewer efforts have been made to examine the impact of MF on patients in a clinical setting. During this presentation we will explore the functional and mechanistic connections and differences of MF in athletic settings, the workplace, and in clinical environments. Particular emphasis will be placed on the changes in brain activity (EEG) and corticomotor excitability (motor evoked potential resulting from transcranial magnetic stimulation) subsequent to mental fatigue. We will review various behavioral, nutritional, and environmental strategies that may mitigate the impact of MF on performance in these environments. We will also discuss the impact of bitter and sweet tastants on performance during a MF state and the potential mechanisms that underly these countermeasures. Finally, we will discuss various research settings, methodologies, and designs that could further our understanding of the impact of MF on performance in athletic settings and the workplace, along with function of patients in a clinical environment.

## Oral presentations

### OP-PN03 Skeletal muscle metabolism and quality

**SHORT-TERM LOWERING OF CARBOHYDRATE INTAKE REDUCES SKELETAL MUSCLE GLYCOGEN AND BODY WEIGHT, BUT HAS NO EFFECT ON SHORT-TERM EXERCISE CAPACITY OR MAXIMAL POWER-OUTPUT IN RECREATIONALLY ACTIVE MEN**

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INTRODUCTION: In the days preceding competition most endurance athletes consume a diet rich in carbohydrates (CHO) with the aim of storing high amounts of skeletal muscle glycogen. However, glycogen-loading could be associated with increased body weight (glycogen with associated water) and may not be necessary for short-term (1-15 min.) exercise performance. In this study, we investigated the effect of a short-term manipulation of dietary CHO intake on muscle glycogen content, body weight and short-term exercise performance.
METHODS: In a randomized and counterbalanced cross-over design twenty-two recreationally active males (maximal oxygen consumption: 56.5 ± 5.4 mL O2 · min-1 · kg-1) completed two maximal ergometer cycling exercise tests of either 1- or 15-min. (Group 1 and 15, respectively), after different CHO consumption strategies in the preceding days. Muscle glycogen was manipulated after a glycogen depletion training consisting of both arm cranking and cycling exercise where the subjects received a diet consisting of either a moderate (M-CHO: 4 g · kg-1 body weight · day-1) or high (H-CHO: 10 g · kg-1 body weight · day-1) amount of CHO for the remaining of the training day and for the following two days. Muscle biopsies from vastus lateralis were obtained prior to and immediately after each test and glycogen content was determined biochemically. Peak power-output was determined pre and immediately after the post-exercise biopsies. All data were analyzed by validated linear mixed models and presented as mean ± 95 % confidence interval.
RESULTS: The CHO manipulation led to different muscle glycogen contents between conditions (M-CHO: 367 mmol · kg-1 dry weight [DW] (337:396); H-CHO: 525 mmol · kg-1 DW (496:555), P < 0.00001) and caused a higher body weight (M-CHO: 76.6 kg (74.3:78.8); H-CHO: 77.3 (75.1:79.5), P < 0.00001) in H-CHO compared to M-CHO prior to the maximal cycling tests. The average power-output during the 1- and 15-min. of maximal cycling did not differ between conditions (Group 1: H-CHO: 590 W (541:639); M-CHO: 569 W (515:622), P = 0.33) (Group 15: H-CHO: 294 W (269:319); M-CHO: 293 W (267:320), P = 0.99). Peak power-output was reduced by 6.1 % (3.8:8.5) (P < 0.00001) and 5.9 % (3.4:8.5) (P < 0.00001) after 1- and 15-min. of maximal cycling exercise compared to baseline, respectively, and with no difference between conditions (time x diet interaction: P = 0.12 and P = 0.71, respectively).

CONCLUSION: Short-term lowering of the CHO intake from high to moderate in the days preceding competition induced a reduction in both muscle glycogen content and body weight, while short-term performance was unaffected in non-weight-bearing cycling exercise in recreationally active men. The combination of reduced body weight and maintained performance in this non-weight-bearing activity, suggests that a moderate CHO intake prior to competition may have a performance enhancing potential in weight-bearing sports.

### SHORT-TERM MUSCLE DISUSE DOES NOT AFFECT MUSCLE PROTEIN FRACTIONAL BREAKDOWN RATES UNDER FASTED OR FED CONDITIONS.

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INTRODUCTION: Muscle disuse atrophy is attributed to reduced muscle protein synthesis rates, increased muscle protein breakdown rates, or both. Whilst leg immobilisation reliably decreases fasted and fed fractional synthetic rates (FSR) of muscle protein, static molecular markers indicate a marked rise in muscle protein breakdown within the first few days of immobilisation. The aim of this study was to determine the effect of unilateral knee immobilisation on mixed-muscle protein fractional breakdown rate (FBR) using the tracee-release method, during both fasted and simulated-fed conditions. A secondary aim was to determine the contribution of FBR to net protein balance by simultaneously quantifying FSR.
METHODS: Seventeen healthy, recreationally active male participants were allocated to FAST (n=9; age 21±0 y, BMI 23±1 kg·m-2; mean±SEM) or FED (n=8; age 23±2 y, BMI 23±1 kg·m-2) groups in a randomised, single-blind, parallel group design. Participants underwent 48 h of unilateral knee immobilisation (brace) prior to visiting the laboratory for intravenous L-[15N]-phenylalanine and L-[ring-2H5]-phenylalanine infusions. After 3 h, the L-[15N]-phenylalanine infusion was stopped (t=0 h) and replaced with primed-continuous saline or 10% primene infusion (0.675 ml·kg-1·h-1) for participants in FAST and FED, respectively. At t=0, 1 and 3 h, m. vastus lateralis biopsies were obtained from control (CON) and immobilised (IMM) legs. Arterialised-venous blood samples were collected regularly throughout. An unpaired t-test was used to detect group differences in the area under the insulin vs. time curve (AUC). A two-way ANOVA was used to detect differences in plasma branched chain amino acid (BCAA) and serum insulin concentrations and FBR, FSR and net balances.
RESULTS: Plasma BCAA concentrations were similar between FAST and FED from -2 to 0 h (343±24 and 330±18 µmol·L-1). After t=0, plasma BCAA concentrations were significantly greater in FED vs. FAST (582±21 vs. 356±26 µmol·L-1; interaction P<0.001). Serum insulin concentrations increased in FED but not FAST (interaction P<0.05), with 3h AUC greater in FED vs. FAST (48.1±7.2 vs. 28.7±5.1 mU·L-1·3h; P<0.05). Immobilisation did not influence FBR in either FAST (CON: 0.113±0.016; IMM: 0.128±0.015 %·h-1) or FED (0.146±0.015; IMM: 0.152±0.015) groups (all P>0.05). FSR was significantly lower in IMM vs. CON (P<0.05) in both FAST (0.074±0.004 vs. 0.090±0.006 %·h-1) and FED (0.065±0.024 vs. 0.119±0.016 %·h-1) groups. Net protein balances in CON legs were -0.023±0.016 %·h-1 in FAST and -0.027±0.021 %·h-1 in FED. Immobilisation decreased net protein balance to -0.054±0.015 and -0.087±0.025 %·h-1 in FAST and FED, respectively (P<0.01).
CONCLUSION: In summary, short-term disuse does not affect muscle protein breakdown rates measured under both fasted and simulated-fed conditions. Rather, decreased net muscle protein balance, and therefore muscle disuse atrophy, induced by short-term immobilisation is driven by reduced fasted and fed muscle protein synthesis rates.

### MUSCLE GLYCOGEN UNAVAILABILITY AND FAT OXIDATION RATE DURING EXERCISE: INSIGHTS FROM MCARDLE DISEASE

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INTRODUCTION: Carbohydrate availability has been reported to affect fat oxidation capacity during exercise. However, the effects of complete muscle glycogen unavailability on fat oxidation capacity remains unknown. The aim of this study was to examine the maximal fat oxidation (MFO) rate of patients with McArdle disease – a condition caused by inherited, complete blockade of muscle glycogen metabolism that represents a unique human model for the study of fat exercise metabolism – compared to sex- and age-matched healthy individuals.
METHODS: 10 McArdle patients were excluded from the analyses due to intense hyperpnea that clouded substrate oxidation. Nine physically active patients (3 women, 36±12 years) and 12 healthy controls (4 women, 40±13 years) were studied. Cardiorespiratory fitness (peak oxygen uptake, VO2peak), MFO, the exercise intensity eliciting MFO (FATmax), and the MFO-associated workload, respectively, were determined in all participants by indirect calorimetry during an incremental exercise test on a cycle ergometer.
RESULTS: Despite showing a lower VO2peak compared to controls (24.7±4 vs. 42.5±11.4 ml·kg-1·min-1), patients presented considerably higher values of MFO (0.53±0.12 vs. 0.33±0.10 g·min-1), FATmax (94.4±7.2 vs. 41.3±9.1 % of VO2peak) and MFO-associated workload (1.33±0.35 vs.0.81±0.54 w·kg-1) than controls (all p<0.05).
CONCLUSION: McArdle patients show an exceptionally high MFO, which they achieve near their maximal exercise capacity. These findings support the influence of glycogen availability on MFO and suggest that McArdle patients develop a quite unique fat oxidation capacity as an adaptative response to compensate for the inherited blockade in glycogen metabolism, with MFO appearing as a potential limiting factor of exercise tolerance in these patients.

### EFFECTS OF A 3-DAY HIGH-FAT OR HIGH-CARBOHYDRATE DIET ON MAXIMAL FAT OXIDATION AND FATMAX IN MODERATELY TRAINED MEN

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INTRODUCTION: Strategies aiming to spare glycogen and promote fat oxidation have shown potential to enhance exercise performance (1) (2). Previous literature has established the relationship between diet manipulation and substrate utilisation but until now, the direct impact of short-term diet interventions on maximal fat oxidation (MFO) and the relative exercise intensity at which MFO occurs (3) (Fatmax) has not been assessed. Therefore, this study aimed to determine the effects of a short term fat-rich or carbohydrate-rich diet on MFO and Fatmax in healthy males.

METHODS: In a randomised, controlled mixed-design; 40 moderately trained men (VO2peak 56.2 ± 1.2 ml/kg/min (mean ± SEM) were allocated to either a 3-4 day isocaloric high-fat (HIFAT: 65 E% fat, 20 E% carbohydrate and 15 E% protein) (n = 20) or high-carbohydrate diet (HICHO: 70 E% carbohydrate, 15 E% fat and 15 E% protein) (n = 20). Six participants completed both intervention diets, with a minimum of 4 weeks washout. Standardised, graded Fatmax and VO2peak tests were carried out in the fasted condition on the first and last day of each dietary intervention to determine MFO and Fatmax, consisting of a 5-minute warm-up at 60W, followed by increases of 35W every 3 minutes thereafter until a respiratory exchange ratio of ≥1.0 was reached (3). Subsequently, VO2peak testing began at 95W and load was increased by 35W each minute until exhaustion.
RESULTS: MFO increased from 0.41 ± 0.05 g/min to 0.59 ± 0.05 g/min (p>0.001) after HIFAT and reduced from 0.36 ± 0.04 g/min to 0.28 ± 0.06 g/min (p>0.001) following HICHO. Fatmax demonstrated a similar trend increasing from 37 ± 2% to 44 ± 2% (p>0.001) in response to HIFAT (p < 0.001), and decreasing from 37 ± 2% to 33 ± 2% (p>0.001) after HICHO. Significant time-by-diet interactions were observed in absolute VO2peak values and when expressed relative to body weight. Post-hoc analysis revealed absolute VO2peak and VO2peak relative to body mass were increased by 1.7% (p=0.036), and 2.7% (p=0.002), respectively after HIFAT. No significant changes in VO2peak were observed following HICHO.
CONCLUSION: A high-fat diet resulted in significantly increased MFO and Fatmax, whilst a high-carbohydrate diet significantly reduced MFO and Fatmax in healthy males. This demonstrates trained individuals can likely achieve metabolic adaptations facilitating greater fat utilisation during exercise following just 3 days of a fat-rich diet.
REFERENCES:
1. Frandsen J, Vest SD, Larsen S, Dela F, Helge JW. Maximal Fat Oxidation is Related to Performance in an Ironman Triathlon. Int J Sports Med. 2017;38(13):975–82.
2. Maunder E, Plews DJ, Kilding AE. Contextualising maximal fat oxidation during exercise: Determinants and normative values. Front Physiol. 2018;9(May):1–13.
3. Achten J, Gleeson M, Jeukendrup AE. Determination of the exercise intensity that elicits maximal fat oxidation. Med Sci Sport Exerc. 2002;34(1):92–7.

## Oral presentations

### OP-BM02 Motor learning and motor control

#### SHORT-TERM BALANCE CONSOLIDATION RELIES ON THE INVOLVEMENT OF THE PRIMARY MOTOR CORTEX (M1): A RTMS STUDY

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INTRODUCTION: Structural and functional adaptations occur in the primary motor cortex (M1) after only a few balance learning sessions (1, 2, 3). However, despite the high interest in balance control in general and the role of M1 in particular, the role of M1 in consolidating balance tasks is still not clear. The reason for this is that causal studies are missing and that it is a distinct possibility that adaptations in M1 might be a consequence of improved balance (e.g. less postural sway) rather than the actual driving force for improved balance coordination. One technique to investigate the impact of M1 in learning processes more directly is to impair the consolidation with the application of repetitive TMS (rTMS).
METHODS: Thirty young and healthy participants were randomly allocated into the rTMS or sham-rTMS group without knowing their group affiliation. The experimental design included a balance acquisition phase (6 series (S1 to S6) with 8 trials), followed by either 15 minutes of rTMS (1 Hz at 115 % of rMT to disrupt the involvement of M1) or sham-rTMS. 24 hours later, participants performed a retention test (Ret). RTMS was delivered to M1, more precisely at the hot-spot for the soleus muscle. The rMT was defined in a seated position as the intensity that triggered motor evoked potential peak-to-peak amplitudes greater than 50 µV in at least 5 out of 10 trials.
RESULTS: The two investigated balance parameters (i.e. 'mean deviation' and 'time in +/- 4 degrees') indicate that the postural performance on the rocker-board significantly improved during the acquisition phase ('mean deviation': $F_{1,27} = 81.613$, $p < .001$, $n2p = 0.751$; 'time in +/- 4 degrees': $F_{1,27} = 67.099$, $p < .001$, $n2p = 0.713$) independent of the intervention group (rTMS vs. sham-rTMS 'mean deviation': $F_{1,27} = 0.059$, $p = 0.810$, $n2p = 0.002$; 'time in +/- 4 degrees': $F_{1,27} = 0.147$, $p = 0.704$, $n2p = 0.005$). However, the TIME*GROUP interaction of the ANCOVA with S1 as covariate revealed differences in consolidation (i.e. from S6 to Ret) between the rTMS and sham-rTMS group ('mean deviation': $F_{1,26} = 10.537$, $p = 0.003$, $n2p = 0.288$; 'time in +/- 4 degrees: $F_{1,26} = 10.022$, $p = 0.004$, $n2p = 0.278$).
CONCLUSION: The present results demonstrate for the first time a causal relationship between the involvement of M1 and the early learning and consolidation of a balance task. This can be concluded as the rTMS group demonstrated a worse consolidation (i.e. loss of performance from the end of the acquisition phase to the start of the retention phase) of the balance task in contrast to the sham-rTMS group, which showed a significant increase in performance. The present results confirm and extend previous findings that higher cortical centers (especially M1) adapt in response to balance learning (4, 5).
REFERENCES:
1) Taubert et al., J Neurosci, 2010
2) Taubert et al., NeuroImage, 2011
3) Taubert et al., NeuroImage, 2016
4) Jacobs & Horak, J Neural Transm, 2007
5) Taube et al., Acta Physiol, 2008

### CORTICOSPINAL EXCITABILITY DURING RAPID MUSCLE CONTRACTIONS AND ITS ASSOCIATION WITH TORQUE PRODUCTION

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INTRODUCTION: Rate of force development (RFD) is an important limiting factor of many daily and sporting activities (1). RFD is greatly influenced by neural drive at the start of contraction; specifically motor unit recruitment speed and discharge rate (2). Corticospinal mechanisms affecting neural drive and consequently RFD throughout rapid contractions are unknown. Measuring the amplitude of motor evoked potential (MEPs) and silent period duration (SP) in response to transcranial magnetic stimulation (TMS) during contraction can assess corticospinal excitability and intracortical inhibitions. This study investigated MEP amplitude and SP at different time points during rapid force production and assessed the relationship between these factors and RFD.
METHODS: 14 participants (5 female) completed 1-s isometric rapid voluntary contractions ('fast and hard') and 3-s maximal voluntary contractions (MVCs; 'push hard') of the knee extensors. EMG responses were recorded from the vastus medialis (VM) and lateralis (VL), and rectus femoris (RF). Some contractions were superimposed with TMS at 140% of the active motor threshold. Stimulation was triggered to elicit an MEP and SP responses at approximately 45, 115, and 190 ms after VM EMG onset in the rapid contractions, and at the force plateau in MVCs. MEPs amplitudes were normalised to maximal M-waves, and torque was recorded at the same time points as the MEPs and normalised to MVC torque. 2-way ANOVAs assessed the influence of muscle and time point on the dependent variables and bivariate correlations assessed the relationship between normalised rapid torque and both normalised MEP and SP at match time points.
RESULTS: Normalised MEP was affected by time point ($p=0.021$), being greater at MVC plateau than at 115 ms in rapid contraction ($P=0.031$). SP duration was also affected by time point ($P=0.002$), due to it being longer at MVC plateau than at different time points during the rapid contractions, particularly in the RF. There was no correlation between SP and normalised rapid torque at any time point ($r<0.1$; $P>0.9$). However, normalised rapid torque at 115 ms was correlated with average normalised MEP at 45 and 115ms ($r=0.73$, $p=0.003$).
CONCLUSION: In conclusion, corticospinal excitability (determined via MEP) was constant throughout the rapid contractions but lower, at least at one time point, than at the MVC plateau. The SP lengthened throughout the rapid contractions and was longest at the MVC plateau, suggesting intracortical inhibition increases with torque. The observed correlation between MEP and torque at 115 ms suggests corticospinal excitability determines neural and thus RFD during rapid contractions.
(1) Maffiuletti et al. (2016) Eur J Appl Physiol, 116(6), 1091–1116
(2) Del Vecchio et al. (2019) J Physiol, 597(9), 2445–2456.

### ACUTE EFFECTS OF ALCOHOL CONSUMPTION ON CORTICOSPINAL PARAMETERS MEASURED BY TRANSCRANIAL MAGNETIC STIMULATION

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INTRODUCTION: Although alcohol affects many brain functions and induces evident behavioural changes such as locomotor impairments, its short-term effects on the excitability of the corticomotoneuronal pathway are scarcely known. It is widely accepted that alcohol reduces glutamatergic and increases GABAergic neurotransmission. Since GABA-related inhibition is fundamental for motor control and motor learning, this suggests that alcohol might have a strong influence on these brain functions. One non-invasive method to study excitability and GABA-related inhibition parameters is transcranial magnetic stimulation (TMS). Surprisingly, however, and despite the wide use of this method in the field of motor control and motor learning, only few studies have investigated the acute effects of alcohol on corticospinal parameters using TMS (1). Therefore, the aim of this study was to investigate the acute effects of moderate alcohol consumption on excitability and inhibition parameters measured by TMS.
METHODS: 24 participants were allocated to either the alcohol or the placebo group. Before and after the drinks, TMS was applied on the primary motor cortex to elicit motor evoked potentials in the flexor carpi radialis muscle. The following TMS parameters were assessed: (i) corticospinal excitability (CSE), measured at rest, during an isometric contraction and during a precision task; (ii) cortical silent period (CSP), measured during an isometric contraction; (iii) short-interval intracortical inhibition (SICI), assessed using 1 ms (SICI-1) and 3 ms (SICI-3) interstimulus intervals, and measured at rest as well as during a precision task. Data were analyzed using two-way mixed model 2x2 ANOVAs.
RESULTS: Alcohol significantly reduced CSE measured during the precision task (significant interaction effect of TIME x GROUP: $F(1, 22) = 8.645$, $p = 0.008$, $n2p = 0.282$). A trend towards reduced CSE was also observed during the isometric contraction (interaction of TIME x GROUP: $F(1, 22) = 2.119$, $p = 0.160$, $n2p = 0.089$), while no differences were found at rest. Furthermore, we found a trend towards a reduction of SICI-1 by alcohol, both at rest (interaction effect of TIME x GROUP: $F(1, 21) = 2.971$, $p = 0.099$, $n2p = 0.124$) and during the precision task (interaction effect of TIME x GROUP: $F(1, 22) = 2.165$, $p = 0.156$, $n2p = 0.093$). No significant alcohol-related effects were found for SICI-3 and CSP duration.
CONCLUSION: Increases in inhibition due to alcohol intake could be observed in motor cortical circuits. More specifically, a decrease in corticospinal excitability was found during the execution of a precision task as well as a trend towards an increase in SICI-1. However, as not all TMS parameters were affected by alcohol it might be assumed that at moderate concentration levels, alcohol affects motor cortical circuits mainly through the extrasynaptic GABA system (2).
REFERENCES:
1) Turco et al., Brain Sci, 2020
2) Wallner et al., Proc Natl Acad Sci, 2003

### MODULATION OF CORTICOSPINAL EXCITABILITY BY VIRTUAL REALITY: THE ROLLER COASTER EFFECT

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INTRODUCTION: Virtual Reality (VR) is a training tool that consists of a computer simulation of a three-dimensional environment, displayed in front of an individual by means of a specific electronic equipment such as a headset with integrated screens. The interest, as compared to a classical 2-D display, is based on the interactive and realistic aspect of the simulation. VR is known to consistently stimulate the autonomic nervous system, as evidenced by increases in heart rate and skin conductance, which are two physiological markers of stress and anxiety (1). Significant brain activation in sensori-motor regions is also noted, especially when participants can interact in their virtual

environment (2). However, little is known regarding a possible effect of VR on the modulation of corticospinal excitability, neither the links that could exists between autonomous and voluntary nervous systems modulations during such condition.
METHODS: Ten healthy young participants were enrolled in a single-session experiment. They were seated in a comfortable chair and equipped with a VR headset that displays a simulated roller coaster (RC) ride, known to be particularly efficient to modulate autonomous responses (1). Anxiety was monitored throughout the experiment by recording Galvanic Skin Response (GSR). Corticospinal excitability was quantified by measuring the amplitude of the motor evoked potential (MEP), elicited by transcranial magnetic stimulation on the right First Dorsal Interosseous (FDI) muscle's cortical representation. Several responses were evoked at rest and throughout the whole RC ride, during flat, uphill and downhill sections. MEP amplitudes were normalized to their corresponding maximal M-waves, evoked by stimulation of the ulnar nerve.
RESULTS: First, all MEP/Mmax were significantly higher during RC ride as compared to rest (P=0.02). Then, MEP/Mmax were significantly modulated according to the roller coaster section. The modulation of corticospinal excitability seems to follow an inverse gradient according to the trajectory of the RC cart, being increase during downhill (MEP/Mmax: 0.21±0.07) and decreased during uphill (MEP/Mmax: 0.17±0.05) as compared to flat sections (MEP/Mmax: 0.19±0.08) (main effect of slope: P=0.03). The evolution of MEP/Mmax was concomitant to the evolution of GSR.
CONCLUSION: Popular for its effects on the markers of stress and anxiety, the present study showed that VR can also be an efficient stimulus to modulate motor corticospinal excitability. Moreover, these preliminary data suggest a potential link between voluntary and autonomic nervous systems regulation during VR. Taken together, these promising results highlight the interest of VR in training and rehabilitation as an efficient stressor for both autonomous and motor systems.
(1) Fadeev et al., 2020. Behavioural Neurology, 2020: 5758038
(2) Djebbara et al., 2019. PNAS, 116(29).

**INFLUENCE OF VISUAL AND PROPRIOCEPTIVE INPUTS ON A FORCE REPRODUCTION TASK PERFORMED WITH THE INDEX FINGER IN FEMALES AND MALES**

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INTRODUCTION: Along with the kinaesthetic senses (the senses of position and movement), the sense of force is another aspect of proprioception which represents the ability to correctly perceive and reproduce a given level of force (1). It can be assessed by a force reproduction task consisting of matching a target force with visual feedback of the force produced (TARGET phase) and reproducing the target force without visual feedback (REPRODUCTION phase) after a period of rest. Even though the sense of force contributes to the control of our movements, it has received less attention than kinaesthetic senses. The sensory substrates used to form the estimate of the force during the TARGET phase remains, for example, an open question. Therefore, the objective of the study was to determine the contribution of muscle proprioception (Experiment 1) and vision (Experiment 2) to form the force estimate during the target phase in females and males.
METHODS: Sixty healthy young adults aged from 19 to 27 years [30 females and 30 males] participated in the study. Both experiments consisted of performing a force reproduction task with the index finger in abduction direction at 5% and 20% of the force produced by the participant during a maximal voluntary contraction (MVC). Experiment 1 (n=30) consisted of trials performed with and without local vibration applied on tendon of the first dorsal interosseous during the TARGET phase. Local vibration was used to disrupt the proprioceptive signal. Experiment 2 (n = 30) compared the force reproduction error between trials performed with and without visual feedback during the TARGET phase. Removing the visual feedback during the TARGET phase was used to investigate whether the mismatch in the available sources between the TARGET and the REPRODUCTION phases contributes to the force reproduction error.
RESULTS: The force reproduction error was greater in trial with local vibration than without at 5% ($p = 0.011$) but not 20% MVC ($p = 0.88$). In contrast, the error was lesser in trials without than with visual feedback for the 5% ($p = 0.003$) but not the 20% MVC ($p = 0.19$). No sex difference was observed in the force reproduction error, regardless of the experimental conditions.
CONCLUSION: These results support the contribution of muscle proprioception in the sense of force (2), and further indicate that muscle proprioception contributes to form the force estimate during the TARGET phase. In contrast, providing visual feedback of force during the TARGET phase biases the sense of force assessment for low-force contractions. The greater effect of proprioceptive and visual perturbation at 5% compared with 20% MVC also suggests that contrasting low and moderate force intensities may help to refine the assessment of the sense of force.

## Oral presentations

### OP-AP05 Strength testing and training

**POST ACTIVATION PERFORMANCE ENHANCEMENT OF PUNCH FORCE AND NEUROMUSCULAR PERFORMANCE OF AMATEUR BOXERS FOLLOWING TWO PUNCH-SPECIFIC UPPER-BODY CONDITIONING ACTIVITIES.**

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INTRODUCTION: Peak punch force and rate of force development (RFD) are two key performance indicators in boxing. The use of prior voluntary muscle activity may enhance subsequent athletic performance via Post Activation Performance Enhancement (PAPE); however, research has largely comprised conditioning activities (CA) that are impractical to an amateur boxing warm-up environment. This study aimed to assess the efficacy of two punch-specific CA's (isometric [ISO], and elastic resistance [ER]) in enhancing punch force and neuromuscular performance of amateur boxers.
METHODS: Ten male senior elite amateur boxers performed a standardised warm-up, followed by either 3 x 3-second repetitions of the ISO CA, 2 x 5 repetitions of the ER CA, or a control trial, on 3 separate days. Punch force variables and counter-movement jump (CMJ) height were measured via a vertically mounted force plate and a photocell system, respectively. Boxers performed tests at baseline, and at 3, 5, 7, 9, 11, and 13-minutes post CA, with the same time intervals for the control trial. Worthwhile changes in performance were assessed by comparing change scores from baseline at each time interval, to a previously determined smallest worthwhile change (SWC), in addition to

effect sizes (ES) and signal:noise (S:N) ratio. Any mean difference that was greater than the SWC, or where the S:N ratio was > 1, was deemed a worthwhile change.
RESULTS: Punch performance increased above the SWC threshold at several intervals in both the ISO and ER CA, but rarely in the control trial. Peak punch force and RFD was improved following the ISO CA in the cross (+226 N, ES = 0.42, S:N = 1.97; +48472 N.S-1, ES = 0.76, S:N = 3.80), lead hook (+167 N, ES = 0.33, S:N = 1.46; + 28952 N.S-1, ES = 0.34, S:N = 1.61), and rear hook (+231 N, ES = 0.44, S:N = 1.92; + 43560 N.S-1, ES = 0.46, S:N = 2.03). Likewise, the ER CA induced worthwhile increases in the punch force of the cross (+157 N, ES = 0.30, S:N = 1.37) and rear hook (+208 N, ES = 0.36, S:N = 1.73), and in both punch force and RFD of the lead hook (+171 N, ES = 0.35, S:N = 1.50; +20955 N.S-1, ES = 0.27, S:N = 1.17). A single worthwhile increase in jab RFD was found following the ISO CA. No increases in CMJ performance was observed
CONCLUSION: The ISO and ER CA's typically produced worthwhile improvements in punch force and rate of force development (RFD); however, the ISO CA clearly induced greater increases, and across a larger time course overall. The CA's produced a localised effect, as evidenced by a lack of worthwhile improvement in CMJ performance. Peak PAPE was typically observed between 7 to 9-minutes, though this varied between individuals. In conclusion, the ISO and ER CA's appear to elicit worthwhile improvements in punch force and RFD of senior elite amateur boxers, though the punch-specific isometric hold appears to be the superior CA. Future research should apply a more individualised approach to the CA in this study, indeed the current research group are presently exploring this.

### EFFECTS OF DIFFERENT VELOCITY LOSS THRESHOLDS ON SUBSEQUENT MECHANICAL PERFORMANCE IN THE FLYWHEEL SQUAT EXERCISE

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INTRODUCTION: INTRODUCTION
In resistance training, the velocity loss in real-time during the set execution is a practical strategy to elicit different acute mechanical responses [1]. When free weights were used, the lower the velocity loss, the lower the mechanical performance detriment. Other modern training equipment is the flywheel resistance training devices [2]. However, it is still unknown how different velocity loss thresholds may affect physical performance. Therefore, this study aimed to analyse the subsequent mechanical performance after executing different velocity loss thresholds in a flywheel device.
METHODS
Ten participants (weight 75.5 ± 17.1 kg, height 1.74 ±0.12 m) with no previous experience using flywheel devices participated in the study. Before the intervention, the participants were familiarized with eight training sessions using the half-squat exercise on a flywheel device (Kbox 3, Exxentric, Sweden). The participants attended the laboratory for four days, where they executed two countermovement jumps and one maximum voluntary isometric force squat test before the intervention and after each set. The intervention consisted of three sets of the half-squat exercise with a moment of inertia of 0.050 kg·m 2 or 0.150 kg·m2 . Each load was executed for two different days. The repetitions were individualized based on three randomised velocity losses (5%, 10%, and 15%). We monitored the velocity losses using a rotary encoder in real-time (SmartCoach lite, Sweden). For jump height and peak force, we
tested the pre vs. post (Time) differences using an ANOVA repeated measures test with three
within-subjects factors (Load (2) x Time (2) x Velocity Loss (3)). In case of a significant interaction, we explored post-hoc differences with Bonferroni adjustment. We set the statistical significance level at p< 0.05.
RESULTS
There was a significant Time x Velocity Loss difference in the jump height (p= 0.010). In addition, there was a significant reduction in the jump height in Time (p< 0.001) and in Velocity Loss as main factors (p< 0.010). Jump height was significantly reduced (p< 0.001) after losing 5% (-19.5%), 10% (-19.8%), and 15% (-27.5%) of speed. Those losses were significantly different between 5 and 15% (p=0.00) and between 10% and 15% (p= 0.004).The peak force only showed a significant reduction in Time as main factor (p<0.001, -15.6%).
CONCLUSION
Higher velocity losses induced higher jump height losses in the flywheel half-squat exercise. Using a velocity loss of 5% or 10% within the set resulted in the same jump performance impairment. However, peak force was not dependent on the velocity loss. Finally, for these two key performance indicators, the load (i.e., moment of inertia) does not influence subsequent impairments. The results of this study are of practical importance for programming basic training variables in flywheel resistance training devices.
1.Medina & González-Badillo (2011) 2. Muñoz-López et al. (2021)

### METHODS: RESULTS: CONCLUSION: MATURITY OFFSET, ANTHROPOMETRIC PROFILE, AND THE VERTICAL FORCE-VELOCITY PROFILE IN YOUTH BASKETBALL PLAYERS

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INTRODUCTION: Two of the main current problems in training sports reside in the wide anthropometric differences that exist in the different categories (U-14, U-16 and U-18) (1) and the need to individualize training in order to optimize the present and future performance of basketball players (2, 3). The objective of this work was to analyze the relationships between maturity offset, anthropometric variables and the vertical force-velocity profile in youth (12-18 years old) male and female basketball players. We hypothesized that there will be significant correlations between maturity offset and force-velocity profile.
METHODS: The vertical force-velocity profile was measured in 84 basketball players (44 female players and 40 male players), grouped in competitive-age categories, i.e., under 14, 16 and 18 years of age (U-14, U-16, and U-18, respectively). A bivariate correlational analysis was carried out between maturity offset, anthropometric variables (height, body mass, % fat, muscle mass, bone mass and BMI) and vertical force-velocity profile (Theoretical maximal force, theoretical maximal velocity, theoretical maximal power, force-velocity imbalance and force-velocity profile orientation).
RESULTS: The results showed significant correlations (p <0.05) between force-velocity imbalance (Fvimb) and maturity offset at early ages of training (12-15 years). The anthropometric profile was correlated (p<0.05) with F0 in U-14, V0 in U-16 and Pmax in U-18 basketball players.

CONCLUSION: The vertical force-velocity profile is hypothesized as a useful index to correct vertical force-velocity deficits according to the maturity offset of the female and male basketball players. A novel finding not contemplated in the initial hypotheses is the discovery of the so-called "determinant variable", which could be defined as "the variable of the vertical force-velocity profile that presents the greatest number of significant correlations with the anthropometric data measured and, therefore, is the one that offers us the greatest combined information". that it would be advisable to take into account for the training in youth basketball players variables such as: body mass, height, muscle mass (total and right and left legs), bone mass, F0 (especially in U-14), V0 (especially in U-16) and Pmax (especially in U-18).

**EFFECTS OF PERIPHERAL MUSCLE STRENGTH ASYMMETRIES ON MUSCLE FATIGABILITY IN PROFESSIONAL SOCCER PLAYERS**

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INTRODUCTION: Soccer is a high-intensity intermittent team sport, during which neuromuscular factors are heavily taxed to perform quick accelerations, decelerations, and changes of direction (COD) [1]. Inter-limb strength asymmetries have been reported to negatively affect physical performance including COD tasks across various team sports [2], however little is known about their impact on muscle fatigability during soccer specific exercises such as repeated CODs. Therefore, this study examined the effect of peripheral muscle strength asymmetries across a repeated COD task on muscle fatigability in adult professional soccer players.
METHODS: A total of 249 male professional soccer players (age: 25±5 yrs; stature: 182±6 cm; body mass: 78±7 kg) participated in this study. Each player performed a repeated COD test at least once (range: 1-23; total number of individual test sessions: 1.009). The repeated COD test encompassed four levels of intermittent runs with multiple CODs performed at increasing standardized intensities over an 8-m course. After each level, right and left knee extensors were electrically stimulated in resting isometric conditions to evoke a peak twitch (PT) response (an indicator of peripheral muscle strength). The main outcomes were PT torque after the first (PT1) and fourth (PT4) levels as well as the highest absolute value (PTmax) for both sides. Players were then allocated to specific groups according to their inter-limb asymmetry in PT1, PT4 and PTmax (LOW: ≤10%, MID: 10-20%, HIGH: >20%) and according to the difference in asymmetry between PTmax and PT4 (ΔPT4-PTmax). Muscle fatigability (PTdec) was calculated as the mean percentage decline from PTmax to PT4.
RESULTS: Mixed models were used to determine differences in PTdec between asymmetry groups. No significant differences in PTdec were observed between groups for PT1 and PTmax asymmetries ($p=0.402$ and $p=0.102$, respectively). On the other hand, PTdec was moderately affected by asymmetries observed at PT4 ($p<0.001$; LOW, 17.8%, range: 3.4%-49.5%; MID, 19.1%, range: 3.5%-58.7%; HIGH, 25.7% range: 5.3%-79.6%). In the same way, asymmetries based on ΔPT4-PTmax largely influenced PTdec ($p<0.001$; LOW, 16.2%, range: 3.4%-39.6%; MID, 22.4%, range: 7.2%-52.5%; HIGH, 35.5%, range: 12.0%-79.6%).
CONCLUSION: The current findings suggest that larger peripheral muscle strength asymmetries under fatigue (i.e. at PT4) and larger changes in asymmetries during the COD test (ΔPT4-PTmax) were associated to higher levels of muscle fatigability during repeated CODs in professional soccer players. This study provides novel insights about how peripheral muscle strength asymmetries may impact a soccer-specific task in the presence of muscle fatigability. The present results also highlight the need to evaluate inter-limb strength asymmetries under fatigue and possibly to reduce their extent with the ultimate goal to enhance physical performance.
REFERENCES:
1. Rampinini et al. (2011)
2. Bishop et al. (2018)

**HANDGRIP STRENGTH TESTING AND SHOOTING PERFORMANCE IN ICE HOCKEY PLAYERS**

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INTRODUCTION: Handgrip strength is a valuable indicator of quality of life, performance, and recovery. In ice hockey the stick is held with both arms. More successful ice hockey teams were thus found to have higher combined handgrip strength. This study was designed to determine possible relationships of handgrip strength assessed at different shoulder positions with on-ice shooting performance in professional ice hockey players.
METHODS: Sixteen competitive male ice hockey players (forward/defenseman: 10/6, age: 23-34 years, BMI: 22-29 kg/m²) volunteered to participate in this cross-sectional study. Handgrip strength was measured at both sides during upright standing off-ice in three different shoulder positions using a handheld dynamometer (SH5001, Saehan Corporation, Masan, South Korea). The first position was with the arm adducted and neutrally rotated, elbow flexed at 90° and forearm in neutral (NORM). To involve the shoulder joint, the second and third positions were with the arm abducted at 90° and externally rotated at 90° (ABER), and with the arm elevated and the elbow extended (ELEX). The maximum of two maximal effort trials was used, cumulated from both sides, and normalized to athletes' body mass. After a brief independently executed specific warm-up on-ice, athletes shot three slap shots (SS) and three wrist shots (WS) at an empty goal. The puck speed was recorded by a radar gun system (Stalker Solo 2, Stalker, Plano, TX, USA). The average speed of successful shots only was used. Differences between playing positions were verified by applying Student's unpaired t tests. Possible relationships were explored using Pearson's r statistics.
RESULTS: The playing position did not affect any outcome measured ($p = 0.1$-$0.5$). Athletes' mean combined handgrip strength was 1.37 kg/kg (minimum-maximum: 1.20-1.56), 1.30 (1.13-1.59) and 1.30 (1.17-1.58) at NORM, ABER and ELEX, respectively. The averaged puck speeds of SS and WS were 136 km/h (128-149) and 113 (104-128). There was a relevant and significant association of combined handgrip strength at ABER with SS puck speed ($r = 0.54$, $p < 0.05$), explaining 29% of the variance. However, no relevant associations were found at NORM or ELEX for either shot type ($r < 0.4$, $p > 0.14$).
CONCLUSION: In order to estimate on-ice shooting performance in ice hockey players using general off-ice strength tests, handgrip measurements should be run with the arm abducted, externally rotated and with the elbow flexed at 90°.

## Oral presentations

### OP-PN30 Relative energy deficiency in sports (RED-S)

#### IMPACT OF EXERCISE IN THE FASTED STATE ON PROSPECTIVE FOOD CONSUMPTION

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INTRODUCTION: Exercise is recommended for weight management, yet weight loss from exercise is often less than expected based on measured energy expenditure. This is primarily due to compensatory energy intake, which occurs in most exercisers and overrides the appetite-suppressing effects of acute exercise. Exercising in a fasted state seems to be a promising way to decrease overall energy intake, as it has been reported that ad libitum 24h energy intake following fasting exercise is significantly lower than after non-fasting exercise. Acute effects of fasted exercise on post-exercise energy intake and particularly on post-exercise decision-making about food remain poorly understood. Therefore, the present study aimed to investigate whether fasting exercise and exercise after a standardized breakfast have different effects on hypothetical post-exercise food intake.
METHODS: In this crossover study, ten healthy participants (29.7 [SD=2.2] years, 22.8 [SD=2.1] kg/m2, 50% women, regular habitual exercise, regular breakfast consumption) completed two identical 30-min exercise sessions on either a treadmill or bike ergometer (as preferred). The exercise sessions occurred following (1) an overnight (12h) fast (FE) or (2) a standardized breakfast (BE; oatmeal, low-fat milk, and apple; ~10-15% of individual daily energy requirements) after an overnight fast. Before (pre), immediately after (post), and 30 minutes after (post30) the exercise session, participants completed electronic questionnaires with visual food cues to determine hypothetical food amount preferences and intertemporal food preferences (immediate vs. delayed consumption after 4 hours).
RESULTS: The preferred food amount for immediate consumption was significantly decreased compared to pre immediately after FE (161 [SD=85] kcal vs 236 [SD=81] kcal, p=0.006) but not after BE (p=0.26). For both exercise conditions, the amount of food selected for immediate consumption at post30 was significantly greater compared to pre (FE: 309 [SD=93] vs 236 [SD=81], p<0.001; BE: 201 [SD=103] vs 124 [SD=67], p=0.009). The preferred food amount for immediate consumption was significantly greater for FE compared to the BE, both for pre (difference: 113 [SD=57] kcal, p<0.001) and post30 (difference: 109 [SD=87] kcal, p=0.004) but not post (p=0.47). There were no significant differences between time points for delayed consumption in either exercise condition.
CONCLUSION: The results of the present study suggest that fasting exercise may contribute to an overall daily energy deficit despite higher post-exercise energy intake (at post30) compared to exercise after a small breakfast. Importantly, hypothetical food intake did not differ between the two conditions immediately after exercise, suggesting that consumption of a meal at that time might maximize the calorie deficit-related benefits of fasting exercise. More (longitudinal) research in larger samples is needed to determine whether fasting exercise is an adequate method for weight loss.

#### CARBOHYDRATE AVAILABILITY IN FEMALE ENDURANCE ATHLETES WITH SYMPTOMS OF RELATIVE ENERGY DEFICIENCY IN SPORT (RED-S)

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INTRODUCTION: Endurance athletes with high training loads and weight focus have increased risk of low energy and carbohydrate (CHO) availability. Sufficient CHO availability throughout the day is needed to provide substrate to e.g., muscles and hypothalamic-pituitary hormone production. The aim of this study was to investigate the dietary intake with special focus on timing of CHO intake in relation to training load in athletes with symptoms of Relative Energy Deficiency in Sport (RED-S).
METHODS: Female endurance athletes (n=12) [26 ± 4 years, BMI: 21 ± 2 kg/m2, training: 13 ± 4 hours/week], with symptoms of RED-S (Low Energy Availability in Females Questionnaire total score ≥ 8), and without disordered eating behavior were included. Athletes recorded their dietary intake (prospective weighed food records) and training for seven consecutive days. The type of activity and time spent in each intensity (I) zone (1-5) were recorded for each training session. I1 was defined as a workload of 60-72% of max heart rate (HR) (individual performance test), I2 as 72-82% of max HR, I3 as 82-87% of max HR, I4 as 87-92% of max HR and I5 as > 92% of max HR. The nutrient analysis program DietistNet, Sweden was used to assess dietary intake. CHO intake was furthermore analyzed for; key training sessions (high intensity, in the present study starting from I3)/≥120 min) and easy training sessions (all other sessions >30<120 min) as well as for training days; hard training days (≥ 1 key session) and light training days (all other days). Mean difference, 95% confidence intervals (CI) not including 0, and a paired student's t-test were used to determine differences between participants dietary and CHO intake and international sport nutrition recommendations.
RESULTS: The mean daily energy intake was 2821 ± 529 kcal. None of the participants met the recommended daily CHO intake based on individual training load [CI -1.7 (-2.4 to -0.9)], or CHO intake immediate after (1 g/kg) [CI -0.7 (-0.9 to -0.5)] or between (1 g/kg/h) [CI -1.2 (-2.0 to -0.4)] key training sessions. Only 27% fulfilled the CHO intake during (30-60 g/h) key training sessions [CI -15.2 (-29.1 to -1.3)] even though the minimum CHO recommendation of 30 g/h was used in the analyze. The daily CHO recommendations were more difficult to fulfill during hard compared to light training days (p=0.014). All participants met the international sport nutrition recommendations for protein (2.1 ± 0.6 g/kg/day vs. 1.2-2.0 g/kg/day) and fat (36.5 ± 7.2 E% vs. 25-35 E%).
CONCLUSION: In the present study, female endurance athletes with symptoms of RED-S did not match their total or timing of CHO intake in relation to training load according to international sport nutrition recommendations, while protein and fat intake was sufficient. Hence, these results indicate that focus on optimizing CHO intake is needed to prevent and treat RED-S.

**EVALUATION OF THE FUEL INTERVENTION – A RECOVERY PROGRAM FOR FEMALE ENDURANCE ATHLETES WITH RELATIVE ENERGY DEFICIENCY IN SPORT (RED-S)**

FAHRENHOLTZ, I.L., MELIN, A.K., GARTHE, I., HOLLEKIM-STRAND, S.M., WASSERFURTH, P., LOGUE, D., KOEHLER, K., MADIGAN, S., KLUNGLAND TORSTVEIT, M.

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INTRODUCTION: Relative Energy Deficiency in Sport (RED-S) is a complex syndrome describing health and performance consequences of low energy availability and is commonly reported among female endurance athletes. However, no systematic multicenter intervention study aiming to improve symptoms of RED-S exists. The aim of this study was therefore to develop and test a nutritional intervention study for female athletes with symptoms of RED-S and to investigate their experiences with the program.
METHODS: The Food and nUtrition for Endurance athletes – a Learning (FUEL) program was developed; a practice orientated 16-week sports nutrition intervention for female endurance athletes with risk of RED-S, and with low risk of eating disorders [Low Energy Availability in Females Questionnaire (LEAF-Q) score ≥8 + Eating Disorder Evaluation Questionnaire (EDE-Q) score <2.5]. The program consisted of weekly online sports nutrition lectures and individual consultations with an experienced sports nutritionist every other week. Athletes (n=34) from Norway (n=8), Sweden (n=18), Ireland (n=5), and Germany (n=2) were included, and all but one completed the intervention. One week after the intervention, 29 of the 33 athletes (88%) filled out a questionnaire consisting of 21 questions regarding their experience of participating in the FUEL program.
RESULTS: On a scale from 1 to 10, the overall satisfaction for participating in the FUEL project was 9.3 ± 0.9 and the level of satisfaction for the individual nutrition consultations was 9.4 ± 1.2. Athletes reported having experienced increased surplus energy (69%), improved mood (66%), improved food pleasure (62%), improved self-esteem (59%), improved enjoyment of training (48%), improved ability to cope with everyday stress (45%), and improved body satisfaction (45%) during the intervention. Few negative effects were reported; reduced surplus energy (n=1), decreased ability to cope with everyday stress (n=1), reduced enjoyment of training (n=1), reduced food pleasure (n=1), and reduced body satisfaction (n=1) during the intervention. The negative effects were reported by n=5 in combination with several positive effects and an overall satisfaction level of 10. Among the participating athletes, 73% found the level of the teaching videos appropriate, while 14% found the level too low and 14% found the level too high. Athletes' motivation on a 1-10 scale for participating in the individual consultations was 8.8 ± 1.3 and 7.7 ± 1.9 for online lectures and was unchanged during the intervention period for most (59%) athletes, although motivation for participating in the individual consultations increased during the intervention for 38% of the athletes. All responders replied that they would recommend the program to other female endurance athletes.
CONCLUSION: Based on the positive participant experiences, the FUEL program has potential for a wider range implementation among European female endurance athletes.

**SHORT TERM ENERGY RESTRICTION LOWERS RESTING METABOLIC RATE AND SLOWS POST-OCCLUSIVE FOREARM BLOOD FLOW RECOVERY RATE IN ACTIVE EUMENORRHEIC FEMALES.**

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INTRODUCTION: Amenorrheic exercising females demonstrate lower resting metabolic rate (RMR) and impaired vascular function compared to their regularly menstruating counterparts. While estrogen deficiency due to ovarian disruption has been linked with these perturbations, the independent effects of low energy availability (LEA), the primary cause of menstrual disturbances in female athletes, remain unclear.
METHODS: Healthy, regularly menstruating, active females (n=16, 23.3±4.2 years, BMI=22.5±2.2 kg·m2, VO2peak=46.7±8.6 ml·kg-1·min-1) completed two 3-day conditions of controlled energy availability: 15 (LEA) or 45 kcals·kg fat-free mass-1·day-1 (balanced energy availability, BAL). Each condition was assessed during days 1-9 of the menstrual cycle (low estrogen phase). RMR (indirect calorimetry), augmentation index normalised to 75 bpm heart rate (AIx@HR75, applanation tonometry), resting and peak forearm blood flow (FBF, venous occlusion plethysmography), and other variables of interest were measured at pre- and post-intervention. General estimating equations were used to create statistical models with condition and time as predictors. Interactions were examined and pairwise comparisons were made for pre- to post-intervention in each condition, $p<0.05$ was considered significant. Data are expressed as estimated marginal mean ± SE.
RESULTS: Significant interactions were observed for FFM ($p<0.001$), RMR ($p=0.033$), resting FBF ($p=0.005$), fifth post-peak to resting FBF ratio ($p=0.019$), and peak to fifth post-peak FBF ratio ($p=0.030$). FFM and RMR decreased by 0.9±0.2 kg and 111±33 kcals·day-1 in LEA (both $p<0.001$) and remained stable in BAL (both $p>0.148$), however, change in RMR was not correlated with change in FFM ($r=0.19$, $p=0.311$). Resting FBF decreased in LEA and increased in BAL, but neither change was significant in pairwise comparison (both $p>0.170$). In LEA, the fifth post-peak to resting FBF ratio increased by 0.25±0.10 ($p=0.019$), the peak to fifth post-peak FBF ratio decreased by 4.79±1.94 ($p=0.014$), and both ratios remained stable in BAL (both $p>0.428$). Change in fifth post-peak to resting FBF ratio was not correlated with change in resting FBF ($r=0.07$, $p=0.752$), and change in peak to fifth post-peak FBF ratio was not correlated with change in peak FBF ($r=0.19$, $p=0.345$). There were no significant interactions for heart rate, systolic and diastolic blood pressure, plasma volume, AIx@HR75, or peak FBF (all $p>0.177$).
CONCLUSION: These findings suggest that short term energy deficiency lowers resting metabolism and modulates vascular function in healthy eumenorrheic women, highlighting an independent role for LEA in these perturbations. These observations may have relevance in understanding the effects of LEA on metabolic and vascular health in female athletes presenting with menstrual disturbances.

## Oral presentations

### OP-AP15 Winter Sports

#### RELIABILITY OF CROSS-COUNTRY SKI SPECIFIC PERFORMANCE TESTS AND PHYSIOLOGICAL MEASUREMENTS IN HIGHLY-TRAINED SWISS CROSS-COUNTRY SKIERS

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INTRODUCTION: Measurements of performance and physiological characteristics in elite athletes need to be reliable and valid, in order to differentiate between meaningful changes, trends and inherent test variability [1]. However, reliability measures for cross-country ski specific test protocols involving various sub-techniques are currently lacking or remain unreported. This study aimed to investigate the test-retest reliability of a comprehensive cross-country ski specific test battery involving endurance, sprint and neuromuscular testing procedures.
METHODS: Twenty-seven highly-trained cross-country skiers (17 male and 10 female, age: 22 ± 4 years, VO2max: 70.1 ± 4.5 and 58.8 ± 4.4 ml/kg/min, respectively) performed a test-retest protocol separated by two days in between. Performance testing consisted of a graded exercise test skating (GXT), a VO2max-test classic (VO2max-test), a 24-min double poling time-trial (24-min DP), a double poling peak velocity test (DP Vpeak), and a 1-min anaerobic capacity test skating (V2 1-min) all using roller skis on a treadmill. In addition, participants also performed a 20-s double poling peak power test on a ski ergometer (SkiErg DP) and explosive strength test for the upper body (UB-ST) on a custom-made device with light, medium and heavy load. Intra-class correlation coefficient (ICC), standard error of measurement (SEM), and coefficient of variation (CV) test statistics were calculated for all variables.
RESULTS: Time to task failure performance in the GXT and VO2max-test, time-trial performance in 24-min DP and V2 1-min, as well as peak velocity in DP Vpeak all demonstrated excellent ICC (0.96 – 0.99) and CV (1.0 – 2.3%). Measured absolute VO2max during the ski specific treadmill test displayed excellent reliability (ICC: 0.99; CV: 1.4%; SEM: 62 mL/min). Relative peak power during the SkiErg DP showed excellent reliability (ICC: 0.99; SEM: 0.18 W/kg; CV: 2.4%), whereas reliability measures for relative upper-body peak power in the UB-ST were acceptable (ICC: 0.89 – 0.95; SEM: 0.59 – 0.91 W/kg; CV: 5.0 – 7.9%) across all loads.
CONCLUSION: In highly-trained cross-country skiers, sport-specific aerobic and anaerobic performance tests on a treadmill using roller skis demonstrated high test-retest reliability, while neuromuscular performance measures for the upper body being somewhat less reliable. The current study provides comprehensive cross-country ski specific test-retest reliability measures for power and endurance based test protocols in various skiing sub-techniques. These findings allow athletes, coaches and scientists to accurately track performance changes between trials, which is a requirement in the elite athlete population with its small inherent performance variation.
1. Hopkins, W.G., E.J. Schabort, and J.A. Hawley, Reliability of power in physical performance tests. Sports Med, 2001. 31(3): p. 211-34.

#### ANNUAL TRAINING CHARACTERISTICS OF ELITE NORWEGIAN FEMALE CROSS-COUNTRY SKIERS AND BIATHLETES: THE FENDURA PROJECT.

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INTRODUCTION: Periodization of training is a systematic regulation of training content through the manipulation of exercise session duration, intensity, frequency, and modality to achieve optimal performance at the appropriate time. Several studies have previously reported the annual training periodization of elite, endurance winter-sport athletes; however, this research has primarily used small samples sizes (e.g., n<20), or not included female athletes. Therefore, the present study aimed to describe the annual training characteristics of elite female Norwegian cross-country skiers and biathletes, and to compare athletes of different performance-levels.
METHODS: A total of 89 elite, female cross-country skiers and biathletes (21 ± 2.8 y; 62.5 ± 4.6 kg, 628 ± 109 training h/year) systematically recorded all day-to-day training session data in an online training diary for the 2020-21 season. Variables collected included duration and frequency of endurance training sessions distributed across three intensity zones (low intensity [LIT]; moderate intensity [MIT]; and high intensity (HIT]), and self-reported session intensity (Borg CR10 scale). Data were grouped into five training phases: general preparatory 1 (GP1; May – July [13 weeks]), general preparatory 2 (GP2; July – October [13 weeks]), specific preparatory (SP; October – December [9 weeks]), competitive period (CP; December – March [14 weeks]), and recovery (April [4 weeks]). Data were analysed with linear or cumulative logit-link mixed models and presented as mean ± standard deviation or [95% confidence intervals].
RESULTS: Over the annual season, athletes trained 634 ± 171 h across 412 ± 89 sessions. The proportion of time spent as LIT was relatively constant (~90%) across all phases and only rose during recovery. In contrast, the proportion of MIT was initially elevated during GP1 (5.2% [4.6-5.8%]) and then decreased in GP2, while HIT started at a lower proportion in GP1 (4.2% [3.6-4.7%]) and increased in subsequent phases (p=.001-.008), peaking during CP (5.6% [5.1-6.2%]). Session intensity was constant across GP1 and GP2 but then decreased for SP and CP (p=.011-.032). National-team athletes performed relatively more MIT than the non-national team athletes during the competitive phase (4.8% [4.2-5.4%] vs 3.6% [2.5,4.6%]; p=.039), although there was no difference between the groups when presented as total MIT duration across the phase (p=.136).
CONCLUSION: This sample of elite female cross-country skiers and biathletes reported a high annual training duration (600+ hours/year). The majority of training was completed as LIT and this proportion was relatively constant throughout the season. Periodization between training phases appeared to be regulated via a shift from MIT to HIT over the season.

#### THERMOREGULATORY RESPONSE TO EXERCISE IN COLD ENVIRONMENT MEASURED AT DIFFERENT BODY PARTS IN ELITE BIATHLETES

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INTRODUCTION: Extreme cold conditions have a negative impact on endurance exercise performance such as in biathlon, where muscle as well as shooting performance, due to a decrease in manual dexterity, is affected. Hence, it is paramount that biathletes adopt clothing

strategies preventing excessive cooling during downhill sections and on the shooting range, while avoiding excess heat production during the skiing bouts. The purpose of the present study was to measure the thermoregulatory response at different body parts during exercise in a cold environment in biathletes.
METHODS: Thirteen Swiss elite biathletes (6 females, 7 males; age: 27 ± 4 years) performed two skiing exercise bouts (men: 4.12 km; women: 3.49 km) lasting approximately 15 min in the skating technique on two consecutive days at about 78 ± 4 % of maximal heart rate. They were wearing a race suit in accordance to skiing conditions (ambient temperature: -3.7 ± 2.3 °C; relative humidity: 92.9 ± 6.3%). Heat flux, core and skin temperature were measured with a synchronized sensor-system (CORE, greenTEG AG, Rümlang, Switzerland) placed on the thigh, back, anterior and lateral thorax throughout the entire bout. The subjective perceived rate of thermal comfort (SUBJ) was assessed for the torso, arms, hands, legs, feet, head, neck and whole-body via a visual analog 7-point Likert-scale [1] in winter clothing (REF), right before (PRE) and after exercise (POST).
RESULTS: Heat flux measurements during the warm-up demonstrated differences ($p < 0.001$) between sensor locations, with the thigh showing the highest heat loss (344 ± 37 kJ/m2), followed by the back (269 ± 56 kJ/m2), the lateral thorax (220 ± 47 kJ/m2), and the anterior thorax (192 ± 37 kJ/m2). While core temperature slightly increased from 37.0 ± 0.2°C to 37.5 ± 0.2 °C (NS), skin temperature decreased for all measured body parts ($p < 0.001$). However, the thigh skin temperature decreased to a larger extent (-7.5 ± 1.2 °C) compared to the skin temperature on the back (-2.8 ± 1.0 °C), the anterior thorax (-4.4 ± 2.0 °C) and the lateral thorax (-2.5 ± 1.5 °C). From PRE to POST, SUBJ at the hands decreased from 0.51 ± 0.9 a.u. to -0.53 ± 1.8 a.u. ($p < 0.01$). Although SUBJ for other body parts did not change significantly from PRE to POST, a large inter-subject variability was measured, in particular for the hands, head, and whole-body.
CONCLUSION: During moderate intensity cross-country skiing in cold environment, heat flux in the lower extremities appears to be higher compared to the upper body, resulting in a significant drop in skin temperature and potential negative impact on performance.
Reference
1. ASHRAE. (2013). Standard 55-2013. thermal environmental conditions for human occupancy. New York: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

**AUTOMATIC FRAME RECOGNITION FOR VIDEO TECHNIQUE ANALYSIS IN CROSS-COUNTRY SKIING USING CONVOLUTIONAL NEURAL NETWORKS**

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*MCI INNSBRUCK*

INTRODUCTION: Professional sports is data-driven. Talent acquisition, optimal training, performance analysis and more rely heavily on data. Technique analysis in Cross-Country Skiing (XCS) is no exception. Papers from [1-3] analyzed the motion and classified techniques of XCS athletes based on inertial measurement unit data. The mandatory sensor nodes make the approach unsuited for everyday XCS training. Therefore, most XCS teams implement technique analysis by filming the athletes. However, extracting the relevant frames manually is inefficient. To make the process more functional, this paper provides a proof of concept that automizes the common video analysis approach employed by XCS teams.
METHODS: A common approach is to extract five key frames from lateral or frontal training videos, according to a reference motion pattern for the respective technique. The five patterns for skating 1-1 would be 1) the initial pose, just before the 2) pole plant followed by the 3) push, 4) pole release and the 5) leg push. To identify these five patterns within the video, a sequence of algorithms have been set up. Each frame of a video is analyzed by Yolov3 [4] to extract the athlete within the respective frame. The result is a bounding box and its coordinates in each frame. After cutting the frame using the bounding box the feature extraction algorithm open pose [5] is applied to extract 25 keypoints of the athletes' pose. Therefore, each frame delivers the bounding box, its coordinates, and key point information. After concatenating the data of a frame into a vector, a trained convolutional neural network is able to predict whether the frame is likely to be of pattern 1, 2, 3, 4, 5, or none of them. Since this is done for all frames within the video, the algorithm is able to pick the five most suitable frames for the five patterns. The network was trained according to videos, which were already labeled by coaches.
RESULTS: The sequence of algorithms performed well on the test dataset of frontal skating 1-1 training video with an accuracy of 87.18% for pose 1, 59.15% for pose 2, 81.43% for pose 3, 85.26% for pose 4, 97.09% for pose 5 and 73.86% for all poses except 1 to 5. The lateral test dataset has led to accuracies of 82.65% for pose 1, 86.21% for pose 2, 77.5% for pose 3, 85.87% for pose 4, 86.42% for pose 5 and 68% for all poses except 1 to 5.
CONCLUSION: Using a neural network approach to classify the poses within frames in XCS leads to highly accurate classifications for frontal and lateral videos. As an exception pose 2 was often mispredicted in frontal videos. This can be explained by the missing information on the pole joint positions. If pole joints were to be included in the feature extraction, a higher accuracy could be expected.
1. A. Rassem et al. (2017), 2. O. M. H. Rindal, et al. (2017), 3. J. Tjønnås, et al. (2019), 4. J. Redmon & A. Farhadi (2018), 5. Z. Cao, et al. (2018)

## Oral presentations

### OP-BM09 Dynamic and static balance

**EVALUATION OF ANKLE DYNAMIC BALANCE AND MOBILITY THROUGH STAR BALANCE TEST AFTER TOTAL ANKLE REPLACEMENT**

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*UNIVERSITY OF BOLOGNA*

INTRODUCTION: Ankle osteoarthritis (AO) is a leading cause of chronic disability in a wide range of the world's population. Frequently, AO is secondary to traumas, and it is associated with obesity, metabolic disease, chronic inflammatory joint diseases, septic arthritis, and anatomical pathological variations. In case of no improvement of conservative management, surgical treatment may be necessary. Total ankle replacement (TAR) is a treatment for end-stage AO which aims to reduce pain and restore ankle function i.e. range of motion and mobility. However, the functional improvements of TAR are still debated. The Star Execution Balance Test (SEBT) is proven to be useful for

screening deficits in dynamic postural control among groups with lower extremity conditions. SEBT allows to assess strength, flexibility, neuromuscular control, core stability, range of motion, balance, the interaction between proprioception, and joint stability. The aim of this study is to evaluate dynamic balance and ankle mobility differences between side-to-side pre-and post-TAR. We hypnotize that, after the implantation of the ankle prothesis, patients will improve the outcomes of SEBT.
METHODS: Eighteen patients (mean age = 60.3±10.1) on the waiting list for total ankle arthroplasty were enrolled in this study. All patients were evaluated before and at minimum 9 months after the surgery. Each patient performed the short version of SEBT, which consist of 3 directions to reach with one foot: anterior (A), postero-medial (PM), and postero-lateral (PL). The means of tree trials for each direction were reported. All directions were reached first with the non-operated leg (NoOp) and then with the operated leg (Op). The outcome was normalized upon leg length ((distance cm/leg length cm) x 100). The pre-post surgery and the side-to-side difference in SEBT scores in A, PM, and PL directions were calculated pre- and post-TAR and compared through a paired sample t-test ($p<0.05$).
RESULTS: Considering the pre- and post- surgery evaluation of the replacement ankle, all SEBT have improved (A pre=57.3, post=58.1, $p>0.05$; PM pre=71.9, post=75.3, $p>0.05$; PL pre=53.1, post=60.6, $p<0.05$). Moreover, the outcomes of the healthy leg improved, even though the results were not statistically significant ($p>0.05$). The mean difference between side-to-side pre-and post-TAR were 3.6% [-1.3-8.5], 2.0% [-3.0-5.3], and 5.9% [2.2-9.5] for A, PM, and PL respectively. A significant reduction in side-to-side difference was found for PL direction ($p=0.004$, Cohen's $d=0.79$). No significant differences were found in A and PM directions ($p>0.05$).
CONCLUSION: The results of the study showed that the SEBT outcomes in patients with TAR improved after the implantation of the prosthesis. Indeed, the side-to-side difference between the Op and NoOp leg decreased, showing an improvement in dynamic balance and mobility. The ankle prosthesis allows to partially restore symmetrical levels of dynamic balance between Op and NoOp legs measured through the SEBT.

### THE KINEMATICS OF THE FOOT DURING STATIC BALANCE: A SIX-SEGMENT FOOT MODEL APPROACH

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INTRODUCTION: Understanding the foot's motion during different types of exercises is crucial when investigating balancing abilities and processes important for performance and particularly rehabilitation [1,2]. Balancing is a key ability in posture and motion. However, limited previous research investigated the movement of multiple foot segments during static balancing. In order to understand the role of foot segments in stance and locomotion and the implementation of these findings in rehabilitation and treatment, a kinematic analysis of the foot segment's motion during static balancing tasks was performed.
METHODS: 17 subjects (M(age) =24 years, SD = 5) performed three different balancing tasks captured using a 3D kinematic motion capture system from Qualisys AB (Göteborg,
Denmark). The Ghent Foot Model with 21 markers was used, dividing the foot in six kinematic segments [1]. The tasks increased in difficulty level from standing on two feet, to a one foot stance and a one foot stance with eyes closed. The kinematic analysis included joint rotational angles on all three movement planes and cumulative range of motion (cum ROM) defining the amount of motion over time using an individualize MATLAB script (The Math Works Inc., Natick, USA). The Ghent Foot Model divides the foot in the six joints: Rearfoot to tibia (RF_T), midfoot to rearfoot (MF_RF), medial forefoot to midfoot (MFF_MF), lateral forefoot to midfoot (LFF_MF), lateral forefoot to midfoot (LFF_MFF) and hallux to medial forefoot (H_MFF) . The mean CumROM on each anatomical plane was first calculated for each subject and then for each joint. A linear mixed model was used to compare segments motion.
RESULTS: The analysis of the motion of the foot segments over time (CumROM) during the three balancing tasks with increasing difficulty of all joints on all three anatomical planes show significantly different ($F_{20, 1324}= 5.94$, $p < 0.001$). Furthermore, high values for the CumROM are present within the frontal plane of midfoot and both medial and lateral forefoot joints, demonstrate high motion within the forefoot section.
CONCLUSION: The results indicate that during the static balancing anatomical structures represented as the midfoot and medial and lateral forefoot in the Ghent Foot Model have relatively high flexion and extension as well as inversion and eversion CumROM values. Potentially indicating that these structures are of high importance during the execution of static balancing tasks. The current findings indicate special importance of these areas of the feet within therapy concepts after foot and ankle injuries. Further research is needed to support this indication.
1. De Mits et al, J Orthop Res, 30 (4): 655-661, 2012.
2. Carson et al, J Biomech, 34: 1299-307, 2001.

### THE RELATIONSHIP BETWEEN BALANCE ABILITY AND RATE OF FORCE DEVELOPMENT OF TOE GRIP FORCE.

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INTRODUCTION: The foot is the only body part in contact with the ground. Among them, the toes have been suggested to be associated with the stability of the posture during standing and walking. Currently, toe grip force is used as an evaluation of toe muscle strength, that is associated with dynamic and static balance ability. However, the relationship between balance ability and toe grip force is not clear. One of the factors is thought to be related to the type of muscle strength. Most of the previous studies have measured maximum voluntary contraction (MVC) as an outcome for toe grip force. However, as an evaluation of muscle strength, it is recommended to evaluate not only MVC but also Rate of Force Development (RFD), which is an index of instantaneous muscle strength exertion. RFD is a calculation of the gradient of muscle strength change at regular time intervals from muscle exertion. It has been reported that RFD is important for the reaction to unexpected COP sway. Therefore, the purpose of this study was to examine the relationship between balance ability and RFD of toe grip force.
METHODS: This study targeted 25 healthy young men and 25 healthy young women (n=50). Those with orthopedic disease on the feet were excluded. The balance ability was measured by dividing the total trajectory length (mm), rectangular area (mm2) of the center of pressure (COP) when standing on one leg for 40 sec. Toe grip force was measured by dedicated device. The Pearson correlation or Spearman's rank correlation analysis was used to analyze the relationship between balance ability and RFD of toe grip force.
RESULTS: A significant negative correlation was observed between RFD of toe grip force and the rectangular area of COP (0-50ms：$r=-0.43$, $p<0.01$; 0-100ms：$r=-0.36$, $p<0.01$; 0-200ms：$r=-0.34$, $p=0.01$). No significant correlation was observed in the total trajectory length and RFD of toe grip force.

CONCLUSION: This study suggested that there is relationship between RFD of toe grip force and the rectangular area of COP. It is conceivable that the RFD of toe grip force is instantly exerted to control the center of gravity before COP sway significantly when standing on one leg. In addition, the shorter the time from the start point of muscle strength, the stronger the correlation tends to be. It has been reported that RFD is strongly associated with twitching of muscle fibers in the early RFD within 50ms of muscle exertion, and that late RFD after 90ms after muscle exertion is strongly associated with maximum muscle strength. It is considered that the higher the early RFD, the more motor units could be mobilized and the sway of the center of gravity was suppressed. Therefore, it was considered that the subjects with high RFD of toe gripping force had a small rectangular area of the center of gravity sway when standing on one leg.

**RATE OF TORQUE DEVELOPMENT AND CONTRACTILE PERFORMANCE DURING ANKLE PLANTAR FLEXION IN ELITE ATHLETES**

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INTRODUCTION: The ability to generate high force levels in limited time (i.e., rate of torque development, RTD) is key factor of performance in sprint running. As an example, a world-class athlete generates horizontal force over 10 N/kg in less than 400ms during sprint start (1). While neural drive has been reported as the key determinant of early RTD (2), muscle-tendon interactions of the medial gastrocnemius (MG) seem to contribute to later phases of RTD (3). However, very little is known about RTD determinants regarding elite athletes. The aim of this study was to investigate elite athletes' ability to rapidly generate high force levels in relation to the contractile characteristics of plantar flexors.
METHODS: 57 French elite athletes (32 track athletes, 22 rugby players, 3 bobsledders; 54% female; 1.75 ± 0.08 m; 70.5 ± 11.3 kg; including Olympic, World and European medallists) were tested. All participants completed 2-3 explosive force production trials "as fast and hard as possible" (3). Rate of torque development (RTD) was calculated over sequential windows (RTD 0–50ms, RTD 50–100ms, RTD 100–150ms and RTD 0-200ms). MG fascicle dynamics was assessed during the first 200ms using an ultrafast ultrasound scanner (sampling rate = 1000 Hz). MG fascicle shortening amplitude as well as mean and maximal fascicle shortening velocity were calculated.
RESULTS: Rate of torque development at each sequential window was 437 ± 159 N.m/s [0-50ms], 1000 ± 323 N.m/s [50-100ms], 682 ± 223 N.m/s [100-150ms], 620 ± 165 N.m/s [0-200ms] (group mean ± SD). MG fascicles shortened throughout the first 200ms of contraction by 1.1 ± 0.4 cm, and maximal shortening velocity was -10.8 ± 3.7 cm/s and peaked at 50ms on average.
CONCLUSION: This study brings novel insights about elite athletes' explosive force ability with exceptionally high rate of torque development, two-fold greater than those reported in healthy individuals using the same method (3). We also found that MG fascicle shortening velocity peaked on average around 50ms in elite athletes in comparison to around 100ms in healthy individuals. This clearly demonstrates the high explosiveness ability of elite athletes. Specifically, not only neural but also mechanical factors determine early RTD and thus sprint propulsion in elite athletes.
REFERENCES:
1) Rabita et al., Scand J Med Sci Sports, 2015
2) Del Vecchio et al., J Appl Physiol, 2018
3) Hager et al., J Appl Physiol , 2020

## Invited symposia

### IS-SH01 Creativity, physical education and sport: fostering developmental trajectories

**FREE PLAY AND ALTERNATIVE SPORTS THROUGH PARADOXES AND OPPORTUNITIES**

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Creativity can be conceived as freedom in the limits of rules/constraints. It represents a prominent ability of individuals, dynamically arising from a process, occurring in a context, and resulting into a novel product. In particular, creative motor actions emerge from adaptive movement variability while exploring the environment, eventually optimized by manipulating constraints. Once a child develops fruitfully motor creativity, its retention becomes easier. Considering creative moving and playfulness are interconnected, we should strive for a virtuous loop connecting playful activities and creativity. Play needs to be discussed with an interdisciplinary criticism encompassing pedagogy, kinesiology, neuroscience, psychology, philosophy, anthropology, sociology, medicine, and ethology. This complex approach moves inside the areas of creativity, human behaviour, and development. Into this framework, free play can emerge as an effective tool for favoring creativity, both in physical education and sport. However, aiming to this effect, free play should be fun, voluntary, challenging, relaxed, exaggerated in forms, spontaneous, pleasant, flexible, not stereotyped, led by intrinsic motivation and supported by reward (Bondi & Bondi, 2021). Therefore, we should prioritize to enrich the environment, tutoring, interacting, providing a non-threatening and non-controlling environment, and setting stress-free conditions. Moving over, through unconventional creative expression, the sense of freedom prospers inside the public spaces. Therefore, lifestyle (or alternative) sports, as playful physical activities opportunities, are fruitful resources for open and flexible curricula in physical education and sport. These aesthetic and functional forms of self-exploration, as types of creative free play, contrast to conventional ways of moving and interacting with people and places. As an example, referring to parkour city itself becomes an open-ended toy, and material obstacles become possibilities for developing creative outcomes. Linking the design of urban spaces for physical movements and outdoor sports with imagination and personal skills, these unconventional playful sports may be used as inherently educational disciplines. Building alternative sports-friendly environment could convey social benefits, promote motor competencies, and encourage active lifestyle.
Bondi, D., & Bondi, D. (2021). Free Play or Not Free Play: An Interdisciplinary Approach to Deal with Paradoxes. Creativity Research Journal, 33(1), 26–32.

### EMPOWERING CREATIVE EDUCATION AND SPORTS CREATIVITY

LEAL DOS SANTOS, S.

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Creativity is one of the essential skill sets for shaping the possibilities of 21st-century and is a key feature of teaching and coaching that is influencing worldwide educational and sports policies. The goal of education should be the nurturing of creative young people who are sufficiently skilled to adjust constantly to new challenges and find innovative and original solutions, that would satisfy the needs of fast changing society. Likewise, sports have emerged as a suitable environment to ignite creativity. In this field, creativity should be understood as the process of perceiving, exploring, and generating novel affordances (opportunities for action) within a given context (training session or formal game) considering the importance of contemplating the experiential process (Rasmussen, et al., 2019). Furthermore, evidence of implementing sports-creativity training programs to cultivate overall creativity is growing. Therefore, this presentation will be centrally focused on the Skills4Genius program tenets (Santos et al., 2017), grounded in the 'Creativity Developmental Framework' assumptions (Santos et al., 2016). The Skills4Genius is a sports creativity-based intervention intended to develop social and emotional skills, such as creative thinking, as well as in-game creativity. Besides, related research supports an interplay between thinking and sports creativity revealing commonalities in the underlying processes responsible for driving creative thinking and children's novel behaviors on the field (Santos et al., 2017; Santos & Monteiro, 2020). The Skills4Genius has been implemented around 2000 Portuguese primary school-aged children and is supported by the Calouste Gulbenkian Foundation, within the Gulbenkian Program for Knowledge, an initiative that establishes one of the most extensive European networks of educational innovation in partnership with OECD. This presentation will be filled with fresh creative thinking strategies and a set of constructivist models to support Physical Education teachers and coaches in order to offer a supportive environment for creativity to thrive. Finally, it will be discussed the potentials and barriers related to the design for creativity.

Rasmussen, L., Østergaard, L., & Glăveanu, V. (2019). Creativity as a developmental resource in sport training activities. Sport, Educ. Soc, 24(5), 491-506.

Santos, S., Jiménez, S., Sampaio, J., & Leite, N. (2017). Effects of the Skills4Genius sports-based training program in creative behavior. PLoS One, 12(2).

Santos, S., Memmert, D., Sampaio, J., & Leite, N. (2016). The Spawns of Creative Behavior in Team Sports: A Creativity Developmental Framework. Front Psychol, 7, 1282.

Santos, S., & Monteiro, D. (2020). Uncovering the role of motor performance and creative thinking on sports creativity in primary school-aged children. Creat Res J., 33(1) 1-15.

### A COMPLEX SYSTEMS APPROACH ON CREATIVE BEHAVIOUR IN SPORT AND MOVEMENT-BASED PRACTICES

TORRENTS, C.

*UNIVERSITY OF LLEIDA*

Based on recent research under the complex dynamical systems approach, this presentation aims to explain how constraints can release degrees of freedom in sport and movement-based practices. It also aims to clarify the process of emergence of creative behaviors taking into account the interrelatedness and nesting of constraints acting on the system (Balagué et al. 2019; Torrents et al. 2021a; Torrents et al. 2021b). We base it on the formation of spontaneous multiscale synergies emerging in complex living systems when interacting with cooperative/competitive environments. This is especially important in our domain, as the specificity of motor creativity is conditioned by the time scale where actions emerge, as well as by the interaction with other persons (teammates and opponents).

It will be discussed how constraints form boundaries around the exploration of certain action possibilities, while allowing the emergence of other exploration possibilities. These actions emerge from the nonlinear interaction between the intrinsic dynamics of the creator (individual or team) and environmental constraints. Moreover, self-interaction and co-adaptive loops, as well as the interaction of all constraints acting on the system at different time scales, allow the emergence of creative behaviour. Some team sports and contemporary dance examples related with the manipulation of task constraints from our lab will be presented (Cantón et al. 2021; Lacasa et al. under review; Torrents et al. 2015).

Balagué, N., Pol, R., Torrents, C., Ric, A., & Hristovski, R. (2019). On the Relatedness and Nestedness of Constraints. Sports Medicine - Open, 5(1), 6.

Cantón, A., Torrents, C., Ric, A., Guerrero, I., Hileno, R. & Hristovski, R. (2021). Exploratory Behavior and the Temporal Structure of Soccer Small-Sided Games to Evaluate Creativity in Children. Creativity Research Journal, 33 (1), 16-25.

Lacasa, E., Cantón, A., Brufau, I., March-Llanes, J. & Torrents, C. (under review). Rink Hockey "Ok-XS". Motor behavior effects of scaling games in U8 players.

Torrents, C., Balagué, N., Hristovski, R., Almarcha, M. & Kelso, J.A.S. (2021). Metastable Coordination Dynamics of Collaborative Creativity in Educational Settings. Sustainability, 13, 2696.

Torrents, C., Balagué, N., Ric, Á., & Hristovski, R. (2021). The Motor Creativity Paradox: Constraining to Release Degrees of Freedom. Psychology of Aesthetics, Creativity, and the Arts, 15 (2), 340-351.

Torrents, C., Ric, A., & Hristovski, R. (2015). Creativity and emergence of specific dance movements using instructional constraints. Psychology of Aesthetics, Creativity, and the Arts, 9(1), 65–74.

# Oral presentations

## OP-MH09 Measurement of performance in different populations

### REPEATED MAXIMAL EXERCISE TESTS OF PEAK OXYGEN CONSUMPTION IN PEOPLE WITH MYALGIC ENCEPHALOMYELITIS/CHRONIC FATIGUE SYNDROME: A SYSTEMATIC REVIEW AND META-ANALYSIS

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INTRODUCTION: We aimed to synthesise studies in which the test-to-retest (24 h) changes in VO2 and work rate have been compared between people with Myalgic Encephalitis/Chronic Fatigue Syndrome (ME/CFS) and controls.
METHODS: Seven databases (CINAHL, PubMed, PsycINFO, Web of Knowledge, Embase, Scopus and Medline) were searched. Included studies were observational studies that assessed adults over the age of 18yrs with a clinical diagnosis of ME/CFS compared to apparently healthy controls. The methodological quality of included studies was assessed using the Systematic Appraisal of Quality for Observational Research critical appraisal framework.
RESULTS: The pooled mean differences in test-to-retest changes in VO2peak and VO2 at the anaerobic threshold were small and not clinically relevant at -1.1 (95%CI -3.3 to 1) ml.kg-1min-1 (Tau = 1.6 ml.kg-1min-1) and -1.83 (95%CI -3.98 to 0.32) ml.kg-1min-1, (Tau = 1.4 ml.kg-1min-1). There was a greater decrease in the pooled mean difference in peak work rate (5 studies), measured at retest, in ME/CFS compared to controls by -8.55 (95% CI -15.38 to –1.72, Tau =4.4) W. The pooled mean difference in work rate at anaerobic threshold (4 studies) measured at retest was greater in ME/CFS compared to controls by -21 (95%CI -38 to -4, tau = 9.8) W. The effect size for this difference was large (d = -0.95) providing evidence that WR at AT effectively discriminates between ME/CFS and controls. The 95% prediction interval was -62.4 to 21.1 W, indicating a high degree of uncertainty. The likelihood that a future study in a similar setting would report a difference in work rate at anaerobic threshold which would exceed a minimal clinically important difference (10 W) is 78% (95%CI 40% to 91%).
CONCLUSION: Synthesised data indicate that test-retest reductions in work rate at peak and at anaerobic threshold may provide a possible objective marker for the presence of ME/CFS.

### CAN SUPRA-MAXIMAL TEST BE USED TO VERIFY MAXIMAL OXYGEN UPTAKE IN ADULT WITH OBESITY? A COMPARISON BETWEEN MAXIMAL EXERCISE TEST ON TREADMILL VS. CYCLE ERGOMETRY

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INTRODUCTION: People with obesity often have below average VO2max values compared to normal levels for their age group and sex. Additionally, many do not show the VO2 plateau at exhaustion, which is the primary criterion of attainment of VO2max.
Aims: 1) compare VO2max and the present of plateau using a maximal graded exercise test (GXT) on bike and treadmill ergometers, between obese (OB) and normal weight (NW) individuals. 2) Use a supramaximal exercise test (SMT) to verify that peak O2 uptake in GXT reflects “true” maximal VO2max in the absence of a VO2 plateau.
METHODS: METHODS: 34 sedentary participants volunteered to participate; 17 NW (median BMI 22.1 kg/m2 (20.9-23.3)) and 17 with obesity (median BMI 34.6 kg/m2 (31.4-36.3)). During 2 laboratory sessions, participants completed either a GXT on a cycle ergometer or on a treadmill in random order. 10 minutes post GXT a 2 min SMT to verify O2 consumption values was performed. SMT involves a constant load, one phase higher than the last load reached on the treadmill (Bruce-Ramped Protocol), or 10% higher than the maximum Watt reached on cycle ergometer. VO2max from GXT was considered as verified if peak VO2 in the SMT was <5% higher than that attained in GXT. O2 consumption (VO2), respiratory exchange ratio (RER), maximal heart rate (Max HR) and rate of perceived exertion (RPE) were recorded at the end of the GXT.
RESULTS: Peak VO2 ml /kg /min at GXT was higher in NW compared to OB on treadmill (NW-37.45±7.95 ml/kg /min; OB-29.05±4.82 ml/kg /min p<0.001) and bike (NW-29.26±7.71 ml /kg /min; OB-22.26±3.50 ml /kg/min p<0.001). 56% of participants reached VO2 plateau on the treadmill vs. 17% on the bike, with no significant differences between groups. Max HR and RPE were higher on Treadmill than bike (F=21.86 p<0.0001 and F=14.54; p=.0006 respectively), in both groups with no significant differences between groups.
Of those not reaching a plateau true VO2max was verified by SMT in 38% tested by bike and 63% tested by a treadmill in the NW group, and in the OB group 56% on the bike and 73% on the treadmill, were verified.
CONCLUSION: Obese participants had lower aerobic fitness levels than the NW sedentary group when VO2 was normalized to body weight. However, no significant differences in reaching plateau were observed between the groups. Fewer participants reached plateau on the bike than on the treadmill. In the absence of a plateau phase, the SMT verified VO2max determined by the GXT in 68% and 48% of our cohort tested on treadmill and bike, respectively. These findings suggest that incorporation of a SMT to verify VO2max provides additional data about the maximal aerobic capacity and can be performed using a treadmill or bike.

### LONGITUDINAL DEVELOPMENT IN OXYGEN UPTAKE IN 6–12-YEAR-OLD NORWEGIAN CHILDREN. THE HEALTH-ORIENTED PEDAGOGICAL PROJECT (HOPP).

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INTRODUCTION: Enhanced aerobic capacity is associated with improved health and reduced mortality in adulthood. Aerobic capacity is best reflected by V̇O2peak, and the level of V̇O2peak is traceable from childhood to adulthood. Mapping of V̇O2peak in childhood is therefore important for detecting deteriorations at an early stage and initiate interventions to prevent disease in adulthood. The purpose of the present study was to evaluate the development in V̇O2peak in 6–12-year-old Norwegian children.
METHODS: Six-year-old students (n=451), included in the Health-Oriented Pedagogical Project, was invited to an annual V̇O2peak test for six years. V̇O2peak was tested using an incremental treadmill test with a maximal speed of 10 km·h-1 and a maximal inclination of 16%. In the first year, the metabolic cart was a K4b2, after that a K5 was used, both from Cosmed sri, Rome, Italy. The K4b2 used the breath-by-

breath method, K5 a (micro) mixing chamber. A mixed linear model split by sex and grades as fixed effects were performed to evaluate the development in V̇O2peak.
RESULTS: The development of aerobic power from 6- to 12-year age differed according to the expression of V̇O2peak used. Absolute V̇O2peak increased from 1.09/1.06 L·min-1 to 1.93/1.84 L·min-1 (boys/girls). The yearly increase tapered off from 11th to 12th year. V̇O2peak relative to body mass increased until age 8: from 47.1/44.3 ml·kg-1·min-1 to 52.9/48.9 ml·kg-1·min-1. At age 12, the results were close to the results at age 6: 46.9/44.0 ml·kg-1·min-1. Allometrically scaled oxygen uptake increased from 132.6/125.4 ml·kg-0.67·min-1 at 6-year age to 169.3/158.6 ml·kg-0.67·min-1 at age 11. The results at age 12 were 157.7/150.2 ml·kg-0.67·min-1. Boys and girls differed significantly on relative and allometrically scaled oxygen uptake from 6 to 11-year age. Absolute oxygen uptake differed significantly for boys and girls only at age 10 and 11 year. When scaling oxygen uptake with fat-free mass, the results at age 12 year was a little higher for girls: 57.3/57.6 ml·FFMkg-1·min-1.
CONCLUSION: When describing the development of cardiometabolic fitness in children, the choice of units has importance. Expressing oxygen uptake in absolute form, as ml (or L) pr. minute will give another impression of the development than relating oxygen uptake to different conditions of body mass. If sex differences are important to document, allometric scaling seems to be appropriate. To describe the bodily growth, oxygen uptake should not be related to body mass in any form. The reason for presenting children's fitness should thus guide the decision of which units to use.

### EFFECT OF SLEEP BEHAVIOR ON VO2MAX CAPACITY IN A SAMPLE OF ACTIVE YOUNG SUBJECTS

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INTRODUCTION: In addition to being an essential physiological process in humans, sleep is acknowledged as an important factor in influencing physical performance. Sleep deficiency, also linked to higher self-perceived fatigue, could negatively affect physical performance, especially endurance performance [1]. Notwithstanding this background, VO2max has been poorly investigated in relation to sleep quality [2]. The present study aims to shed light on this relationship in a sample of active young subjects.
METHODS: Ninety-six university students (males 54.2%; 21.5 ± 2.9 yrs) were assessed for sleep quality, self-perceived fatigue and motivation by the Pittsburgh Sleep Quality Index (PSQI) and two visual analogue scales (VAS), respectively. Subsequently, they completed an incremental exercise test on a bicycle ergometer. Analyses were performed separately for males and females. Based on PSQI categorization, VO2max, self-perceived fatigue and motivation were compared between good and bad (PSQI score 5 respectively) sleepers and longer and shorter sleepers (sleep duration >/<7.5 hours respectively), while regression analysis defined the predictors of VO2max.
RESULTS: In the male sample, good sleepers and longer sleepers reported higher VO2max (53.9 ± 8.4 vs 49.0 ± 14.1 ml.kg-1.min-1; 54.2 ± 10.9 vs 50.0 ± 8.4 ml.kg-1.min-1) and self-perceived motivation (7.1 ± 1.6 vs 6.3 ± 2.1 a.u.; 7.2 ± 1.5 vs 6.4 ± 2.1 a.u.), but only self-perceived fatigue was significantly lower in good sleepers (2.3 ± 2.1 a.u.) compared to bad sleepers (3.6 ± 1.7 a.u.; p = 0.04). The regression analysis showed sleep (β = - 0.3, p = 0.02) as predictors of VO2max. There were no significant differences between good and bad sleepers and different sleep durations in the female sample. Self-perceived fatigue (β = -0.4, p = 0.03), and not sleep, was a significant predictor of VO2max in females.
CONCLUSION: Sleep seems to affect differently the VO2max the performance between males and females. Even without statistically significance, good and long sleepers tend to perform better and suffer significantly less from fatigue. Furthermore, sleep accounts for 20% of the variance in males, indicating a relevant factor for cardiovascular performance. In females, physical performance seems more affected by fatigue rather than sleep. Probably, taking into account the phase of the menstrual cycle, a different role of sleep on VO2max could have been highlighted [3].
References
1. Watson, AM, Sleep and Athletic Performance. Current Sports Medicine Reports, 2017. 16(2):413–418.
2. Antunes, BM., et al., Sleep quality and duration are associated with performance in maximal incremental test. Physiology and Behaviour, 2017. 177:252–256.
3. Crowley SK., et al., Cardiorespiratory fitness, sleep, and physiological responses to stress in women. European Journal Sport Science 20(10):1368–1377.

### ASSOCIATION OF EARLY RFD DURING A FUNCTIONAL TASK AND AN ISOMETRIC LEG EXTENSION WITH GAIT SPEED AND BALANCE FROM THE TOLEDO STUDY FOR HEALTHY AGING IN MIDDLE AGE

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INTRODUCTION: The rate of force development (RFD) is positively associated with athletic performance in young people and physical function in older people (1). Furthermore, RFD provides information on the structural and neuromuscular features of skeletal muscle and its functional state (2). RFD is most frequently evaluated using a force plate in traditional exercises such as knee extension, squat or leg press. However, it has been also evaluated during the sit-to-stand (STS) task (3). In this sense, it is currently unknown whether RFD during the STS task (RFD-STS) is more strongly associated to physical performance during other functional tasks as the leg press exercise (RFD-LP) in middle-aged adults.
METHODS: A total of 78 middle-aged adults participating in the Toledo Study for Healthy Aging in Middle Age (TSHA-ma) (32 men and 46 women; 55.3±1.9 years old) took part in this investigation. Early RFD (at 100 ms) was assessed during the first repetition of the 5-rep STS test. On a separate occasion, early RFD was also assessed during a unilateral maximal isometric contraction in the leg press (RFD-LP, knee joint angle: 90°). The best of 2 and 4 trials were selected for RFD-STS and RFD-LP, respectively. Functional performance was assessed by the timed up-and-go test (TUG), maximal 30-m gait speed test and the Y-balance test.
RESULTS: There was an association between RFD-STS and RFD-LP (r=0.42, p<0.001) independently of age and sex, although there were significant differences between both measures (3485±2976 vs 2221±1063 N/s). In addition, RFD-STS was more strongly associated to TUG velocity and 30-m gait speed (r=0.34, p=0.003 and r=0.44, p<0.001) when compared to RFD-LP (r=0.32, p=0.005 and r=0.31, p=0.008). In contrast, balance performance was more associated with RFD-LP (r=0.39, p<0.001) when compared to RFD-STS (r=0.27, p=0.019).
CONCLUSION: Early RFD obtained during the STS task was more strongly associated to gait speed test than early RFD recorded during an isometric unilateral leg extension action, while the latter was more strongly associated to unilateral balance. These findings may help interpret the functional relevance of these distinct RFD measures.

# Oral presentations

## OP-AP25 Women and sport

### BETWEEN-GENDER DIFFERENCES IN TRUNK ROTATIONAL POWER IN ATHLETES OF GYMNASTIC AND DANCE SPORTS

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*FACULTY OF PHYSICAL EDUCATION AND SPORT, COMENIUS UNIVERSITY IN BRATISLAVA*

INTRODUCTION: A previous study revealed sport-specific differences in power-velocity-force profiling during trunk rotations at loads ≥10.5 kg [1]. The highest power is produced by combat sports athletes (boxing, thai boxing, karate, tae kwon do) with a maximum achieved at 10.5 kg, followed by water sports athletes (canoeing, kayaking) with a maximum at 20.0 kg, grappling sports athletes (judo, wrestling) with a maximum at 15.5 kg, and ball sports athletes (golf, hockey, tennis) with a maximum at 10.5 kg [1]. Since body rotations represent one of the essential elements of performance also in gymnasts and dancers, we were interested in whether between-gender differences exist in trunk rotational power at various loads.
METHODS: Groups of female (n=24, age 20.1±1.7 y, height 168.5±6.8 cm, body mass 57.5±5.8 kg) and male (n=15, age 23.1±2.7 y, height 177.9±9.7 cm, body mass 78.3±11.2 kg) competitive gymnasts, aerobic, ballroom and rock & roll dancers completed two trials of standing trunk rotations at each side with a barbell of different weights (increasing from 1 kg up to a weight at which maximal values of power were achieved) placed on their shoulders. The power produced during trunk rotations was evaluated using the FiTRO Torso Premium.
RESULTS: Mean power in the acceleration phase of trunk rotations was significantly higher in male than female athletes at loads of 10.5 kg (206.8±22.0 W and 165.4±17.8 W respectively, p=0.033), 15.5 kg (231.8±27.5 W and 155.6±24.4 W respectively, p=0.001) and 20 kg (196.9±25.3 W and 111.4±20.9 W respectively, p=0.001). Similar significant between-gender differences for angular velocity at weights ≥10.5 kg were observed. Alternatively, power and force were significantly higher at lower velocities in male than female athletes. However, some females were able to produce slightly greater power and force at higher velocities in spite of their lower values at lower velocities when compared to males.
CONCLUSION: While the highest power in males is produced at a higher weight of 15.5 kg (in few of them at 20 kg), females are able to generate the highest power at a lower weight of 10.5 kg (or at higher velocities). This may be ascribed to both the genetic predispositions and the specificity of their acrobatic and dance elements including trunk rotations at various velocities under different load conditions. Male athletes need to exert high forces of upper and lower body in order to lift female counterparts and perform repetitive rotational movements of the trunk.
References
1. Zemkova E, Poor O, Jelen M (2020). Sport-specific differences in power-velocity-force profiling during trunk rotations at different loads. Appl Sci 10(23):8366.doi:10.3390/app10238366
Acknowledgment: This work was supported by the Slovak Research and Development Agency under the contract No. APVV-15-0704 and the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences (Nos. 1/0089/20, 1/0754/20).

### SALIVARY DHT CONCENTRATIONS IN WOMEN AFTER TWO DISTINCT RESISTANCE EXERCISE.

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*UNIVERSITY OF ROME*

INTRODUCTION: Distinct forms of resistance exercise can stimulate different hormonal response. Hormonal response is associated with the intensity of exercise, time under tension, volume of exercise and muscle masses involved. Different protocols of strength exercise can induce different changes in circulating Dihydrotestosterone - DHT. DHT responsiveness to exercise appeared greater during a heavy volume, and for females. In females DHT is produced from the reduction of free testosterone in peripheral tissues of the body by 5α-reductase. DHT increases in response to acute exercise [Cook, C. J. et al. 2021]. We hypothesized that DHT responses would differ after two distinct protocols and for this reason the aim of this study is to compare the effect of two different strength exercise on salivary DHT release in women.
METHODS: Ten resistance trained women from different sport or fitness activity were recruited to this study. All participants had a minimum strength training history of 2 years with back squat exercise (4 +/- 2,36 Year). They were randomly assigned into 2 groups: Velocity Loss - VL (n = 5) or Failure Training - FT (n = 5). After ten minutes of incremental full squat warm up, both training groups completed one intervention using the back squat exercise. The VL group executed maximum number of repetitions for five sets of back squat at 75% of 1 RM. Every set ended when the barbell losses 10% of velocity recorded in the first repetition of the set. (16,4 +/- 3,5 Reps) All subjects were constantly stimulated to move the barbell at maximum velocity as possible. The FT group executed maximum number of repetitions for five sets of back squat at 75% of 1 RM. Every set ended when the subject failed the last repetition. (85 +/- 27,5 Reps) All subjects were constantly stimulated to complete the maximum number of repetitions as possible. After each set RPE were collected and session RPE were calculated. VL (6,52 +/- 1,07) FT (9,56 +/- 0,49) Saliva samples were collected before warm up (T0), at the end of training (T1) and 30 minutes after the end of training (T2). Salivary DHT concentrations were measured by ELISA Assay Kit.
RESULTS: Our preliminary data suggested that Salivary DHT was not significantly different in the FT protocol than for VL protocol. There were no statistically significant differences in DHT concentration from T0 to T1, from T0 to T2 and form T1 to T2, and no differences were observed among the protocols, on the other hand, we observed a high individual variation. VL (Δ% [DHT] T0-T1 24,39% +/- 50,06%; T0-T2 -17,77% +/- 24,15%; T1-T2 -6,65% +/- 21,34%) FT (Δ% [DHT] T0-T1 11,70% +/- 42,50%; T0-T2 -1,60% +/- 36,94%; T1-T2 -2,38% +/- 14,14%).
CONCLUSION: These variations can be related to training status and the menstrual cycle of the participants. Due to the small number of participants, statistical analysis taken into account the menstrual cycle was not applicable.

### EVOLUTION OF REPETITION VELOCITY THROUGHOUT ONE SET UNTIL FAILURE AGAINST TWO RELATIVE INTENSITIES IN THE SQUAT EXERCISE IN WOMEN

CANO-CASTILLO, C., PAREJA-BLANCO, F., SÁNCHEZ-MORENO, M., BACHERO-MENA, B.

*UNIVERSIDAD PABLO DE OLAVIDE*

INTRODUCTION: Recently, velocity-based training (VBT) has been proposed as a valid method to objectively quantify and adjust training intensity with high precision on a daily
basis (González-Badillo and Sánchez-Medina 2010). Most of the studies using VBT have been carried out in men (Hagstrom et al. 2020). However, there is little information about the acute responses to resistance training in women when controlling and measuring velocity (Rissanen et al. 2022). For this reason, the aim of this study was to analyse the evolution of repetition velocity throughout a set up to failure in the full-squat (SQ) exercise with two different intensities (60% vs. 80% 1RM) in young women.
METHODS: Ten young physically active and resistance-trained women participated in this study (21.2 ± 2.2 years old; 63.5 ± 5.8 kg; 1.66 ± 0.05 m; 72.2 ± 14.6 kg 1RM). The protocols consisted of two training sessions separated by 1-week, performing a single set until failure with two different intensities (60 and 80% 1RM) in SQ exercise. Firstly, an incremental loading test session was carried out in order to establish the individual load-velocity relationship, as well as the 1RM in SQ for each participant. The order of the protocols was randomized. The relationships between the percentage of repetitions performed (%Rep) and the velocity loss (VL%) of two protocols were analysed.
RESULTS: Significant differences ($p \leq 0.001$) were observed in the number of repetitions performed among protocols. Higher number of repetitions were observed for the 60% 1RM protocol (18.1 ± 3.2) compared to the 80% 1RM protocol (6.8 ± 2.1). However, there were no significant differences observed in VL% among the different protocols (52.7 ± 8.1 vs. 47.2 ± 6.8 for 60% and 80% 1RM, respectively). In addition, significant relationships were observed between %Rep and VL% for 60% (R2 = 0.77) and 80% (R2 = 0.74) 1RM protocols.
CONCLUSION: The highest intensity training protocol (80% 1RM) allowed to perform a lower number of repetitions and showed a lower VL% compared to the 60% 1RM protocol. Similar results have been previously reported in men (Rodríguez-Rosell et al. 2020), indicating that as loading magnitude increases, both, the number of performed repetitions and the magnitude of VL% progressively decrease in SQ exercise. However, the number of repetitions performed in our study by women was slightly higher and the VL% lower than those observed in men, for the same relative intensity. On the other hand, the relationships found between %Rep and VL% were strong enough to consider the VL% as an acute measure for quantifying the degree of effort in women.

### ACUTE EFFECTS OF COMBINED LOWER BODY ENDURANCE AND UPPER BODY STRENGTH EXERCISE ON EXPLOSIVE STRENGTH PERFORMANCE IN NATURALLY MENSTRUATING WOMEN

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*GERMAN SPORT UNIVERSITY*

INTRODUCTION: We have previously shown that lower body high-intensity interval training (HIIT) does not reduce upper body explosive strength, while lower body HIIT combined with upper or lower body strength exercise has been shown to reduce both explosive squat and bench press strength[1]. Thus, it seems that adding strength exercise to lower body HIIT impairs the subsequent explosive strength performance irrespective of the muscle group, leading to a reduced exercise quality and consequently compromised adaptations. However, evidence on these effects have been addressed exclusively in men and data in women are lacking. Therefore, the purpose of this study was twofold: First, we aimed at investigating the acute effects of lower body HIIT on upper and lower body explosive strength in naturally menstruating women. Additionally, we assessed the combined effects of lower body HIIT and squat compared with lower body HIIT and bench press on both upper and lower body explosive strength.
METHODS: Twelve naturally menstruating women (age: 22.5±2.3 years, menstrual cycle length: 28.4±2.1 days) completed two concurrent training modalities consisting of HIIT (4x4 minutes at 80% of peak power output) followed by lower (HIIT+LBS) or upper body (HIIT+UBS) strength loading (3x5 followed by 3x3 repetitions at 80% of the one-repetition maximum) in a randomized order. Both exercise modalities were performed in two consecutive menstrual cycles within the follicular phase (days 5-10). Squat and bench press mean propulsive velocity was assessed before HIIT (T0), after HIIT (T1) and after the strength loading (T2).
RESULTS: Mixed factorial ANOVA indicated a significant effect for time (squat: $F(2,44)=10.845$, $p=.001$; bench press: $F(2,44)=10.845$, $p=.001$) but no interaction was present for neither squat ($F(2,44)=.332$, $p=.634$) nor bench press ($F(2,44)=1.642$, $p=.205$). Pairwise comparison showed that squat statistically decreased at T1 following HIIT (HIIT+LBS: -5.9±9.1% and HIIT+UBS: -4.1±5.0%, p=.013), while bench press remained statistically unchanged (HIIT+LBS: -0.6±4.5%, HIIT+UBS: -0.02±9.4%, p=1.000). Squat was found to be decreased at T2 compared to T0 in both conditions (HIIT+LBS: -7.3±3.0%, HIIT+UBS: -6.9±6.1%, p<.001) but not compared to T1 (p=1.000). Bench press was statistically reduced at T2 compared to T0 (HIIT+LBS:-7.7±3.7%, HIIT+UBS: -12.4±11.6%, p<.001) and T1 (HIIT+LBS:-7.0±3.4%, HIIT+UBS: -12.3±9.0%, p<.001) following both loadings.
CONCLUSION: These findings indicate that lower but not upper body explosive strength is reduced by lower body HIIT in naturally menstruating women. However, lower body HIIT combined with upper or lower body strength loading resulted in a reduction of both squat and bench press explosive strength. Importantly, the magnitude of reductions in explosive strength in the two loadings was similar to that previously shown in men.
References
[1] B. Dragutinovic, et al. Int. J. Sports Physiol. Perform. In Press

### INFLUENCE OF MENSTRUATION/WITHDRAWAL BLEEDING ON SELF-REPORTED PHYSICAL AND PSYCHOLOGICAL DAY-TO-DAY PARAMETERS IN NORWEGIAN CROSS-COUNTRY SKIERS AND BIATHLETES: THE FENDURA PROJECT.

ENGSETH, T.P.1, OSBORNE, J.1, SOLLI, G.S.1,2, MORSETH, B.1, THOMASSEN, T.O.1, TAYLOR, M.1, WELDE, B.1, ANDERSSON, E.P.1

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INTRODUCTION: Menstruation, as well as the 1-4 days before bleeding has been reported to negatively interfere with sleep quality and motivation to train. Furthermore, around 50-70% of female athletes use hormonal contraceptives (HCs), with the reduction of menstrual-related symptoms as one common reason for using HCs. Although, previous studies provide initial insight, the influence of menstruation/withdrawal bleeding and pre-bleeding has not been investigated from a long-term perspective. The purpose of this study was there-

fore to investigate the influence of three different phases (pre-bleeding, menstruation/withdrawal bleeding, and non-bleeding) on self-reported readiness to train (physically and mentally), sleep quality, menstrual-related symptoms, sickness, and injury in female cross-country (XC) skiers and biathletes.
METHODS: A total of 67 XC skiers and biathletes stratified as HC and non-HC users (21 ± 3 y; 170 ± 5 cm; 63 ± 5 kg; 632 ± 111 annual training hours) volunteered to participate in a 12-month prospective cohort study. The athletes used an online training diary to report self-perceived menstrual-related symptoms, sleep quality, and readiness to train on a 1-10 scale, as well as menstruation/withdrawal bleeding, sickness, and injury on a day-to-day basis. Data were grouped into three phases, i.e., bleeding-days, 1-4 days pre-bleeding and non-bleeding days.
RESULTS: In total, 63% (n = 42) of the athletes reported using HC, with 76% (n = 32) preferring progestin-only HC. Menstrual-related symptoms were significantly more likely to occur during bleeding or pre-bleeding compared to non-bleeding for all athletes (cumulative probability of score >1 = 57% [bleeding]; 10% [pre-bleeding]; and 3% [non-bleeding], $p < 0.001$). Sleep quality was lower during pre-bleeding compared to bleeding- and non-bleeding days ($p < 0.001$), with no differences between HC-users and non-HC users ($p = 0.104$). Mental readiness to train was lower in non-HC users compared to HC users for all phases ($p = 0.025$). No significant differences in sickness, injury days or physical readiness to train were found between the different phases or between HC users and non-HC users.
CONCLUSION: In this study of highly trained endurance athletes followed during a 12-month period, we found sleep quality to be lower during the pre-bleeding phase compared to bleeding and non-bleeding phases, independent of HC use and non-HC use. Mental readiness to train was positively influenced by HC use.

## 11:30 - 12:45

## Invited symposia

### IS-PN03 Adding hypoxia in the sport and health practitioner's toolbox

#### ANALYSIS OF THE ROLE OF HYPOXIA IN ENHANCING MUSCLE GROWTH: CURRENT STATE OF KNOWLEDGE

FERICHE, B.

*GRANADA UNIVERSITY*

Resistance training in hypoxia has recently emerged as a potential stimulus favoring muscle mass development. There is an association between the production of metabolites and some ions and the activation of mechanisms related to the muscle mass growth by the recruitment of additional motor units, inflammatory response, protein synthesis or satellite cell proliferation. Several studies have focused on the hypoxic effect on protein synthesis and muscle cell proliferation, but the molecular mechanisms are largely unknown and the results on muscle hypertrophy and strength are not conclusive. This proposal will analyze the current state of knowledge about resistance training in hypoxia and its effect on muscle mass development.

#### RESISTANCE TRAINING IN HYPOXIA TO IMPROVE BONE AND CARDIOVASCULAR HEALTH IN OLDER ADULTS

TIMON, R.

*SPORT SCIENCES FACULTY. UNIVERSITY OF EXTREMADURA*

Bone and cardiovascular health deteriorates with age. Resistance training has been proposed as a fundamental tool to deal with these age-induced pathologies. The addition of hypoxic stress provides a beneficial synergistic effect on disease prevention and quality of life in older adults. The long-term effect of resistance training in hypoxia-induced adaptations will be analysed with a particular focus on metabolic biomarkers and inflammatory responses, bone remodelling and body composition, and physical condition and functionality in older people.

#### TARGETING PERFORMANCE AND HEALTH ENHANCEMENT WITH HIGH-INTENSITY HYPOXIC TRAINING

BROCHERIE, F.

*FRENCH INSTITUTE OF SPORT*

Among the panorama of altitude/hypoxic training methods, the "living low-training high" approach is becoming an important intervention for modern sport. In particular, systemic or local hypoxic training methods – or their combination – based on the repetition of "all-out" efforts can be used to induce a potent physiological stimulus, up-regulate signalling pathways and eventually maximize performance outcomes in a wide range of sports. Further, recent evidences suggest that such high-intensity exercise performed in hypoxia might be a valuable and viable "therapeutic strategy" in conditioning/rehabilitation or clinical setting. This presentation will therefore summarize and discuss the last "living low-training high"-based evidences related to performance or health enhancement.

## Invited symposia

### IS-AP02 Sport science and climbing: Welcome to the Olympic arena!

#### ROLE OF PSYCHOLOGICAL PROCESSES IN SPORT CLIMBING EXAMINED

SANCHEZ, X.

*UNIVERSITÉ DORLÉANS*

The influence of psychological factors in sport performance has, in general, been extensively demonstrated. However, the study of the role of the psychological aspects in the performance of climbing has not yet been systematically dealt with. Indeed, little research has examined the psychological requirements of climbing although these are vastly acknowledged by sport scientists, coaches and practitioners alike as being a key element in elite successful performance.
Even though climbing is considered unique from both scientific and sporting perspectives, this sporting discipline has not attracted much interest from sport psychology field until recently, when compared to other disciplines such as physiology, biomechanics, and motor control. The present talk will address research developed by the presenter examining the role of psychological processes in climbing. Identified climbing performance predictors will also be discussed. Lastly, a conceptual model with which to understand optimal climbing performance will be presented. As the sport of climbing continues to develop, the present talk will also provide a basis to develop further multidisciplinary research to examine most effectively how psychological aspects influence performance. From an applied perspective, the present talk will provide an opportunity to discuss how best to plan, design and deliver holistic and coherent training programmes aimed at enhancing competitive climbing performance.
The session will be of interest to researchers and applied scientists as well as sport practitioners with an interest in developing sport psychology work and applied performance interventions. The talk will also be of relevance to anyone interested in the field of psychology and behavioural sciences with an interest in the psychological processes engaged in the practice of sport; here climbing is used as a case-example.

#### CLIMBING FLUENCY AND INTER-LIMB COORDINATION

SEIFERT, L.

*UNIVERSITY OF ROUEN*

Skilled climbers ascend fluently – without excessively jerky movement – and are able to link together different sections of a climb without unnecessary stoppages. In competitive climbing, fluency is likely to be important in the lead climbing event because it relates to efficiency – useful when climbing long pitches (or multi-pitch routes) where economy is required. And, also in the speed climbing event because climbers want to maintain momentum as they ascend. Quantifying the spatio-temporal path of the climber over time allows us to assess learning and compare climbers of different skill levels. Fluency may not be so important in the bouldering event because of the limited number of moves and the nature of the routes that require fairly static periods and occasional dynos.
This session will discuss the assessment of movement fluency, through spatial (geometric index of entropy), temporal (stationary/motion ratio) and spatio-temporal measurements (smoothness of hip trajectory, i.e., jerk coefficient), and also the subsequent inter-limb coordination leading to this climbing fluency (notably through contact time on the wall and limb + body motions). We will examine the role of expertise, practice and climbing route setting. We will conclude with a discussion of current limitations and potential solutions.
The session will be of particular relevance to climbers but also to anyone interested in how we think about efficient movement of the body through the environment.

#### PHYSIOLOGICAL ADAPTATIONS IN CLIMBERS EXAMINED: ANTHROPOMETRY, STRENGTH, VO2, MUSCLE VO2, AND HEMODYNAMIC ADAPTATIONS

ESPAÑA-ROMERO, V.

*MEDICAL RESEARCH COUNCIL*

The popularity of the sport climbing as a recreational activity and as a training mode for rock climbing has been increasing over the last years. Due to such increase in participation, interest in improving personal climbing performance through specific practice and training is growing. Consequently, an increasing number of research outputs related to climbing performance has been produced lately; studies have focused on both physiological and anthropometric characteristics of the climbers. The present talk will examine the physiological adaptation in climbers such as aerobic capacity and muscular strength, as well as climbers' anthropometric characteristics. Moreover, knowing that climbing performance is largely dependent on the endurance of the forearm flexors, the present talk will also discuss the role of forearm flexor's specific hemodynamic adaptations in climbers.
Lastly, since the sport of climbing is also promoted as a regular activity to improve strength (e.g., by the American College of Sports Medicine), the talk will address how the physiological adaptations of the sport may help the general population when it comes to dealing with public health issues including depressive symptoms and back problems.
The session will be of interest to researchers and applied scientists as well as sport practitioners with an interest in developing strength and conditioning work, including local intermittent endurance. The talk will also be of relevance to anyone interested in the field of physiology and sport performance as well as sport and its health applications.

## Invited symposia

### IS-PN02 Catching your breath – the air we breathe, the food we eat, and respiratory health

#### COLD, HEAT AND THE LUNGS

KIPPELEN, P.

*BRUNEL UNIVERSITY LONDON*

Many athletes are routinely exposed to cold or hot environmental conditions while training and competing. In this presentation, we will explore the challenges faced by the respiratory system when athletes exercise in extreme thermal conditions. We will also discuss the potential implications to sport performance, and present various non-pharmacological options available to athletes to mitigate thermal-related respiratory issues.

One key role of the respiratory system is to bring inspired air to body conditions before it reaches the alveoli. As the ventilatory demand increases dramatically during exercise, the human body air-conditioning system can become overwhelmed. This is particularly the case when athletes exercise in cold air, as heat and water losses within the airways are then substantial. Heat and water losses within the airways often lead to dehydration of the protective airway surface lining, thereby promoting airway epithelial injury and airway inflammation. As a consequence, airway dysfunctions (such as exercise-induced bronchoconstriction) are particularly common in cold-weather athletes, and precautions to limit airway dehydration are warranted. After presenting how exercise could damage the fragile airway epithelium, we will present the pros and the cons of heat and moisture exchange masks on airway function and sport performance — those working with athletes will then to be able to make informed decisions as when, and how such face masks may be recommended.

At the other end of the thermal spectrum (i.e. in hot humid environments), there is a reduced risk for athletes to develop exercise-induced bronchoconstriction. However, when heat load becomes excessive, humans hyperventilate. When athletes exercise for prolonged periods of time and become hyperthermic, a ventilatory drift therefore occurs. While the underlying mechanisms and consequences of the so-called 'hyperthermia-induced hyperventilation' are still disputed, the potential impact of this excessive ventilatory response on blood gases homeostasis and sport performance will be explored.

#### AIR POLLUTION AND SPORT PERFORMANCE: IS THE RESPIRATORY SYSTEM THE WEAKEST LINK?

BOUGAULT, V.

*UNIVERSITÉ CÔTE DAZUR*

Climate change is accompanied by a growing release of pollutants in the air we breathe. In some parts of the world, pollution levels are dangerously high on a daily basis, while in other countries, the frequency and duration of peaks of pollution are increasing. Several events, such as the forest fires during the 2020 Melbourne tennis tournament or ozone pollution during the 1984 Los Angeles Summer Olympic Games, have raised concerned about the safety for athletes to compete in polluted environments. Many athletes indeed complained of respiratory symptoms – sometimes severe – during these events, which prompted some to withdraw from competition.

Since the 1984 Olympic Games and the well-known Los Angeles ozone fog, air measurements are taken to check pollution levels in the run-up to major sporting events. During the last Summer Olympic Games (Tokyo 2020), the organizing committees took measures to reduce car traffic and improve air quality. Such approach is however rarely in place for lower profile events. In this context, it is reasonable to wonder about the physiological and performance consequences of acute exposure to air pollutants. Due to the complexity of the research process, there is still very little literature on the subject. However, with the development of new tools for measuring pollutants, research under ecological conditions is growing.

In this talk, we will identify first the main pollutants that athletes encounter while exercising indoor and outdoor. We will then present the known effects of these pollutants on sports performance, and explore the possible mechanisms leading to performance decrement. We will finally discuss how the respiratory system – as the point of entry of the pollutants into the body – copes with these environmental insults, and consider preventative strategies to reduce pollution-induced respiratory issues.

#### HARNESSING THE GUT MICROBIOTA AND NUTRITION FOR RESPIRATORY HEALTH IN ATHLETES

WILLIAMS, N.

*NOTTINGHAM TRENT UNIVERSITY*

With the continued growth of evidence for the far-reaching health benefits of the gut microbiota, interest in the role of the gut for athlete health is not surprising. Respiratory issues, including respiratory illnesses and asthma, are a leading cause of training and in-competition time losses. The need to prevent illness and maintain health is paramount to both, athletic success and exercise adherence in the general population. The gut microbiota is implicated in areas that are pivotal to preserving respiratory health, such as: immunity, energy provision and defence against respiratory infections. There is emerging evidence that appropriate dietary strategies to target the gut microbiota could be a novel management tool for respiratory issues in the exercising individual – this will be the focus of the presentation.

Initially, the talk will present the beneficial effects that exercise has upon the gut microbiota. From increasing the number of beneficial microbial species to enriching the gut microbial diversity, exercise can help to maintain human health. Beyond the effects of exercise per se, we will highlight the proposed interaction between the gut microbiota and respiratory health, often termed the gut-lung axis, in athletes. In particular, we will focus on the latest evidence supporting the use of probiotics and prebiotics. There are now numerous studies reporting positive improvements in athlete's health – in particular, a reduction in the risk for upper respiratory symptoms (including infections), asthma and exercise-induced bronchoconstriction following probiotic and prebiotic interventions –, and the talk will critically discuss the existing evidence and apply it into sporting practice. An important message that the audience will be able to take away from this talk is that sports nutrition practices are not only fuelling the athlete, but also impacting on their gut microbiota.

## Invited symposia

### IS-MH01 Fragile do not touch! Role of antioxidant capacity, physical activity and exercise interventions in the management of frail older adults.

#### COENZYME Q10 AND PHYSICAL CAPACITY IN OLDER ADULTS, A DIRECT RELATIONSHIP

LÓPEZ-LLUCH, G.

*PABLO DE OLAVIDE UNIVERSITY*

Coenzyme Q10 (CoQ10) is an essential factor for mitochondrial activity and antioxidant protection of cells, tissues, and plasma lipoproteins. Its deficiency has been associated with aging progression in animal models and in humans. Some studies have determined that levels of CoQ10 in plasma correlate with the physical capacity of older adults (aged >65 years). We have observed that the levels of this compound are higher in people out of frailty scores in the senior fitness tests. Interestingly, CoQ10 is also higher in people able to maintain a healthy lifestyle related to physical activity as well as adequate fitness levels. On the other hand, CoQ10 levels show a strong inverse relationship with sedentarism and the up-and-go test. Gender differences will be revised, as there is evidence indicating stronger correlations in women than in men. Finally, we will highlight that the importance of the maintenance of CoQ10 levels in older adults can be related not only with muscle performance but also with vasculature endothelial function and senescent phenotype as high CoQ10 levels are associated with better endothelial antioxidant protection, low oxidative damage, and low inflammatory cytokines that affect muscle performance. The combination of CoQ10 with physical activity in older adults can be an important therapeutical procedure to reduce the progression of age-related sarcopenia and frailty.

#### ACCELEROMETER-ASSESSED ACTIVITY PATTERNS AS NOVEL BIOMARKER OF FRAILTY IN OLDER ADULTS

DEL POZO-CRUZ, B.

*UNIVERSITY OF SEVILLE*

Regular physical activity has an important role in maintaining health and functional status with ageing. Accelerometers allow detailed measurement of free-living quantity and patterns of physical activity and sedentary time. These devices, worn on different body locations, provide new opportunities to quantify detailed movement behavior throughout the 24-hour period. In this talk, I will present different ways to utilize and analyze accelerometer data and to measure movement behavior among older people, illustrating their potential to transform the way we investigate movement in older adults. I will first describe the role of overall physical activity and sedentary behavior to assess the level of frailty and physical function in older adults. Next, I will illustrate how to derive, analyze, and interpret data on complex and nuanced physical activity patterns. I will then present novel results describing the associations of physical activity patterns with frailty and mortality outcomes in older adults. To do so, I will utilize two well-known datasets: the Toledo Study for Healthy Ageing (Toledo, Spain; n=800 older adults with accelerometer) and the National Health and Nutrition Examination Survey, a population-based dataset with more than 3000 older adults with accelerometry and health measurements. Collectively, the presentation will address a variety of accelerometer methods, metrics, and analytical methods, which provide meaningful insights into physical activity behavior among people with advancing age.

#### PHYSICAL EXERCISE AS A DRUG FOR FRAILTY AND ENHANCEMENT IN QUALITY OF LIFE

GUADALUPE GRAU, A.

*CASTILLA-LA MANCHA UNIVERSITY*

The state of vulnerability that characterizes the geriatric syndrome of frailty exposes the older individual to an increased risk of morbidity, disability, inappropriate healthcare use, institutionalization, poor quality of life, and death. The old framework approaches frailty by treating diseases. Overcoming it by acting on functional issues arises from the main idea of detecting and intervening in the earliest phases of the functional deterioration leading to disability and dependence. Loss of muscle mass and its main functions (strength, power, and endurance) is fundamental to the concept of physical frailty. When older adults are frail or at risk of being frail, muscle power training reaches a higher level of relevance, since it is a cornerstone of the neuromuscular system and has a great influence on functional capacity during aging. The effectiveness of multicomponent training programs focused on muscular power in the prevention and treatment of frailty and multimorbidity will be discussed. Three possible scenarios of exercise programs implementation will be approached: online, healthcare (frailty management units), and sports centers.

## Oral presentations

### OP-GSSI GSSI Sport Award presentation session

#### UPTAKE AND UTILIZATION OF 15N-LABELLED DIETARY NITRATE BY SKELETAL MUSCLE

KADACH, S., PARK, J.W., STOYANOV, Z., BLACK, M.I., VANHATALO, A., WALTER, P.J., CAI, H., SCHECHTER, A.N., PIKNOVA, B., JONES, A.M.

*UNIVERSITY OF EXETER*

INTRODUCTION: The nitrate (NO3-) and nitrite (NO2-) stored in skeletal muscle may be important in the maintenance of systemic nitric oxide (NO) bioavailability, especially when NO requirements are elevated such as during exercise. At any given time, skeletal muscle NO3- concentration ([NO3-]) reflects the balance between metabolism of NO3- into other nitrogen-containing species, oxidation of NO produced via nitric oxide synthases (NOS), and NO3- uptake consequent to dietary NO3- ingestion. The purpose of this study was to use a stable

isotope tracer (15N-labelled NO3-) to investigate the metabolic fate of ingested NO3- through the determination of changes in NO3- concentration in skeletal muscle alongside other tissues at rest and following exercise.
METHODS: 10 healthy adults volunteered to participate in this double-blind, randomised, placebo-controlled study. Participants completed two experimental visits in which they consumed a beverage containing 12.8 mmol 15N-labelled potassium nitrate (K15NO3) or a potassium chloride placebo. Skeletal muscle (m. vastus lateralis) samples were collected at baseline, for 3 h post-supplement ingestion, and immediately following the completion of 60 maximal, unilateral contractions of the knee extensors over 5 min. All biological samples were analysed using ozone-based chemiluminescence to quantify total [NO3-] and [NO2-], and by mass spectrometry to determine the endogenous vs. exogenous origin of NO3- and NO2- (i.e., by determining the recovery of 15NO3- and 15NO2- in these tissues following the ingestion of K15NO3).
RESULTS: Neither muscle [NO3-] nor [NO2-] were altered following placebo ingestion compared to baseline. Following K15NO3 ingestion, muscle [NO3-] was elevated above baseline at both 1 h and 3 h (baseline, 35 ± 9 nmol.g-1; 1 h, 147 ± 71 nmol.g-1; 3 h, 105 ± 41 nmol.g-1; P<0.001). The majority of the increase in NO3- in muscle at 1 h was 15N-labelled (baseline: 0.9 ± 0.4 nmol.g-1; 1 h: 100 ± 63 nmol.g-1; 3 h: 50 ± 25 nmol.g-1; P<0.001). However, at 3 h, there was also an increase in skeletal muscle [NO3-] that was not 15N-labelled (baseline: 34 ± 9 nmol.g-1 vs. 3 h: 55 ± 21 nmol.g-1; P<0.05). Although there was no change in total skeletal muscle [NO2-] following the ingestion of the K15NO3 bolus, there was an increase in the contribution of 15N- labelled [NO2-] in skeletal muscle at 1 h (baseline: 0.02 ± 0.01 nmol.g-1 vs. 1 h: 0.12 ± 0.14 nmol.g-1; P<0.05), but not at 3 h, following NO3- ingestion. Exercise did not induce significant changes in total skeletal muscle [NO3-] or [NO2-]; however there was a reduction in 15N-labelled skeletal muscle [NO3-] from pre- to post-exercise (50 ± 25 vs. 28 ± 21 nmol.g-1; P<0.05).
CONCLUSION: This study shows for the first time that skeletal muscle rapidly and robustly takes up 15N-labelled dietary NO3-. This 15N-labelled NO3- appears to be utilized to support skeletal muscle metabolic processes, such as conversion to NO2- and NO, during maximal contractions.

## A HIGH-PROTEIN VEGAN DIET IMPROVES BLOOD-BORNE INDICES OF CARDIOMETABOLIC HEALTH BUT DOES NOT ALTER MICRONUTRIENT STATUS COMPARED WITH AN ISONITROGENOUS OMNIVOROUS DIET DURING RESISTANCE TRAINING.

VAN DER HEIJDEN, I., WEST, S., MONTEYNE, A.J., COELHO, M.O.C., FINNIGAN, T.J.A., STEPHENS, F.B., WALL, B.T.
*UNIVERSITY OF EXETER*

INTRODUCTION: A hypercaloric high animal protein diet is often advocated to meet increased macro- and micro- nutrient demands for optimal resistance training induced adaptations; though such diets are also associated with impairments in cardiometabolic health. Equivalent resistance-training induced increases in skeletal muscle mass and strength can be achieved consuming high-protein vegan diets which have also been used to improve markers of cardiometabolic health. Vegan diets, however, are potentially lower in key micronutrients required for optimal health and adaptation during prolonged training. In the current retrospective analysis, we investigated whether a hypercaloric, high-protein vegan diet consumed during high-volume resistance-training modulates blood-borne indices of cardiometabolic health or micronutrient status compared with an isonitrogenous omnivorous control diet.
METHODS: Twenty-two healthy young adults (age: 24±1 y, BMI: 23±1 kg·m2) undertook a 10-week progressive resistance training program (5-days/week), while following a high-protein (2 g·kg bm-1·day-1), hypercaloric (~10% daily energy surplus) omnivorous (OMNI: n=12; m=6, f=6) or mycoprotein-rich vegan (VEG: n=10; m=5, f=5) diet. Fasting venous blood samples were collected weekly to assess circulating glucose, insulin, micronutrient and lipid (using quantitative and targeted NMR-based metabonomics) statuses. Two-way repeated measures ANOVAs were performed to detect differences in each parameter. A false discovery rate of 0.276 was applied for metabonomics analyses.
RESULTS: Fasting plasma glucose concentrations remained unaltered, but serum insulin concentrations increased during training in OMNI only (from pre of 12±1 to post of 14±1 mU·L-1) resulting in an increased HOMA-IR index in OMNI (from pre of 2.4±0.2 to post of 2.9±0.2; P<0.05) but not VEG (from pre of 2.3±0.1 to post of 2.2±0.1; P>0.05). Out of 165 lipid targets, 5 differentially changed between groups throughout training (P<0.05). Large lipid classes (e.g. total cholesterol, triglycerides, phospholipids and fatty acids) did not change throughout training, but were higher in OMNI compared with VEG (P<0.05). Fasting serum ferritin concentrations decreased throughout training equivalently in both groups (OMNI: from pre of 54±14 to post of 38±9 µg·L-1, VEG: from pre of 73+31 to post of 52±20 µg·L-1, P<0.05) while serum vitamin B12, vitamin D and calcium concentrations did not change.
CONCLUSION: A hypercaloric and high-protein, mycoprotein rich, vegan diet can be followed during high-volume resistance-training to positively influence markers of cardiometabolic health without compromising micronutrient status when compared with a more traditional omnivorous dietary strategy.

## PRE-SLEEP PROTEIN INGESTION STIMULATES MITOCHONDRIAL PROTEIN SYNTHESIS RATES DURING POSTEXERCISE OVERNIGHT RECOVERY

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INTRODUCTION: Protein ingestion prior to sleep has been shown to stimulate myofibrillar protein synthesis rates during overnight recovery from exercise. Whether pre-sleep protein ingestion can also be applied to augment mitochondrial protein synthesis rates remains to be established. Furthermore, the impact of the type of protein to modulate overnight myofibrillar or mitochondrial protein synthesis rates has not yet been addressed.
The purpose of this study is to assess the impact of pre-sleep casein and whey protein ingestion on myofibrillar and mitochondrial protein synthesis rates during overnight recovery from a bout of endurance exercise.
METHODS: Thirty-six healthy, young men performed a single bout of endurance-type exercise in the evening (19:45 h) after a full day of dietary standardization. Thirty min prior to sleep (23:30 h), subjects ingested 45 g casein protein, 45 g whey protein, or a noncaloric placebo. Continuous intravenous L-[ring-13C6]-phenylalanine infusions were applied, with blood and muscle tissue samples being collected to assess overnight mitochondrial and myofibrillar protein synthesis rates. Overnight muscle protein synthesis rates were compared between treatments with a one-way ANOVA with a Bonferroni correction.
RESULTS: Protein ingestion resulted in higher mitochondrial (0.087±0.020 vs 0.067±0.016 %·h-1, P=0.005) and myofibrillar (0.060±0.014 vs 0.047±0.011 %·h-1, P=0.012) protein synthesis rates when compared to placebo. Casein and whey protein ingestion did not differ in their capacity to stimulate mitochondrial (0.082±0.019 vs 0.092±0.020 %·h-1, P=0.690) and myofibrillar (0.056±0.009 vs 0.064±0.018 %·h-1, P=0.440) protein synthesis rates.

CONCLUSION: Protein ingestion prior to sleep stimulates both mitochondrial and myofibrillar protein synthesis rates during overnight recovery from endurance exercise. There is no apparent difference in the capacity of pre-sleep whey or casein protein ingestion on overnight muscle protein synthesis rates.

### EFFECT OF ACUTE KETONE BODY SUPPLEMENTATION ON CARDIORESPIRATORY EXERCISE RESPONSES AND THE INFLUENCE OF BLOOD ACIDOSIS: A RANDOMIZED, CROSSOVER TRIAL

MCCARTHY, D.G., BOSTAD, W., BONE, J., POWLEY, F.J., RICHARDS, D.L., GIBALA, M.J.

*MCMASTER UNIVERSITY*

INTRODUCTION: Acute ketone monoester supplementation (KE) induces hyperketonemia and blood acidosis; both can affect exercise responses but the relative influence of each is unclear. We previously found that ingestion of 0.6 g/kg body mass KE increased heart rate (HR) and ventilation (VE) during cycling at ventilatory threshold (VT) compared to placebo (1). The present study used the same protocol (1) to examine the effect of KE on exercise cardiac output (Q) and the influence of blood acidosis. We hypothesized that KE vs placebo would increase Q and co-ingestion of a pH buffer would mitigate this effect.
METHODS: A sample size estimate (G*Power) determined n=12 provided 80% power to detect a change in Q (effect size f=0.4, alpha=0.05) with repeated measures analysis of variance (ANOVA). Trained adults (11 males, 4 females; VO2peak = 60±9 mL/kg/min) completed 3 trials in random order. Participants ingested 1 g/kg carbohydrate and 400 mL water 2 h before exercise, followed by either 0.20 g/kg body mass of sodium bicarbonate or a salt placebo 60 min pre-exercise, and a 0.6 g/kg bolus of KE or ketone-free placebo in 500 mL of fluid 30 min pre-exercise. This yielded 3 conditions: low blood ketone bodies and neutral pH [control (CON)], hyperketonemia and lowered pH (KE), and hyperketonemia and neutral pH (KE+BIC). Venous blood was sampled before and during exercise. Participants cycled for 30 min at VT intensity. Q was measured in duplicate over the last ~5 min using inert gas rebreathing (Innocor). After a 10-min rest, VO2peak and peak Q were determined. Data were analyzed using ANOVA and a Tukey post hoc test as appropriate with alpha=0.05.
RESULTS: Blood concentration of the major ketone body beta-hydroxybutyrate differed between conditions (CON: 0.1±0.0, KE: 3.5±0.1, KE+BIC: 4.4±0.2 mM, P≤0.001 for all). Blood pH was lower in KE vs CON (7.30±0.01 vs 7.34±0.01, p<0.001) and KE+BIC (7.35±0.01, p<0.001). Q during VT exercise was not different between conditions (CON: 18.2±3.6, KE: 17.7±3.7, KE+BIC: 18.1±3.5 L/min, p=0.4). HR was higher in KE (153±9 beats/min) and KE+BIC (154±9) vs CON (150±9, p<0.02 for both). VE was higher in KE vs CON (81±16 vs 74±17 L/min, p<0.0001) and KE+BIC (77±16, p<0.01). VO2peak was not different between conditions (CON: 4.55±1.05, KE: 4.34±0.94, KE+BIC: 4.39±0.91 L/min; p=0.2). Peak Q was also not different (CON: 21.8±3.8, KE: 21.5±3.7, KE+BIC: 21.1±3.9 L/min; p=0.3). Peak power output was lower in KE (359±61 W) and KE+BIC (363±63) vs CON (375±64, p<0.02). Peak HR was lower in KE vs CON (179±9 vs 181±9 beats/min, p=0.03) and KE+BIC (182±9, p=0.03).
CONCLUSION: KE increased submaximal exercise HR independent of acidosis and thus was seemingly affected by hyperketonemia. Q was not different between conditions despite differences in HR, which suggests stroke volume may have been altered. The higher cardiorespiratory stress after KE may have lowered exercise capacity such that peak power output at VO2peak was reduced.
1. McCarthy et al. (2021) DOI: 10.1139/apnm-2020-09

### EFFECT OF ACUTE DIETARY NITRATE SUPPLEMENTATION ON CARDIOVASCULAR FUNCTION AND EXERCISE TOLERANCE IN WOMEN USING ORAL CONTRACEPTIVE PILLS

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*LOUGHBOROUGH UNIVERSITY*

INTRODUCTION: Dietary nitrate (NO3-) supplementation has been reported to lower systolic blood pressure (SBP) and improve exercise performance in males and mixed sex groups, but very few studies have assessed these responses exclusively in females. Synthetic exogenous hormone consumption, via oral contraceptive pill (OCP), is highly prevalent in young premenopausal women and is suggested to attenuate endogenously produced nitric oxide, but it has yet to be determined whether OCP use impacts the responsiveness to dietary NO3- ingestion. This study tested the hypothesis that dietary NO3- supplementation would lower brachial and central SBP and improve exercise tolerance in women using OCP.
METHODS: Eight healthy, normotensive, premenopausal women using combined, monophasic OCP were recruited. Following baseline measurements of brachial and central SBP, with the latter determined using pulse wave analysis via applanation tonometry, participants ingested 140 mL of concentrated NO3rich (BR; 13 mmol NO3-) or NO3depleted (PL) beetroot juice. Measurements were repeated 2.5 h post ingestion and a ramp incremental cycling test was subsequently completed. The four experimental trials, BR and PL ingestion in the inactive and active pill phases, were administered in a double-blind, repeated-measures, cross-over experimental design. Data were analysed using repeated-measures ANOVAs and paired-samples t-tests. Values are presented as means ± SD with statistical significance accepted as P<0.05.
RESULTS: There was a main effect for supplement for brachial SBP (P<0.001), but no main effect for pill phase or supplement x pill phase interaction (both P>0.05). Brachial SBP was lower 2.5 h vs baseline in BR compared to PL in the inactive (-6 ± 4 mmHg vs 0 ± 3 mmHg; P=0.003) and active (-4 ± 3 mmHg vs 0 ± 3 mmHg; P=0.002) pill phases. There was a main effect for supplement for central SBP (P=0.015), but no main effect for pill phase or supplement x pill phase interaction (both P>0.05). Central SBP was reduced 2.5 h vs baseline in BR compared to PL in the inactive (-7 ± 4 mmHg vs -2 ± 3 mmHg; P=0.014) and active (-4 ± 3 mmHg vs 0 ± 4 mmHg; P=0.038) pill phases. There were no main effects for supplement or pill phase and no supplement x pill phase interaction effects for peak aerobic power (PAP) or VO2peak (all P>0.05).
CONCLUSION: These results suggest that acute consumption of NO3rich beetroot juice is effective at lowering both peripheral and central SBP in women using combined OCP. However, acute dietary NO3- supplementation did not alter PAP or VO2peak in this population. These findings might have implications for attenuating the proposed elevated cardiovascular strain that accompanies synthetic exogenous hormone consumption in premenopausal women.

# Oral presentations

## OP-PN04 Muscle typology and volume

### MUSCLE FIBER TYPOLOGY IN NATIONAL LEVEL FOOTBALL AND ITS INFLUENCE ON IN-GAME FATIGUE

VAN DE CASTEELE, F., LIEVENS, E., VAN VOSSEL, K., HARDEEL, J., DEPREZ, D., DERAVE, W.

*GHENT UNIVERSITY*

INTRODUCTION: Physical game demands in football (soccer) are position-dependent and a large heterogeneity in muscle fiber typology exists among national level players (1). We could expect that it is advantageous for central midfielders, who cover a large total distance, to have a slow typology and for forwards, who sprint a lot, to have a fast typology. At the higher levels this could lead to a selection effect. Furthermore, it was shown that fast typology individuals (FT) fatigue more than slow typology individuals (ST) (2). Therefore, we investigated if muscle typology is different between national level football players who occupy other positions and secondly if FT experience more in-game fatigue than ST.
METHODS: Muscle typology was estimated in 147 male professional football players (24.7±4.8yr) by measuring carnosine in the soleus muscle via proton magnetic resonance spectroscopy (3). Players were classified as ST, intermediate typology individuals (IT) or FT based on carnosine content. Our sample comprised 17 goal keepers, 27 center backs, 20 full backs, 45 midfielders, 20 wingers and 18 forwards. Time-motion data were collected by a multi-camera system to measure in-game fatigue as the decay in running activities from the 1st to the 2nd half. Following categories were used: total distance; standing/walking 0-6 km/h; jogging 6-15 km/h; running 15-20 km/h; high speed 20-25 km/h; sprinting >25 km/h; max speed; medium and high acceleration 2 to 3 m/s² and >3 m/s²; medium and high deceleration -2 to -3 m/s² and <-3 m/s². Players' category values were averaged and adjusted for playtime, but only for 59 outfield players who completed at least 5 games with 75 min playtime or more. ANOVAs were used to determine differences in muscle typology between positions and differences in distances covered in each intensity category during the whole game, 1st and 2nd half and decay from 1st to 2nd half.
RESULTS: There were no significant differences in muscle typology between positions (p=0.412), indicating that the variance within positions was larger than between positions. FT covered more high acceleration distance in the whole match (+9.3%, p=0.042) and 1st half (+11.9%, p=0.008) than ST players, but no other differences were found between FT, IT and ST considering the whole game, 1st and 2nd half. However, several high-intensity parameters showed a larger decline from 1st to 2nd half in FT players (high speed -10.7%; high acceleration -12.4%; high deceleration -12.7%) than in ST players (high speed -4.3%; high acceleration -7.7%; high deceleration -7.8%; p<0.05) and IT players (high acceleration -6.8%; p=0.011).
CONCLUSION: Possessing a particular muscle typology is not required to play a certain football position at the national level. However, it seems that FT are worse at maintaining their high-intensity performance from the 1st to the 2nd half compared to ST.
1 Lievens et al (2021). Sports Med, 52, 177-185
2 Lievens et al (2020). J Appl Phys, 128, 648-659
3 Baguet et al (2011). PLoS ONE, 6, 1-6

### INFLUENCE OF MUSCLE FIBER TYPOLOGY ON LEG MUSCLE HYPERTROPHY AND DYNAMIC STRENGTH GAINS AFTER 10 WEEKS OF RESISTANCE TRAINING TO FAILURE

VAN VOSSEL, K., HARDEEL, J., WEYNS, A., VAN DE CASTEELE, F., LIEVENS, E., DERAVE, W.

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INTRODUCTION: Considerable heterogeneity exists in the individual hypertrophy and strength responses to resistance training. The high variability in muscle fiber typology across humans might be one of the missing elements in understanding this heterogeneity. A recent gene expression study demonstrated differences in the response of individual fast-twitch and slow-twitch fibers to resistance training (1). Moreover, fast typology individuals were found to recover slower and to be more vulnerable to overreaching (2,3). Therefore, we investigated if the adaptations to resistance training are dependent on the muscle fiber typology and if different training frequencies and volumes cause different responses in slow typology (ST) and fast typology (FT) individuals.
METHODS: Eleven untrained ST (21.9±2.9yr, 6 men) and 10 untrained FT (22.2±1.0yr, 5 men) performed 10 weeks of resistance training. Muscle fiber typology was non-invasively estimated in the calf muscles and vastus lateralis by measuring carnosine using proton magnetic resonance spectroscopy (4). Subjects performed 3-4 sets of leg extensions and leg curls to failure every training session (60%1RM). A within-subject design was used where leg A trained 3x/week (>=48h rest) and leg B trained 2x/week (>=72h rest). Changes in muscle volume of the 4 quadriceps muscles and 3 hamstring muscles were measured by MRI (Springbok Analytics). Increase in maximal dynamic strength was measured by 1RM determination. Paired and Independent Sample t-tests and two-way repeated measures ANCOVAs were used to detect pre-post changes, differences between ST-FT and the 3x and 2x/week conditions.
RESULTS: The training program induced significant hypertrophy and strength increases in all trained muscles (p<0.005). Individual changes in muscle volume and dynamic strength ranged resp. from 0.1%-11.4% and 4.17%-43.75% in the quadriceps and 2.1%-23.1% and 6.7%-90.0% in the hamstrings. However, no significant differences were found between ST and FT in the individual (per muscle) and mean (all muscles combined) hypertrophic and strength changes. In the 3x/week condition mean hypertrophy was 9.5±4.6% (ST) vs 8.3±3.2% (FT) (p=0.53), mean change in 1RM was 23.9±9.13% (ST) vs 28.8±11.9% (FT) (p=0.31). The 2x/week condition caused a hypertrophy of 7.3±3.3% (ST) vs 6.8±3.0% (FT) (p=0.68) and a mean change in 1RM of 23.7±10.3% (ST) vs 21.4±8.6% (FT) (p=0.62). No interaction effect was found between muscle fiber typology and training frequency.
CONCLUSION: The heterogeneous response to resistance training seems not dependent on the muscle fiber typology as training to failure leads to equal hypertrophy and dynamic strength changes in the leg muscles of untrained ST and FT. Additionally, the optimal resistance training frequency and volume do not differ between ST and FT.
1 Raue et al (2012). J Appl Physiol, 112, 1625-1636
2 Lievens et al (2020). J Appl Physiol, 128, 648-659
3 Bellinger et al (2020). J Appl Physiol, 129, 823-836
4 Baguet et al (2011). PLoS ONE, 6, 1-6

### RESISTANCE-TYPE EXERCISE TRAINING COUNTERACTS THE IMPACT OF ANDROGEN DEPRIVATION THERAPY ON MUSCLE FIBRE CHARACTERISTICS IN PROSTATE CANCER PATIENTS

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INTRODUCTION: Androgen deprivation therapy (ADT) represents the cornerstone in prostate cancer (PCa) treatment. In addition to its inhibitory effect on tumor progression, ADT also causes several adverse effects including substantial loss of skeletal muscle mass. Resistance-type exercise training is an effective intervention strategy to counteract muscle mass loss during ADT. However, little is known about the impact of ADT on muscle fibre characteristics in PCa patients and the effect of resistance-type exercise training to reduce this impact. The objective of this study was to define the effect of resistance-type exercise training on ADT-induced changes on muscle fibre characteristics in PCa patients.
METHODS: Twenty-one PCa patients (72±6 y) starting ADT were included in the present study. Changes in muscle fibre characteristics were assessed in tissue samples collected from the vastus lateralis muscle at baseline and after 20 weeks of usual care (CON, n=11) or 20 weeks of progressive resistance-type exercise training (EX, n=10). Type I and type II muscle fibre distribution, fibre size, and myonuclear and capillary contents were determined by immunohistochemistry. Training-induced changes were analysed using a two-way repeated measures ANOVA with time (baseline vs 20 weeks) and fibre type (type I vs II) as within-subject factors and group (CON vs EX) as the between-subject factor. Significance was set at $P<0.05$ and all data are presented as means ± SDs.
RESULTS: A significant decrease in type I (from 7401±1183 to 6489±1293 µm2; $P<0.05$) and type II (from 6225±1503 to 5014±714 µm2; $P<0.05$) muscle fibre size was observed in the CON group. In addition, type I and type II individual capillary-to-fibre ratio (C/Fi) declined substantially (-12±12 and -20±21%, respectively; $P<0.05$) in the CON group. In contrast, significant increases in type I (from 6700±1464 to 7772±1319 µm2; $P<0.05$) and type II (from 5248±892 to 6302±1385 µm2; $P<0.05$) muscle fibre size were observed in the EX group. The training-induced muscle fibre hypertrophy was accompanied by an increase in type I and type II muscle fibre myonuclear content (+24±33 and +21±23%, respectively; $P<0.05$) and type I muscle fibre capillarization (capillary-to-fibre ratio +18±14%; $P<0.05$).
CONCLUSION: Twenty weeks of androgen deprivation therapy is accompanied by a decline in type I and type II muscle fibre size and capillarization in PCa patients. Supervised resistance-type exercise training offsets the negative impact of ADT and increases type I and II muscle fibre size and type I muscle fibre capillarization in PCa patients.

### THE DISTORTED MUSCLE SHAPE OF OLDER ADULTS IS ENHANCED BY THE DECLINE IN SKIN MECHANICAL PROPERTY

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INTRODUCTION: Muscle physiological cross-sectional area (PCSA) decreases with age. Since PCSA is linearly correlated with maximal voluntary contraction force [1], specific tension does not change with age, possibly suggesting that muscle “quality” is comparable between ages. Therefore, it is not clear whether and why the decrease in muscle volume is not progressed in an analogous manner as the age-related loss of muscle mass is accompanied by a decrease in the pennation angle [2].
Our earlier study demonstrated that pennation angle and muscle shear modulus decreased after the removal of skin in Thiel-embalmed cadavers [3]. This study suggests that the skin should play a role to determine the shape and muscle mechanical properties. Since skin stiffness also declines with age [4], age-related distorted muscle shape is potentially due to an age-related decline in skin mechanical properties. On the basis that the facial skin is easily pulled down in old adults at the upright position [5], age-related distorted muscle shape might be affected by the orientation of muscle relative to the direction of gravity. The purpose of this study was to examine the relationship between age, skin mechanical property, gravity, and muscle shape.
METHODS: 15 young (YA) and 15 old adults (OA) laid in supine and prone positions to examine the effect of orientation of gravity on muscle shape. Skin shear modulus (SSM) was measured at the belly of the right medial gastrocnemius (MG) by shear-wave elastography. A 3D ultrasound technique was utilized to reconstruct MG geometry. Then, anteroposterior (AP) and mediolateral (ML) length of the cross section at 30% of proximal right lower leg length were calculated to evaluate MG shape. Two-factor factorial ANOVA was used to examine the effects of age and postures on SSM, AP, and ML length. After calculating the rate of changes in AP and ML length when posture was changed from supine to prone positions and averaging SSM between positions, the correlations between these values were analyzed.
RESULTS: SSM was lower in OA compared with YA ($P < 0.05$). AP length was smaller in the prone position than in the supine position for both age groups ($P < 0.05$). ML length was larger in the prone position than in the supine position for both age groups ($P < 0.05$) and ML length was larger for OA than for YA in the prone position ($P < 0.05$). SSM were positively correlated with rate of change in AP length ($r = 0.58$, $P < 0.05$) and negatively correlated with rate of change in ML length ($r = -0.53$, $P < 0.05$).
CONCLUSION: The results suggest that muscle shape was flatted for old adults more than young adults in the prone position. Distorted muscle shape should be facilitated due to lower skin shear modulus, which cannot maintain the muscle shape against gravity.
REFERENCES
[1] Kawakami. J Sport Health Sci. 2005
[2] Kubo et al. Med Sci Sports Exerc. 2003
[3] Yoshitake et al. Ultrasound Med Biol. 2016
[4] O’Brien et al. Respir Res. 2019
[5] Flament et al. Int Cosmet Sci. 2015

### IDENTIFYING THE DETERMINANTS OF PERFORMANCE DURING PACED AND MAXIMAL MIDDLE-DISTANCE RUNNING EVENTS

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INTRODUCTION: Major championship 800-m and 1500-m races can be won in very fast times, with a sustained pace from the start, or in relatively slow times, but with an extremely fast last lap. It is likely that the underpinning physiological and speed/mechanical determinants would differ during these polarized middle-distance race scenarios. We conducted two separate experimental studies where we aimed to

identify the underpinning physiological and speed/mechanical determinants of performance during maximal and paced 1500-m (study 1) and 800-m running time trials (study 2).
METHODS: In study 1, 32 trained middle-distance runners (n = 21 male) completed a 1500-m time trial in the fastest time possible (1500MAX) and two paced trials whereby the mean speed during the 0–1100 m was reduced by 5% (1500MOD) and 10% (1500SLOW), whereas the last lap was completed in the fastest time possible. In study 2, 20 trained male middle distance runners completed an 800-m time trial in the fastest time possible (800MAX) and one paced trial, whereby mean speed was reduced by 7.5% (800PACE) relative to 800MAX, while the last lap was completed in the fastest time possible. In both studies, a series of additional laboratory and field tests were conducted to determine maximal sprint speed (MAXSS), VO2peak and the velocity corresponding with VO2peak (vVO2peak), running economy (RE), critical speed, maximal accumulated oxygen deficit (MAOD), and sprint force–velocity–power profiles. Carnosine content was quantified by proton magnetic resonance spectroscopy in the gastrocnemius and expressed as a Z-score to estimate muscle typology. Data were analysed using multiple stepwise regression analysis.
RESULTS: In study 1, 1500MAX time was best explained by RE and vVO2peak in female runners (adjusted r2 = 0.80, P < 0.001), in addition to the 0–1100-m speed relative to vVO2peak in male runners (r2 = 0.72, P < 0.001). Runners with a higher carnosine Z-score (i.e., higher estimated percentage of type II fibres) and greater MAOD, reduced their last lap time to a greater extent in the paced 1500-m trials. In study 2, MAXSS and vVO2peak best explained the variation in 800MAX time (r2 = 0.570; P = 0.020),whereas MAXSS was the best explanatory variable for the first 200-m time in 800MAX (adjusted r2 = 0.661, P < 0.001). Runners with a higher estimated percentage of type II fibres reduced their last lap time to a greater extent in 800PACE relative to 800MAX (r2 = 0.413, P < 0.001). A faster final 200-m time during 800PACE was associated with better maintenance of mechanical effectiveness during sprinting, a higher estimated percentage of type II fibres and vVO2peak (r2 = 0.761, P = 0.001).
CONCLUSION: These findings could inform the optimal racing strategies for middle-distance athletes with different physiological and speed/mechanical profiles and provide greater insight for coaches and sport scientists as to the training requirements to maximize performance in different types of middle-distance races.

## Oral presentations

### OP-PN05 Hematology

#### INVESTIGATING CHANGES IN HEMATOPOIETIC STEM AND PROGENITOR CELL CONCENTRATIONS DURING AND AFTER CONTINUOUS VS. INTERVAL-BASED EXERCISE BOUTS

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INTRODUCTION: Hematopoietic stem and progenitor cells (HSPC's) are donated by approximately 60,000 healthy individuals worldwide every year for patients with a variety of blood cancers and genetic disorders. However, barriers exist that limit the effectiveness of this process such as the time commitment to donate and side-effects of the drugs used to mobilise HSPC's (e.g., bone pain and headaches). A single bout of exercise can transiently increase the concentration of HSPC's in peripheral blood up to 2.5-fold; however, many of the exercise bouts used have been too long (30-45 min) to feasibly implement in a donation setting. HSPC kinetics appear to be driven by exercise intensity, yet the optimal balance between exercise intensity and volume to maximize mobilization of HSPC's is unclear. The current study aimed to compare changes in HSPC concentrations during and after bouts of high-volume high intensity interval training (HV-HIIT), low-volume high intensity interval training (LV-HIIT) and moderate intensity continuous training (MICT). Complete blood counts were conducted to determine whether HSPC mobilisation mirrored general leukocyte patterns.
METHODS: Ten males (mean ± SD: age 25 ± 7 years; BMI 25.7 ± 3 kg·m2; Wattmax 3.9 ± 0.8 W·kg-1) undertook bouts of MICT (30 min steady state, 65-70% of a maximum heart rate (HRMax)), HV-HIIT (4 x 4 min, 80-85% HRMax) and LV-HIIT (4 x 2 min, 90-95% HRMax) in a randomised crossover study design. HSPC's were enumerated in whole blood at rest, after each interval and 5- and 10-minutes post-exercise by employing a single-platform, flow cytometric method (defined as CD34+ CD45low SSClow).
RESULTS: HSPC concentrations (cell/ µL) significantly increased over time in response to all exercise trials (p < 0.0001). The peak response was highest after interval four of LV-HIIT (Pre-Exercise: 18.87 ± 2.50, post-Exercise: 34.00 ± 4.72, p = 0.01), but HSPC concentration was already elevated after just one interval (p = 0.0581, ns). Following the exercise trials, HSPC concentration decreased to resting concentration after 5 minutes of HV-HIIT (p = 0.0053), 10 minutes of MICT (p = 0.032), but remained sustained above rest 10 minutes after LV-HIIT (p = 0.0614). The peak fold change in HSPC's relative to rest (+1.80 ± 0.27) was not significantly (p > 0.05) different to total white blood cells (+1.66 ± 0.23) or lymphocytes (+1.89 ± 0.32).
CONCLUSION: LV-HIIT evoked a greater increase in HSPC concentration than MICT or HV-HIIT immediately post-exercise, with just one interval of LV-HIIT (2 minutes exercise) increasing HSPC concentration above rest. The increase in HSPC concentration was sustained for at least 10 minutes following LV-HIIT, but not MICT or HV-HIIT. These findings highlight that exercise intensity is a key factor driving HSPC mobilisation and sustainability in peripheral blood. Supporting some previous work, these changes largely mirrored the general mobilisation of leukocytes.

#### ETHNIC DIFFERENCES IN AEROBIC CAPACITY AND ITS HEMATOLOGICAL DETERMINANTS: THE CAUCASIAN-HAN CHINESE PARADOX

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INTRODUCTION: Maximal oxygen consumption (VO2max), a hallmark of aerobic capacity, is strongly associated with large decrements in cardiovascular events and all-cause mortality in the general population. Yet, to date, whether aerobic capacity is ethnic-specific and thus differences are inherently present in VO2max and its main biological determinants remains uncertain.
METHODS: Healthy young (< 35 yr) Caucasian (n = 18, 44 % females) and Han Chinese individuals (n=18, 44 % females) closely matched by age and moderate-to-vigorous physical activity (MVPA) were included in the study. VO2max was assessed with an established incremental exercise protocol. Exercise economy was determined at a moderate absolute workload (100 W). Hematological determinants such as blood

oxygen carrying capacity, blood volume (BV) and hemoglobin mass (Hbmass) were determined in standardized and controlled conditions using blood gas analyses and gas rebreathing methods.
RESULTS: Physical activity status, as represented by MVPA, was similar between Caucasian and Han Chinese individuals (6.2 ± 3.8 vs 6.3 ± 5.9 hr/wk, P = 0.936). VO2max was 22 % higher in Caucasian compared to Han Chinese individuals (43.8 ± 10.6 vs 35.9 ± 12.0 mL O2/kg/min, P<0.05) in spite of similar exercise economy as measured during submaximal exercise (19.3 ± 5.2 vs 21.0 ± 5.1 mL O2/kg/min, P = 0.342). With respect to hematological variables, BV (87.4 ± 9.5 vs 94.1 ± 10.5 mL/kg, P = 0.055) and Hbmass (11.5 ± 1.8 vs 12.1 ± 1.7 mL/kg, P = 0.240) did not differ between groups. Therefore, the BV/VO2max ratio was 23 % lower in Caucasian compared to Han Chinese individuals (2.04 ± 0.38 vs 2.51 ± 0.63 respectively, P < 0.05).
CONCLUSION: Large ethnic differences between young Caucasian and Han Chinese individuals are present in VO2max despite similar physical activity status and hematological phenotype.

**IRON DEFICIENCY ANEMIA AFFECTING VO2MAX DECREASE IN HYPOXIA**

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INTRODUCTION: Anemia is common worldwide, particularly among women, with the most common underlying cause, iron deficiency, affecting 12–18% of apparently 'fit and healthy' women [Dugan et al. 2021, Anaesthesia, 76(Suppl.4): 56-62]. Physically active females often participate in sports and demanding physical activities performed in hypoxic conditions. Both anemia and hypoxia are factors affecting maximal oxygen uptake (VO2max) via decreases in arterial oxygen content (CaO2) and when combining these two stressors systemic oxygen delivery and peak power output are greatly impaired [Roach et al. 1999, Am. J. Physiol. 276(2): H438-H445]. The aim of this study was to explore whether physically active women with mild iron deficiency anemia would exhibit greater VO2max decrease in hypoxia compared to healthy controls.
METHODS: Two groups of young physically active women matched for age, body weight, height and fitness level participated in the study; one with normal hemoglobin (Hb) concentration and ferritin levels (C; n=15; [Hb]:13.23±0.5 g/dl; ferritin:28.33±16.9 ng/l) and another (IDA; n=15; [Hb]:10.96±0.5 g/dl; ferritin:7.25±2.8 ng/l) with mild iron deficiency anemia (10<[Hb]<12 g/dl, ferritin<12 ng/l). Both female groups performed progressively increasing cycling exercise to exhaustion under normoxia and hypoxia (FIO2 0.21 and 0.14) on two occasions, within the same phase of their menstrual cycle, separated by an interval of at least 24 hrs, and following a counterbalanced order. Cardiopulmonary parameters were recorded in all subjects, while muscle and cerebral oxygenation (NIRS) were monitored in a subgroup of subjects (n=16; 8 from the C and 8 from the IDA group). Data were analyzed using 2-way ANOVA and t-test for independent samples; p was set at 0.05.
RESULTS: Normoxic VO2max did not differ significantly between groups (C:40.4±2.5, IDA:37.8±4.3 ml/kg/min; p>0.05), but the VO2max drop elicited by hypoxia was more profound in IDA than in C (17.6±7.9 vs. 10.7±2.7%; p<0.01). In both conditions the two groups had similar maximal heart rate (p>0.05). At maximal exercise, oxygenated Hb (O2Hb) was lower across groups in hypoxia (p<0.01). Interestingly, higher values in deoxygenated Hb (HHb) were observed in the IDA compared to the C group, only under hypoxia (p<0.05). Cerebral tissue oxygenation index (TSI%) followed the changes in CaO2.
CONCLUSION: It appears that iron deficiency anemia exacerbates the detrimental effect of hypoxia on VO2max, possibly via the role of iron-containing proteins inducing impairment of cellular iron-dependent processes in oxygen utilization.

**EFFECTS OF THE MENSTRUAL CYCLE AND ORAL CONTRACEPTIVES ON ERYTHROPOIETIN LEVELS IN ENDURANCE-TRAINED FEMALES**

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INTRODUCTION: Menstrual bleeding can affect circulating levels of available iron due to iron loss during the bleeding phase [1,2]. Results report that the lowest value of serum iron and transferrin saturation occurs during menses [1,2], concurring with the lower value of hepcidin, the main regulator of iron metabolism [2]. Conversely, another major hepcidin regulator and thus, iron metabolism is erythropoietin (EPO) [3]. Increased erythropoiesis stress and therefore, increased EPO levels could down-regulate hepcidin synthesis [3,4] through its suppression by erythroferrone (ERFE) to facilitate iron supply [3]. Nevertheless, evidence shows differences in iron availability among naturally menstruating compared to oral contraceptive (OC) endurance-trained females [1]. The aim of this study was to compare EPO levels throughout the different phases of menstrual cycle and OC phases in endurance-trained females.
METHODS: Nineteen eumenorrheic (30.8±6.5 years; 48.25±4.4 ml/kg·min-1) and fourteen OC users (25.8±4.8 years; 47.98±4.29 ml/kg·min-1) participated in this study. Blood samples were taken to analyze EPO just before (PRE) an interval running test, consisting of eight bouts of 3 min at 85% of the maximal aerobic speed, and 3 hours later (POST). The test was done in different sex hormonal environments: early follicular (EFP), late-follicular (LFP) and mid-luteal phase (MLP) for eumenorrheic women; and withdrawal (WP) and active pill phase (APP) for OC users. The three-step method was used to verify the menstrual cycle and OC phase [5]. Non-parametric test was used to compare the menstrual cycle and OC phases.
RESULTS: No significant differences were found between the menstrual cycle phases either PRE (EFP: 14.5±6.55 mU/ml; LFP: 16±6.45 mU/ml; MLP: 16.2±7.04 mU/ml) or POST (EFP: 11.9±6.56 mU/ml; LFP: 12.9±4.51 mU/ml; MLP: 13.1±6.24 mU/ml) or between OC phases either PRE (WP: 11.76±5.69 mU/ml; APP: 15.73±6.35 mU/ml) or POST (WP: 9.51±4.19 mU/ml; APP: 12.54±6.22 mU/ml). Additionally, no significant differences were observed between the menstrual cycle phases compared to OC phases.
CONCLUSION: Serum EPO does not appear to be affected by the different sex hormonal environments. Therefore, although EPO is responsible for the regulation of erythropoietic activity, and EPO may indirectly decrease hepcidin and increase plasma iron uptake [3,4], this lack of differences indicates that EPO levels seem not contribute to the reported changes in serum iron throughout the menstrual cycle.
Funding: DEP2016-75387-P
REFERENCES
1 Alfaro-Magallanes VM. et al (2021). doi:10.1080/17461391.2021.2018503.
2 Lainé F. et al (2016). doi:10.1111/bjh.13906.
3 Ganz T. (2019). doi:10.1016/j.freeradbiomed.2018.07.003.
4 Camaschella C. (2020). doi:10.3324/haematol.2019.232124.
5 Peinado AB. et al. (2021). doi:10.3390/ijerph18020735

**THE EFFECTS OF INHALING CARBON MONOXIDE PRIOR TO REPEATED SPRINT EXERCISE TRAINING ON CYCLING PERFORMANCE AND EXERCISE-INDUCED ADAPTATIONS**

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INTRODUCTION: Exercise-induced adaptations and athletic performance are improved more significantly following repeated sprint training in hypoxia than in normoxia. However, natural or artificial altitude training is expensive and not always accessible. Therefore, it is worthwhile to develop more convenient and less expensive training approaches that can induce both physiological adaptations and enhance athletic performance. When inhaled, carbon monoxide (CO) reduces the blood O2 carrying capacity and the O2 diffusion from capillary to muscle tissue, similarly to what happens in hypoxia. CO also regulates vascular and cardiovascular functions, stimulates anti-inflammatory response and mitochondrial biogenesis. Therefore, we hypothesized that, in association with improvements in repeated sprint ability (RSA), CO inhalation before sprint training would improve skeletal muscle oxidative function evaluated by determination in-vivo of skeletal muscle VO2 (VO2m) off-kinetics during the recovery from cycloergometer exercise.
METHODS: 23 endurance trained individuals age 33.2±6.9 years, body mass 78.3±11.0 kg, height 180.7±7.3 m, and VO2max 4.2±0.6 L·min-1 performed 9 supervised repeated sprint exercise sessions (3x5x10s all-out, 1:2 work to rest ratio) within 3 weeks. Cycling performance and physiological tests were performed within a week pre and post intervention. In a single blind fashion, the participants were randomly assigned to inhale either a bolus CO (INCO group) or placebo gas (CTRL group) before each exercise session. Analysis of covariance adjusted for baseline and sex was used to assess the effect of treatment on all variables.
RESULTS: The CO bolus administered prior to training increased HbCO to 5.5±0.4% from baseline and remained elevated (3.3±0.3%) following the training sessions. The training intervention increased the total work produced during RSA test by 26.7±10.3% (p= 0.001) with no difference between groups. RSA mean power decrement differed pre to post between groups (p=0.023) and was reduced in INCO (-2.7±7.9%) and worsened in CTRL (8.2±10.7%). HB-mass differed between groups pre to post intervention (p=0.038) and was preserved in INCO (-0.8±2.9%; p= 0.6) and reduced in CTRL (-4.9±3.5%; p=0.01). VO2m kinetic (tau) from a subgroup (n=10) differed between groups pre to post intervention (p=0.017), decreased in INCO (-38.8±32.9%; p= 0.05) and remained unchanged in CTRL (5.9±1.5%; p=0.72). No significant changes were found in other measured variables as VO2max and endurance performance.
CONCLUSION: These data indicate that CO inhaled prior to repeated sprint training induced beneficial effects on RSA and could be due to an improved mitochondrial function compared to placebo in amateur cyclists. This practice may also be beneficial to preserve HB-mass in periods when high intensity training is prioritized over large volumes of training. The effects of CO on performance and exercise induced adaptations could be advantageous in elite sport where even marginal gains are meaningful.

## Oral presentations

### OP-AP03 Swimming I

**CAN CRITICAL VELOCITY IN YOUNG SWIMMERS BE DETERMINED BY A 10X25M ALL-OUT SWIMMING TEST?**

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INTRODUCTION: In swimming, Critical Speed (CS) is considered one of the key markers of aerobic capacity, which is important for monitoring training and competition. Recently, a 12x25m all out test was validated for CS determination in elite swimmers, a proxy of the 3 min all out test validated for other exercise modalities [1]. In young swimmers it may be pertinent to adjust the test to 10x25m so that the total duration approaches 3 min due to the lower maximal speed of the younger swimmers [2].
Our aim was to compare the CS calculated from the 10x25m with the traditional method using 200 and 400m efforts.
METHODS: Twenty national level swimmers (12 male, 8 female, age 14.5 ± 0.7 years) performed three evaluations, with 48 h in between. Swimmers completed ten 25 m all out front crawl swims from a push start separated by 5 seconds rest, with a maximum of 2 underwater butterfly kicks, in a 25m pool. Subjects were told to swim as fast as they could on each 25 m repetition and hold nothing in reserve for the rest of the test. The CS10x25 was calculated as the mean speed of the slowest two 25 m efforts in the last four repetitions [1]. In the second and third session, swimmers performed, respectively, 200m and 400m maximal but constant efforts. CS400-200 was calculated from the slope of the regression analysis between the distances performed and the correspondent time [3]. T-test for paired samples was used to compare CS10x25 and CS400-200 and Bland Altman analysis and Concordance Corrrelation Coeficient (CCC) were used to determine the agreement between both methods. Significance was set at p<0.05.
RESULTS: Despite a high correlation was observed (r=0.77; p<0.01), CS10x25 significantly overestimated CS400-200 (1.33±0.10 and 1.18±0.07 m·s-1, p<0.01, respectively). Bland Altman analysis showed that the mean difference between methods was 0.16 m·s-1 with wide limits of agreement (-0.03 to 0.29 m·s-1). CCC was 0.27, precision 0.77 and accuracy 0.36, which indicates a poor strength of agreement between the methods.
CONCLUSION: Although the 10x25m is a test that mimic training sets and can be easily integrated in the swimming sessions, our results suggest that in young swimmers the 10x25 all out test overestimates the critical speed and can not be used interchangeably with the classical method based on 200 and 400m maximal efforts. Future studies may consider 5-6x50 to acknowledge the specific physiological responses of young swimmers.
References
[1] Mitchell, L.J.G., et al., Reliability and validity of a modified 3-minute all-out swimming test in elite swimmers. European Journal of Sport Science, 2018. 18(3): p. 307-314.
[2] Sousa, M., Is the Critical Velocity Test a Good Tool For Aerobic Assessment of Children Swimmers? The Open Sports Sciences Journal, 2012. 5: p. 125-129.
[3] Wakayoshi, K., et al., A simple method for determining critical speed as swimming fatigue threshold in competitive swimming. Int J Sports Med, 1992. 13(5): p. 367-71.

### PHYSIOLOGICAL AND KINEMATIC RESPONSES AROUND MAXIMAL LACTATE STEADY STATE IN SWIMMING

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INTRODUCTION: Performance enhancement in sport is closely and decisively related to accuracy in identifying exercise intensities domains toward optimizing daily training [1] and kinematic parameters are particularly important in swimming since athletes´ classifications are often decided by tenths of a second. The aim of the present study was to evaluate the physiological and kinematic responses around maximal lactate steady state (MLSS) in swimming.
METHODS: Fourteen competitive male swimmers completed a maximal 400-m front crawl to use the average velocity between 50 and the 350-m as an estimate of the maximal aerobic velocity (MAV). In the subsequent days, swimmers completed an incremental step test (IST) comprising 5x250- and 1x200-m stages and afterwards, 30 min continuous swimming velocity (SV) tests were performed for MLSSv determination, followed by two 500-m constant SV bouts at 97.5% and 102.5% of MLSSv, for oxygen uptake kinetics (VO2k) evaluation. During all tests, VO2 was assessed through breath-by-breath gas exchange, blood lactate concentrations (BLC) were determined, and kinematic variables stroke rate (SR), stroke length (SL) and stroke index (SI) were evaluated.
RESULTS: SV associated with 4 mmol·L-1 in the IST (1.27±0.04 m·s-1) was significantly lower compared to MLSSv (1.30±0.04 m·s-1, $p<0.05$), but all physiological parameters SVs derived from IST and continuous tests were highly correlated. BLC associated with Log-log methodology (4.2±0.7 mmol·L-1) was significantly lower compared to Dmax methodology (4.9±0.8 mmol·L-1, $p<0.01$), the last was not significantly different from MLSS (4.6±1.1 mmol·L-1). VO2max (57.4±7.1 ml·kg·min-1) determined in the IST, was not significantly different from mean VO2 during 102.5% MLSSv swim trial (56.1±6.0 ml·kg·min-1), both were higher compared to mean VO2 at MLSSv (49.0±8.9 ml·kg·min-1). Mean VO2 were significantly different ($p<0.01$) 2.5% below and above MLSSv, the same was observed regarding SR, SL and SI. Considering the VO2k, the amplitude of the primary phase (Ap) was significantly lower below MLSSv compared to 102.5% (45.9±6.7 vs 49.5±6.9 ml·kg·min-1, $p<0.01$), contrary to the time constant of the primary phase (taup) (21.2±8.6 vs 19.0±7.7-s, $p>0.05$), despite high correlations observed between taup below and above MLSSv and SVs associated to physiological parameters. The same relationships were observed between the Ap and kinematic variables, but only at 97.5% of MLSSv.
CONCLUSION: Both the continuous and IST provide useful indexes of swimming aerobic potential, but they cannot be used interchangeably for MLSSv determination. This SV seems to represent the upper limit of stroke efficiency. MLSS cannot be associated to a fixed BLC, and gas exchange analysis should also be considered in swimming. Since swimmers evidenced a taup of around 20-s, coaches may prescribe training sets close to 80-s to endure VO2max, because 98% of the total VO2max is attained at four times taup [2].
[1] Espada et al. (2021); [2] Burnley & Jones (2007)

### AGREEMENT OF LACTATE AND HEART RATE VARIABILITY THRESHOLDS IN SWIMMING

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INTRODUCTION: Heart Rate Variability (HRV) as a potential marker of athlete adaptation to training load has grown exponentially in recent years. The non-invasive character of this autonomic marker provides the basis for its use in the sports domain. The current research points to a close relationship between the thresholds assessed from HRV indexes and the blood lactate. It reinforces its utility to determine the exercise intensities in training prescription.
METHODS: 10 swimmers (4 male and 6 female) followed an incremental swimming protocol (5x200m freestyle), increasing the speed of each repetition from 80%, 85%, 90%, 95%, and >95% of their personal best performance in the distance (short course). The R-R intervals were collected with a cardiac heart rate band (Polar H10) and recorded with the heart rate monitor (Polar V800). Capillary samples were collected from the earlobe immediately, at the end of each repetition and after 3' and 5' after the last step, to determine the lactate values (Lactate Pro 2). HR data was analyzed through Kubios HRV Software. Fin). A vagal index, the standard deviation of the beat-to-beat instant variability (SD1) that reflects the short term HRV, was used for analysis. Lactate thresholds (LT) and the individual anaerobic threshold (IAT) values were determined through the speed-lactate relationship (Ergonizer Software.De).
RESULTS: The speeds for the Lactate and HRV thresholds do not differ statically ($p=0.203$ and $p=0.211$) for speeds of LT and IAT, respectively. For LT we found 1,26 ± 0.05m.s-1 and 1.27± 0.04m.s-1,( mean difference =0.02m.s-1; ES=0.04) and 1.36±0.08 m.s-1 and 1.39 ± 0.11 m.s-1 ( mean difference= 0.02; ES=0.06) for the speeds calculated from the SD1 HRV index and those determined from the lactate – speed curve respectively.
CONCLUSION: Like others before, which found agreement between HRV and Lactate Thresholds assessed through incremental protocols in running and cycling, this study also confirms the coincidence of the threshold's speeds evaluated in incremental swimming protocol. Although HRV analysis demands expertise to analyze the data and the investment in heart rate monitors able to r-r recording, this result reinforces alternative methods in assessing influential makers of monitoring and training prescription without traditional invasive procedures.

### ANAEROBIC TEST IN FOUR FREE SWIMMING TECHNIQUES THROUGH INERTIAL SENSORS

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INTRODUCTION: Water sports performance optimisation relies on specific, reliable procedures to assess physiological and biomechanical improvement, useful for coaches to monitor the athlete's conditions and predict future performance. [1,2,3]. A new approach to swimming coaching has been offered by innovative wearable technologies and waterproof coatings. They provide not only reliable and objective analysis of stroke mechanics and race performance, but also of physiological qualities such as the anaerobic capacity, all directly in free swimming [5]. The present study aimed to assess if a free-swimming protocol with inertial sensors may provide an effective assessment of kinematic and functional capacity in swimmers, specialized in four different techniques, by measuring speed and stroke parameters and their correlation with race time.
METHODS: Twenty-five highly trained national level [4] swimmers (13 male, 12 female) were recruited for the study. An all-out 75m bout in each athlete competition swimming technique was performed by all subjects in a short course swimming pool. The athletes were instructed to reach maximal velocity as fast as possible and to keep it till the end of the trial. During the protocol, temporal and kinematic variables were recorded through a waist-mounted inertial sensor and analysed as previously described [5]. Blood lactate concentration and RPE were assessed after the end of the test.

RESULTS: Average velocity in all four techniques was significantly correlated with the Time Race on 50m (r = .959, p < .05) and 100m (r = .973, p < .05). The average velocity was strongly correlated with stroke length and stroke efficient index (r = .779 and r = .702, p < .05), demonstrating how velocity may be affected by these variables even over short distances. Concerning the Fatigue Index, a significant correlation was highlighted with the total blood lactate production recorded after the end of the test (r = .567, p < .05). Finally, a negative correlation between RPE and stroke length - stroke efficient index was found (r = -.716, r = -.658, p < .05).
CONCLUSION: Velocities were related to kinematic variables and to swimming performance in 50m and 100m competitions. Swimmers with higher fatigue index presented more blood lactate concentration at the end of the tests, those with worse kinematic qualities suffered higher perception of effort. Therefore, temporal, and kinematic variables measured by the inertial sensor in the 75m all-out tests may be applied to infer and predict swimmers' performance and functional capacity in all four techniques and can be used for training monitoring and planning during the season.
REFERENCES:
1. Minganti et al. Sport Sci Health 2012,7(2),87-91
2. Chirico et al. J Sports Med Phys Fitness 2021
3. Demarie et al. Int J Environ Res Pub Health 2022,19(4):2110
4. McKay et al. Int Sports Physiol Perf 2022,17(2),317-331.
5. Demarie et al. Physiol Meas 2019,40(6):064003

**TIME SPENT NEAR VO2PEAK AT THE MAXIMAL AEROBIC VELOCITY IN SWIMMING – CONTINUOUS VS INTERMITTENT SETS**

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INTRODUCTION: The maximal aerobic velocity (MAV) is usually used by coaches for the planning of training at high swimming intensity since it combines exercise economy and maximal oxygen uptake (VO2peak). Also, the time sustained near VO2peak (e.g., above either the second ventilatory threshold (t@VT2) or 90% VO2peak (t@90%VO2peak)) is associated to long term adjustments that enhance VO2max and performance [1,2,3]. This study aimed to compare the physiological responses when performing continuous vs intermittent sets at MAV to determine which reproduces swimming conditions with higher potential for aerobic capacity development.
METHODS: Thirteen well-trained male swimmers (16.5±1.9 years, 178.6±8.4 cm, 70.4±10.3 kg) completed a discontinuous incremental test [3] for VO2peak, VT2 and MAV assessment. On complementary days, two swimming trials at MAV until exhaustion, continuous (CT) vs intermittent (IT) sets composed of 100 meters repetitions (IT100) with 15 s breaks, were performed for maximal oxygen uptake (Peak-VO2), t@VT2 and t@90%VO2peak evaluation. Distance and time were recorded to determine the tests' time limit (tLim). Maximal blood lactate concentration [La-] and rate of perceived exertion (RPE) were determined. All tests were conducted using a breath-by-breath apparatus connected to a snorkel for pulmonary gas sampling, with pacing controlled by an underwater visual pacer.
RESULTS: VO2peak (4.0±0.4l L·min-1) was only reached in the CT (100.2±3.0 %VO2peak). Still, high values were reached at IT100 (96.3 ± 4.6 %VO2peak). VO2peak was highly correlated with Peak-VO2 during CT (r=0.94, p<0.01) and IT100 (r=0.89, p<0.01). Compared with CT, the IT100 presented significantly higher values for tLim (940.0±470.9 vs 243.6±59.3 s), distance (1215.4±612.5 vs 309.6±64.7 m), t@VT2 (419.7±196.7 vs 137.5±80.2 s) and t@90%VO2peak (290.7±214.7 vs 115.5±79.1 s). tLim between CT and IT100 were not associated. MAV (1.30±0.07 m·s-1) and Peak-V̇O2 during CT and IT100 correlated with the 400 m swimming performance (r=-0.55, r=-0.73 and r=-0.76 p<0.05, respectively). RPE and [La-] were not different between CT and IT100 (8.8±1.0 vs 9.5±0.8 and 7.5±2.9 vs 6.5±1.3 mmol·l-1, respectively).
CONCLUSION: MAV is suitable for planning swimming intensities requiring maximal oxygen rates whatever the exercise schedule (CT or IT). The times to exhaustion at this swimming intensity are not related to swimming performance, however, MAV and Peak-VO2 values were related to middle-distance performance, whatever the exercise schedule and therefore highlighting their role in training for performances requiring maximal aerobic power attainment. Therefore, the results suggest the IT100 as a preferable training schedule compared to CT for aerobic capacity training since IT100 presented a significantly higher tLim, t@VT2 and t@90%V̇O2peak (more ~697, ~282 and ~175 s, respectively), without demanding different cellular acidosis and RPE.
1. Billat (2001); 2. Libicz et al. (2005); 3. Almeida et al. (2021)

## Oral presentations

### OP-AP22 Endurance training and testing

**VALIDITY AND RELIABILITY OF HEART RATE VARIABILITY THRESHOLDS USING DFA A1**

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INTRODUCTION: The short-term scaling exponent alpha1 of detrended fluctuation analysis (DFA a1), a nonlinear index of heart rate (HR) variability (HRV), has been shown to change with increasing exercise intensity. Recent studies have demonstrated that a value of 0.75 and 0.5 correlates with first and second ventilatory threshold (VT1 and VT2), respectively [1,2], and a value of 0.75 has been related to LT1 [3]. On the downside, we have not found any study about reliability of DFA a1 to estimate intensity thresholds. Therefore, the aim of this study was to compare HR derived from a predefined DFA a1 transitional value, to that reached at VT1, VT2 and lactate thresholds, using a Polar H10 and a 3-lead ECG to record RR time series, in order to consider/test the validity of the heart rate monitor too. Furthermore, the study aims to assess the reliability of DFA a1 to measure intensity thresholds.
METHODS: 16 moderately trained volunteers performed two incremental exercise tests to exhaustion on a cyclergometer (Ergomedic 839E, Monark, Denmark). Respiratory gases (MasterScreen CPX, Jaeger, Germany) and HR (Elite HRV and BIOPAC) were measured continuously during cycling, and lactate measures were collected. HRV thresholds (HRVT1 and HRVT2) were defined as the HR reached at a DFA a1 of 0.75 and 0.5, respectively. To evaluate ventilatory thresholds a mixed method was used [4], and lactate thresholds were calculated with baseline +1.0 (LT1) and Log-Exp-ModDmax (LT2). A paired t-test was used to detect changes between methods as well as correlations

(Pearson's r), Bland-Altman plots, intraclass correlation coefficient (ICC), typical error (SEM) and coefficient of variation (CV) to determine validity and reliability. Significance was set at p<.05.
RESULTS: Mean HRVT1 with ECG was 158±14 bpm, compared to HRVT1 with Polar H10 of 155±16 bpm, VT1 of 129±16 bpm, and LT1 of 132±19 bpm. Mean HRVT2 with ECG was 170±10 bpm, compared to HRVT2 with Polar H10 of 170±12 bpm, VT2 of 163±14 bpm, and LT2 of 161±14 bpm. No significant differences were found between ECG and Polar H10 for HRVT1 (P=0.361), and HRVT2 (P=0.747). Moderate and low correlations were seen between methods, with Pearson's r values of 0.43 (HRVT1-VT1), 0.67 (HRVT2-VT2), 0.69 (HRVT1-LT1), and 0.64 (HRVT2-LT2). Bland-Altman analysis for HRVT1 and VT1 showed a mean difference of 33±14 bpm, for HRVT1 and LT1 of 15±11 bpm, for HRVT2 and VT2 of 7±11 bpm, and for HRVT2 and LT2 of 2±10 bpm. ICC was high for both HRVT1 (0.93) and HRVT2 (0.94). SEM for HRVT1 and for HRVT2 was the same (0.29), and CV was 6.7% for HRVT1 and 5.9% for HRVT2.
CONCLUSION: Polar H10 has shown to be a valid device to measure DFA a1 during an incremental cycling test. In addition, intensity thresholds assessed using DFA a1 were moderately correlated to ventilatory and lactate thresholds, showing high reliability.
1. Rogers et al. (2021) 2. Rogers et al. (2021) 3. Rogers et al. (2022) 4. Keir et al. (2021)

### DEVELOPING A COURT-BASED ASSESSMENT OF MAXIMAL AEROBIC SPEED IN NETBALLERS

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INTRODUCTION: Netball is a sport that places high physiological demands on athletes to sustain peak performance, especially at the professional level. Despite the increase in elite performance, there remain limitations regarding the accessibility, time-efficiency, and specificity of testing methods to assess key physiological requirements of the sport, in particular the fundamental component of a high aerobic capacity and maximal aerobic speed (MAS). The purpose of this study was to develop a valid and practical field-based fitness test, assessing the aerobic capacity of netball players, which was compared against the gold standard laboratory-based VO2max test. It was hypothesised that the speed at which VO2max was elicited during laboratory testing (vVO2max) would be similar to the speed at which a 30-court length time trial was completed.
METHODS: Eleven trained female netball players (19±1 years; 176±7.1cm; 67.9±9.3kg) completed a standardised incremental laboratory VO2max test on a treadmill, followed by three subsequent sessions involving a 30-court-length time trial on an indoor netball court (best performance compared to lab). MAS was measured as the speed at which VO2max was elicited on the treadmill (vVO2max) and calculated as the speed of completing the 30 court lengths (total distance/completion time). Heart rate peak (HRPeak) was measured via telemetry (Polar) during all sessions, and blood lactate concentration was obtained via blood samples at 1, 3 and 5-minutes post-cessation of the lab test and final court-based assessment. Paired t-test and linear regression examined the relationship of all outcome measures between the lab and court-based assessments.
RESULTS: Lab-based vVO2max was significantly higher than the court-based measure of vVO2max (4.29±0.30 vs. 3.75±0.25 m/s; p<0.001). HRpeak was also significantly higher during the lab test than the court-based assessment (193±9 vs. 189±10 bpm; p =0.048). Blood lactate was not different between lab test and court-based assessments (10.75±1.83 vs. 10.16±2.06 mmol/L; p =0.144). In addition, centre court players showed the highest vVO2max in both lab and court tests, whilst the goal shooter position displayed the lowest vVO2max values. Consistent with this, there was a very strong correlation between the lab and court-based vVO2max values (r =0.870).
CONCLUSION: In summary, the maximal aerobic speed achieved in the court-based assessment was not a direct reflection of lab-based vVO2max. Potential explanations for this difference include biomechanical factors of change of direction and running mechanics on a treadmill vs on-court, and the time-of-day differences between testing (court-based all early morning). Nevertheless, this is the first- and only-time efficient netball-specific testing method to be compared to gold standard VO2max testing, ultimately providing a tool for practitioners to profile individual players, develop tailored training programmes and improve the performance of elite netballers in the future.

### BREATH TOOLS: HOW TO INSTRUCT AND QUANTIFY ADHERENCE TO BREATHING PATTERN SOUND GUIDANCE DURING RUNNING

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INTRODUCTION: Many runners feel physical distress and psychological discomfort due to exercise-induced dyspnea; this is especially true for female beginners. Breathing pattern (BP) guidance, such as breathing rate (BR) sound instruction, could help runners maintain stable BP during running. Instructing locomotor-respiratory coupling (LRC; synced step & breath) may be especially helpful since it is simple to learn and metabolically advantageous. We sought to examine female runners' adherence to novel BP instruction sounds during running and compare acute effects of the instruction to baseline BP.
METHODS: Two groups of 13 healthy beginner-intermediate female runners (age=27.0±6.7) participated in a series of treadmill and field runs at submaximal intensity. Baseline BP was collected from running without sound prior to each trial. In the first indoor experiments, various BR and LRC sounds were played at fixed tempos derived from each runner's baseline and at progressively slower rhythms (-15, 30%). In the second experiments, one LRC sound was step-synchronized and sonified via a smartphone application ("Breathtool") during a 30 min outdoor run and variable intensity treadmill runs (±10% self-selected speed). BP was gathered using Hexoskin (HX) shirts (Carré Technologies, CAN) and processed via a custom algorithm. Sound instruction adherence was estimated using BR cv (BRV), attachments, and MAPE as done previously. Repeated-measures ANOVA was used to estimate meaningful differences between sounds, within individuals, and experimental conditions. Pearson's correlation coefficients were used to calculate relationships between objective adherence and subjective experience questionnaires.
RESULTS: Baseline BP averaged BR=30.1±5.1 bpm and LRC=4.8±1.0 steps per breath across the experiment. BR sounds reduced BRV 16.5±5.2% to 9.0±3.4%, with overall excellent adherence (MAPE<2.5%, % time attached >85%), individual analysis showed a preference for more information-rich sounds (MAPE η2 =.21). Adherence was lower with slower BR (% attached η2 =.23). LRC sounds stabilized BRV from 15.3±4.0% to 7.2±3.1%. Adherence was moderate (MAPE=1.2-3.3%, % time attached=48.6-77.3%), and best for combined breath+step sound (η2 =.19). With Breathtool, runners exhibited much greater adherence indoors compared to the first study (% time attached=92.6±9.7 vs. 64.9±11.6%). There was lower adherence to Breathtool outdoors versus indoors (η2 =.45) and there was no effect of speed on adherence. LRC instruction resulted in lower respiratory variability (η2 =.16-.21) versus baseline across all conditions. Finally, we observed weak to moderate correlations between BR and RPE (r=0.52), % attached and perceived usability (r=0.31), and HR and subjective vitality (r=-0.36).

CONCLUSION: We suggest using information-rich, step-synced sounds to maximize adherence to BP instruction. Sound adherence can be effectively summarized with two metrics: % time attached and MAPE. Future work should determine if psychophysiological benefits result.

**VALIDATION OF A NON-EXERCISE METHOD FOR ESTIMATION OF VO2MAX BEFORE AND AFTER A PRE-SEASON TRAINING PERIOD IN SUB-ELITE AND ELITE FOOTBALL PLAYERS**

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INTRODUCTION: The gold standard for determination of maximal oxygen consumption (VO2max) is by graded exercise testing (GET) with pulmonary gas exchange measurements and is regularly used to assess fitness status. However, this methodology requires time, maximal exercise and expensive equipment and are therefore not always suitable. These limitations also applies for semi and professional football clubs. A new non-exercise VO2max prediction model using seismocardiography (SCG) at rest in combination with demographic data is now available. SCG is a measurement of precordial vibrations using an accelerometer. The prediction model is validated in normal healthy subjects, but not yet in trained athletes. The aim was to investigate the accuracy of the SCG VO2max prediction model in sub-elite (SUB) and elite (Elite) football players and the detection of changes following a pre-season training period.
METHODS: 35 SUB players from the 3th and 4th best division and 10 Elite players from the best division in Denmark completed both pre and post testing. 12 SUB and 14 Elite players were lost to post testing. The SUB players were tested in 2021, hereafter the SCG VO2max prediction model was adjusted, before testing the Elite players in 2022. Testing included determination of body composition by a DXA scan (Pre: 79.0±2.3 kg and 83.1±5.2 kg (weight), 15.0±1.3% and 12.8±1.4% (fat), 66.9±1.8 kg and 68.5±4.2 kg (fat free mass) for SUB and Elite players, respectively (mean±95% CI)). Subsequently, VO2max was estimated at supine rest with the SCG recording device, SeismoFit®, placed on the lower part of sternum (Pre: 47.2±1.9 ml/min/kg (SUB) and 55.1±2.1 ml/min/kg (Elite). Lastly, a GET on a treadmill until voluntary exhaustion was performed for determination of VO2max (Pre: 57.1±1.6 ml/min/kg (SUB) and 57.8±3.3 ml/min/kg (Elite).
RESULTS: Accuracy of pre testing: SCG VO2max was lower (Student's paired t-test: $p<0.0001$) compared with GET for SUB, but not different for Elite ($p=0.123$). A positive Pearson's correlation of $r=0.56$ ($p<0.0001$) and a standard error of estimate (SEE) of 11.4 ml/min/kg between SCG and GET VO2max was found for SUB, whereas no correlation ($r= 0.50$, $p=0.138$) and a SEE of 5.9 ml/min/kg was found for Elite. Changes from pre to post: GET VO2max increased by 2.7±0.8 ml/min/kg (SUB, $P<0.0001$) and 1.6±1.2 ml/min/kg (Elite, $P=0.033$). SCG VO2max increased by 1.7±1.2 ml/min/kg (SUB, $p=0.011$) and 0.1±1.3 ml/min/kg (Elite, $p=0.921$). No correlation between changes in SCG and GET VO2max was found for either SUB ($r=-0.24$, $p=0.171$) or Elite ($r=-0.06$, $p=0.870$). Weight was unchanged for SUB and Elite ($p>0.05$).
CONCLUSION: The accuracy of the original SCG VO2max prediction model was poor in sub-elite football players. When the prediction model was adjusted the accuracy improved substantially and was good in elite football players. However, the SCG VO2max prediction model is not suitable for detecting changes in VO2max following a training period in a sub-elite and elite population.

**THE ROLE OF A NOVEL HEART RATE VARIABILITY MEASURE IN ESTIMATING THE FIRST VENTILATORY THRESHOLD**

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INTRODUCTION: Evaluating the lactate threshold (LT) is of paramount importance for both training and clinical purposes. The first ventilatory threshold (VT1) has been extensively used as an alternative to LT. This method derives LT indirectly from oxygen consumption ($VO_2$), carbon dioxide production ($VCO_2$), and ventilation ($V_E$) during the incremental cardiopulmonary exercise test (CPET). In detail, VT1 corresponds to the level of exercise at which an increment of the ventilatory equivalent for oxygen ($V_E/VO_2$) without a concomitant increase of the ventilatory equivalent for carbon dioxide ($V_E/VCO_2$) takes place.
Since VT1 requires a laboratory with trained staff and expensive devices, different heart rate variability (HRV) parameters have been proposed in the past as surrogate measures. This approach is based on the assumption that when a subject reaches LT, there is an almost complete vagal withdrawal that corresponds to a great reduction of HRV indexes that are highly correlated with vagal tone. The present study aimed at evaluating a novel HRV index derived from standard frequency-domain HRV measures, namely the sum of the power of the low and high components of the HRV spectrum (LF-HFpower).
METHODS: 27 subjects (6 females) were recruited in this study. All participants underwent a CPET on a cycle ergometer to assess VT1, while LF-HFpower was determined from ECG traces recorded during tests. Then, the values from 10 randomly chosen subjects were utilized to conduct a Watt- LF-HFpower non-linear regression analysis, with the exponential decay being the mathematical model that best fitted the data as demonstrated by an Akaike Information Criterion evaluation.
Afterward, Watt/ LF-HFpower curves of the 10 subjects were calculated, and the average of values at the level of exercise that corresponded to VT1 for each subject were taken and used as a reference value (RF). In the end, the Watt/ LF-HFpower curves of the remaining 17 subjects were calculated, and the LF-HFpower threshold (LF-HFthreshold) was set at the level of exercise corresponding to the value that was closest to RF. Paired sample T-test, Pearson correlation, Bland-Altmann plot analysis, mean bias, standard deviation (SD) of bias, and limits of agreement (LoA) were employed to compare VT1 and LF-HFthreshold.
RESULTS: The paired sample T-test did not show any significant difference between the methods ($p=0.7$). Pearson analysis demonstrated a good correlation ($R2$ 0.79; $p=0.0001$). Bland – Altmanns plot showed good results with mean bias, SD of bias, and Loa equal to -2.06 Watt, 22,17 Watt, and -46,57/+42,56 Watt, with a more significant difference between methods for higher values.
CONCLUSION: LF-HFthreshold demonstrated a good correlation with VT1. Further studies with bigger samples are warranted to refine the ability of LF-HFthreshold to detect VT1 more accurately. However, this method could be a valid inexpensive alternative to VT1 in evaluating athletes and patients fitness.

# Oral presentations

## OP-AP23 Female Team sports

### ANTHROPOMETRIC AND PERFORMANCE CHARACTERIZATION OF U16 AND U18 FEMALE HANDBALL PORTUGUESE NATIONAL TEAMS

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INTRODUCTION: Handball is an invasion team sport, characterized with high levels of impacts, change of direction and intermittent efforts1. Due to all the dimensions that it comprises - technical, tactical, psychological/social and physical characteristics - handball is a very complex sport 2. Each player has its own unique cognitive or physical characteristics that somehow are more suitable for each playing position2. For this reason, it is important to highlight the features that coaches should search when pursuing those differentiated players that might be suitable for national team. This topic gains more importance when it comes to female handball, where research is only growing in the recent years 1,2. The purpose of this study was to characterize the physiological profile of the Portuguese young female handball players.
METHODS: 36 young female handball players belonging to the Portuguese National team participated in our study. We conducted several performance tests in the early phase of the 2021/2022 season (Vertical Jump: squat jump-SJ, Countermovement Jump-CMJ, Countermovement Jump free arms-CMJFA; Horizontal Jump-HJ; Medicinal ball throw-MBT; Handgrip-HG; Sprint ability-10m and 20m; Change of direction-COD). Players were divided by age (U16 n=18 body height (BH): 170,90±5,1 cm, body weight (BW): 68,88±12,88 Kg; U18 n=18 body height (BH): 171,94±6,6 cm, body weight (BW): 70,36±10,27 Kg). IBM SPSS 27 was used for descriptive analyses and differences between groups were analyzed with t-test ($p<.05$).
RESULTS: There were no significant differences in the anthropometric measures between the two groups. However, when looking for all the performance variables, significant differences were found in all the tests, except MBT. As expected, the older players perform better in all the tests, even in MBT.
CONCLUSION: From our results we may conclude that more mature players are better prepared for physical testing. Even though these two groups are only two years apart and not significantly different when referring to the anthropometric measures, the U18 athletes have already started their journey in the National teams a couple of years ago and have yet been present in an international competition. They seem better prepared in the early stages of the season, most of them are already playing in their senior teams, some of them playing the Portuguese first division. Further research should focus on comparing the beginning and the end of the season.

1. Vuleta D, Bojić-ćaćić L, Milanović D, Duraković MM, Dizdar D. Positional differences in anthropometric characteristics of the croatian u18 female field handball players. Kinesiology. 2020;52(1):124-133. doi:10.26582/k.52.1.10
2. Michalsik LB, Aagaard P. Physical demands in elite team handball: comparisons between male and female players. J Sports Med Phys Fitness. 2015;55(9). doi:10.1002/pds.3998

### RELATIONSHIPS BETWEEN LINEAR SPRINT PERFORMANCE, COD VELOCITY, AND COD-DERIVED MEASUREMENTS IN ELITE FEMALE RUGBY SEVENS PLAYERS

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INTRODUCTION: In rugby, change of direction (COD) efforts are determinant during match-play as these actions frequently precede decisive game actions (e.g., a try). Thus, investigating players' ability to effectively accelerate, decelerate, and execute cutting and turning maneuvers in multiple directions is essential (1). When assessing COD ability, variables such as COD deficit (CODD, difference in percentage between a linear sprint test and a COD task of equal distance) and deceleration deficit (DD, difference between the time taken to accelerate and come to a complete stop when changing direction in relation to the linear sprint performance) have been shown to provide meaningful and complementary information for coaches (2,3). However, to date, no study has simultaneously assessed both CODD and DD in female rugby sevens. This research aimed to examine the relationships between linear sprint and COD velocities and indirect COD-derived measurements (i.e., CODD, DD) in a sample of elite female rugby athletes.
METHODS: Nineteen players (age: 23.7±3.5 years; body mass: 66.4±7.5 kg; height: 168±10 cm) from the Brazilian National Team performed linear sprint (i.e., 15-m) and 505 COD tests. Average velocities, CODD, and DD were computed from the sprint and 505 data. The Pearson product–moment analysis was used to test the correlations among the distinct variables.
RESULTS: Linear sprint velocity and COD velocity were not correlated ($r=-0.21$; $p>0.05$) but the former was largely associated with CODD ($r=0.78$; $p<0.05$). Large inverse relationships were observed between 505 velocity and COD-derived variables (CODD: $r=-0.77$; $p<0.05$ and DD: $r=-0.79$; $p<0.05$). Finally, a large relationship was observed between CODD and DD ($r=0.79$; $p<0.05$).
CONCLUSION: The findings indicated that, in this specialized sample, athletes with superior linear sprint velocities were not necessarily faster when completing the 505 task (highlighting the specificity of these physical capabilities). Nevertheless, faster players in linear sprinting actions tended to display superior CODD, which suggests that they were less efficient at changing direction (1). The strong negative correlations between 505 velocity and CODD and DD support that performance in this COD maneuver is highly determined by the athletes' capacity to abruptly (and quickly) decelerate and re-accelerate. From a practical perspective, to improve female rugby sevens' players ability to perform 180º directional changes, training strategies should aim to reduce CODD and optimize their deceleration ability instead of focusing on increasing linear sprint capabilities.

1. Freitas, TT. et al. J Strength Cond Res, 35(11), 3170-3176, 2021.
2. Bishop, C. et al. J Sports Sci, 39(10), 1088-1095, 2021.
3. Loturco, I. et al. Int J Sports Sci Coach, 17479541211068827, 2022.

**PHYSICAL AND PHYSIOLOGICAL PROFILE OF PROFESSIONAL FEMALE HANDBALL PLAYERS**

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INTRODUCTION: Physical profile of professional female handball (HB) team can help coaches and physical trainer to adapt and individualize physical training. Profile knowledges allow to know which fitness qualities are required for a high level of practice. Power, aerobic fitness, strength and an optimal body composition are required in a goal of success in different competition (1,2). To our knowledges, no study in professional female HB has investigated physical and physiological collective and individual profile of players. Therefore, the purpose of this study was (i) to describe collective and individual profile of a professional female HB and (ii) to compare the front line (FL) players composed by wings and pivots, and the rear line (RL) players composed by backs.
METHODS: 11 female HB players (4FL and 7RL), belonging to the French professional League 1 were recruited for the study. Mean values (±SE) of age, height, body mass, fat mass, and lean body mass were respectively 24.5 ±1.3 years, 178.2 ±2.5 cm, 70.5 ±2.2 kg, 20.6 ±0.9 % and 56.0 ±1.3 kg. Datas were monitored in the first week of the pre-season period. Power and strength were monitored on lower body with the iphone application (Apple Inc, USA) Myjump and a strength knee isokinetic test using the Con-trex machine (Medimex, Con-trex Multi-Joint MJ, Ste Foy-les-lyon, France). We assessed height (cm), power (W), strength (N) and speed (m/s) for Counter Movement Jump (CMJ) and Squat Jump (SJ). Isokinetic test has collected absolute and relative peak torque (PT and PT/kg) , peak power (PP) for quadriceps (Q) and hamstrings (H) , and H:Q ratios, using angular velocity of 240°/s (concentric Q and H), 90°/s (concentric Q and H) and 30°/s (eccentric H). Aerobic profile was monitored with the Vameval outside test and the 30-15ift. VO2max was estimated with the Vameval result (3.5 x velocity of the full last step). Anthropometrics datas were assessed by the Geonaute Scale 300 (Decathlon. France) for body mass. Percentage of fat mass was estimated from 4 skinfolds thicknesses technical (Harpenden Skinfold Caliper).
RESULTS: Our results show no significantly difference between FL and RL for absolute and relative PT, PP, Conventional and Functional ratios. Bilateral Force Deficit of FL was higher ($P<0.01$) than RL for H at 90°/s (FL: 20.6±4.1 ; RL: 4.7±1.8). No significant results for anthropometric and aerobic datas are shown between FL and RL players. Concerning jumps tests, power is higher ($P<0.05$) for FL on CMJ and SJ than RL (CMJ datas; FL: 2098.1±30.7W; RL: 1812.3±86.9W ; SJ datas ; FL: 2033.7±20.9W ; RL: 1722.0±93.5W). Strength is significantly higher ($P<0.05$) for FL players than RL players on CMJ (FL: 1560.5±45.8N ; RL: 1374.7±51.4N).
CONCLUSION: A better knowledge about the physical profil of female HB players may improve quality of individual training. Players in the same position can have a different physical profil which means that coaches and physical coaches have to adapt work on individual needs and not only according position.

**THE ANTHROPOMETRIC AND PHYSICAL QUALITIES OF FEMALE INTERPROVINCIAL RUGBY UNION PLAYERS**

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INTRODUCTION: Anthropometric and physical testing provides practitioners with valuable information on normative values for a particular cohort, individual characteristics and group trends (Jones et al. 2016). This information can assist with team selection, identifying areas for development, aid in more precise planning of training/physical preparation and dietary goals for athletes (Agar-Newman et al. 2017; Harty et al. 2019). To date, no study has investigated the anthropometric and physical qualities of female interprovincial rugby union (RU) players.
METHODS: Forty-one interprovincial female RU players (n = 41) from two teams playing in the interprovincial series 2019 volunteered to participate in this study. Each participant underwent anthropometric testing; height, body mass and skinfold assessment and physical characteristics tests; counter movement jump height, speed (5m, 10m and 20m), isometric strength levels and Yo-Yo intermittent recovery test level 1. Players were classified into forwards and backs and positional subcategory groups; front row (FR), second row (SR), back row (BR), half-back (HB), midfield (MF) and back three (B3). An independent t-test was conducted to examine any differences in anthropometric and physical qualities as a consequence of playing position (forward v back). A multivariate analysis of variance was conducted to examine differences in anthropometric profiles and physical qualities between positional category group.
RESULTS: Forwards displayed greater height ($p = 0.000$; $d = 1.47$), body mass ($p = 0.00$; $d = 1.56$), greater total of seven ($p = 0.001$; $d = 1.23$) and eight skinfolds ($p = 0.001$; $d = 1.17$) and a higher percentage of body fat ($p = 0.001$; $d = 1.25$) than backs. Backs were quicker for 10m sprint time than forwards ($p = 0.049$; $d = 0.70$). Further analysis into position groups illustrated differences for both anthropometric and physical qualities. The FR displayed the greatest levels of body mass ($p = 0.004$), with the SR recording the greatest height ($p = 0.041$). The FR reported the highest levels of sum of 7 skinfolds ($p = 0.021$), the greatest levels of sum of 8 skinfolds ($p = 0.024$) and the highest percentage of body fat % ($p = 0.017$). The B3 recorded the quickest 10m and 20m time ($p = 0.004$ and $p = 0.000$, respectively). For strength levels, the FR and BR recorded the greatest peak force ($p = 0.018$ and $p = 0.002$, respectively).
CONCLUSION: This study supports the concept that there are anthropometric and physical characteristic differences between forwards and backs and positional subcategory groups. The results of this study provides normative data for coaches and practitioners who are involved in the planning and preparation of female interprovincial RU players. This study will aid in creating physical profiles of forwards and backs and positional category groups, which has not been investigated to date.
Agar-Newman. et al (2017)
Harty et al. (2019)
Jones et al. (2016)

**ENERGY AVAILABILITY IN ELITE FEMALE AUSTRALIAN FOOTBALL PLAYERS**

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INTRODUCTION: Energy demands of the Australian Football League-Women's (AFLW) competition, combined with limited investment in nutrition support, may result in issues regarding energy availability (EA). There is little published data on EA in female team-sport athletes, with most research focusing on the risk of low energy availability (LEA), as inferred from subjective questionnaires likely due to the difficulty in quantifying energy expenditure (EE). The aims of this study were to quantify EA in AFLW players while contrasting outcomes against validated questionnaires and to investigate associations between dietary intake, EE and EA in AFLW players.
METHODS: Over 10 consecutive days during pre-season (including four training days), EI and EE were collected in 14 elite AFLW players. Weighed food diaries were recorded using the smartphone application Easy Diet Diary (Xyris Software, Australia). Exercise EE was quanti-

fied using individual algorithms, developed from accelerometer data (PlayerloadTM, Catapult Innovations, Scoresby Australia) and oxygen uptake during a maximal aerobic capacity test. PlayerloadTM data was collected during field training and the algorithm used to estimate EE. The SenseWearTM Armband was used to determine EE outside of field training. Fat-free mass (FFM) was measured via Dual Energy X-ray Absorptiometry (DXA, Hologic, QDR) and resting metabolic rate was measured via indirect calorimetry (Cosmed Quark, Italy), EA was calculated on training and non-training days, with LEA ≤30cal/kg FFM. The low energy availability in female's questionnaire (LEAF-Q) was administered to determine the risk of LEA. Generalized linear models were used to estimate the effect of dietary intake and EE on EA.
RESULTS: There was no difference in EA between training [44.3(14.0) cal/kg of FFM] and non-training [14(12.8) cal/kg of FFM] days. EI, carbohydrate (CHO) and protein intake were higher on training vs non-training days ($p<0.001$). Total daily CHO, protein and fat intake were associated with EA on both training ($\beta=0.070$, $\beta=0.077$, $\beta=0.133$, $p<0.001$, respectively) and non-training ($\beta=0.080$, $\beta=0.064$, $\beta=0.153$ $p<0.001$, respectively) days. There was an association between total daily EE and EA on non-training days ($\beta=-0.001$, $p=0.019$). On training days, 1/14 (14.3%) players were classified as LEA and on non-training days 2/14 (7.1%) of players were classified as LEA. The LEAF-Q classified 5/14 (35%) of players as at risk of LEA.
CONCLUSION: This is the first study to investigate EA using objective measures in female team-sport athletes. Irrespective of training, EA remained stable, whilst dietary intake differed, likely a result of the varying EE. The identification of AFLW players 'at risk' of LEA via LEAF-Q was higher compared to objective measures indicating that the LEAF-Q, validated in endurance athletes, may over-represent LEA in team sport athletes. To accurately assess EA in female team-sport athletes, a validated method to measure exercise EE and tool to assess the risk of LEA is required.

## Invited symposia

### IS-MH02 Lifestyle psychiatry: the potential of physical exercise and other healthy habits for severe mental disorders

#### AN ONLINE MENTAL HEALTH INFORMED PHYSICAL ACTIVITY INTERVENTION FOR EMERGENCY SERVICE WORKERS AND THEIR FAMILIES: A STEPPED-WEDGE TRIAL

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Background: Emergency service workers are at an increased risk of experiencing poor mental health including posttraumatic stress disorder due to prolonged, repeated exposure to potentially traumatic events. Promoting healthy lifestyle behaviours including physical activity and diet may help to mitigate some the consequences of emergency service work. This study aimed to evaluate the impact of an online physical activity and diet intervention on levels of psychological distress among emergency service workers and their nominated support partner e.g., spouse, family member.
METHODS: We delivered a 10-week intervention via a private Facebook group facilitated by exercise physiologists, a dietitian and peer-facilitators. Weekly modules on topics including overcoming barriers to exercise, reducing sedentary time, self-monitoring of activity and nutrition were delivered. Weekly group telehealth calls were conducted and participants were provided with a physical activity tracking device (Fitbit). A stepped-wedge design was applied to compare levels of psychological distress (Kessler-6) during baseline, to intervention by comparing slopes of change. Separate slopes were modelled for a) baseline; b) intervention slope 1; c) intervention slope 2; d) change in level of knot points. Secondary outcomes included a pre-post assessment of mental health symptoms, physical activity levels, quality of life, sleep quality and suicidal ideation.
Results: In total, N=90 participants (n=47 emergency service workers and n=43 support partners) were recruited in 4 separate cohorts (mean age 42.3(SD=11.5) years, 51% male). Levels of psychological distress did not change significantly during the baseline (control) slope, while during the first 6 weeks of intervention (intervention slope 1) levels reduced significantly. The interaction between baseline and intervention slopes were significant, $b=-0.351$, $p = 0.003$, (i.e., the trajectories of change were significantly different) and improvements plateaued until the 4-week follow up (intervention slope 2). Retention was high (92%) and participation was associated with improvements in mental health symptoms, weekly minutes of physical activity, sedentary time and quality of life.
Conclusions: A 10-week physical activity intervention delivered via social media is feasible and effective in improving psychological distress among emergency service workers and their support partners.

#### IMPLEMENTING AN EXERCISE PHYSIOLOGY CLINIC FOR CONSUMERS WITHIN A COMMUNITY MENTAL HEALTH SERVICE: A REAL-WORLD EVALUATION

MORELL, R.

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Background: Physical activity significantly improves mental illness symptoms and physical health for people living with mental illness. Mental health services do not routinely provide their consumers with access to exercise professionals for physical activity engagement. Barriers exist to integrating physical activity as part of standard care including staff culture, finance, and resources. This study examines the feasibility of newly established exercise physiology clinic within a mental health service in Sydney, Australia.
METHODS: A single site, open trial was conducted in a community centre within a large mental health district. A meeting room was converted into a part-time exercise physiology clinic where individualised physical activity interventions were delivered by an accredited exercise physiologist. Outcome measures including BMI, cardiovascular fitness, and self-reported physical activity were collected.
Results: A total of 84 mental health consumers (17% of eligible consumers within the mental health service) participated in the clinic on average for one exercise session weekly. Moderate-to-vigorous physical activity significantly increased and sedentary time significantly decreased ($p < 0.001$).
Conclusions: Exercise physiology clinics are feasible within mental health services and should be incorporated as part of standard care.

**PHYSICAL ACTIVITY, SEDENTARY LIFESTYLE AND SLEEP, KEY FACTORS IN THE HEALTH AND WELL-BEING OF PEOPLE WITH SEVERE MENTAL DISORDERS**

BUENO-ANTEQUERA, J.

*UNIVERSIDAD PABLO DE OLAVIDE*

Psychiatric disorders, such as schizophrenia, major depression and bipolar disorder, are among the leading causes of all-cause death, and disability worldwide. The global economic burden of psychiatric disorders in 2010 was similar to that of cardiovascular diseases and higher than that of cancer, chronic respiratory diseases and diabetes and expected to more than double by 2030. Therefore, reducing the growing burden of psychiatric disorders is a global health priority.
To try to close this gap, exercise physiologists from the Universidad Pablo de Olavide promotes a line of research (called PsychiActive) and another for the transfer of knowledge to society (called PowerONyou) to help people with psychiatric disorders to improve their health-related quality of life through physical exercise and other healthy habits.
This talk summarizes two outstanding scientific contributions derived from the PsychiActive project, in detail, (1) the effects of a 18-month lifestyle changes, primarily increasing time engaged in physical activity and eating healthier, improved cardiovascular health and fitness, and reduced sedentary behaviour, body weight, severity of psychiatric symptoms and mediation use in a woman with bipolar disorder and (2) the effects of a 12-week group-based intervention of supervised aerobic and strength exercise training that was safe, feasible, and effective for improving cardiorespiratory fitness, muscular strength, and anthropometric parameters in psychiatric men inmates. Additionally, this talk will present recent results on scientific studies that addressed the changes related to physical activity, sedentary lifestyle and daily sleep in people with psychiatric disorders, applying a statistical technique called analysis of compositional data and the evolution towards the PowerONyou project.
In conclusion, the work carried out highlights the usefulness of physical activity, sedentary lifestyle and sleep to promote the health and well-being of people with severe mental disorder and the need to invest efforts in the transfer of knowledge to get the scientific message to society.

## Oral presentations

### OP-SH03 Learning in PE I

**CHALLENGE-BASED LEARNING INTERVENTION IN PHYSICAL ACTIVITY AND SPORT SCIENCES DEGREE FROM A GENDER PERSPECTIVE**

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Introduction
Challenge-Based Learning (CBL) is an innovative learning methodology that consists of posing a challenge as the main didactic element (Nichols et al., 2016). This methodology has been addressed in different disciplines, although few studies have been carried out in physical activity-related educational (PAE) contexts. However, not only its implementation seems to be a challenge, but also the integration of the Information and Communication Technologies (ICT). A recent proposal in PAE context have been recently developed (Franco et al., 2020). The objectives of the present study were (I) to analyse the effect of implementing this methodology on university students learning outcomes; and to analyse differences in the impact of the intervention by gender.
Methods
The sample consisted of 94 students (71 male and 23 female) studying Physical Activity and Sport Sciences degree (M= 20.04 and SD = 1.74) between year one and year four. The intervention was implemented over 14 weeks. A pre-post questionnaire was administered, with a sample of 105 responses. Mann-Whitney and Wilcoxon tests were performed with each group.
Results
After the experience, significant differences were found between groups in CBL knowledge (M=-1,26 y DT =-1,52), ability to develop proposals with CBL (M=-1,35 y DT =1,44) and innovative proposals (M= -1,06 y DT =-1,42), and ability to use ICT (M=-1,20 y DT = 1,44). When deepening in gender differences, no influence was found.
Discussion
The results of the experimental group showed higher scores after the CBL intervention in all variables. It seems that experiential learning can promote teachers' self-efficacy in the implementation of such a methodology. When teachers perceive self-efficacy, they are likely to use creative teaching, for example, by implementing innovative methodologies or ICT. Finally, no significant differences were found according to gender. Although there is evidence that perceived experiences in PAE contexts differ according to gender, the present study did not found differences between women and men, fact that posits CBL as an excellent alternative regardless of teachers' gender.
References
Franco, E., Martínez-Majolero, V., Almena, A., & Trucharte, P. (2020). Efectos de una experiencia de aprendizaje basado en retos para la enseñanza deportiva en alumnos universitarios. In J. J. Gázquez, M. M. Molero, A. AMartos, A. B. Barragán, M. M. Simón, M. Sisto, R. M. Del Pino, & B. M. Tortosa (Eds.), Investigación en el ámbito escolar. Nuevas realidades en un acercamiento muldimensional a las variables psicológicas y educativas (pp. 399-414). Dykinson.
Nichols, M., Cator, K., & Torres, M. (2016): Challenge Based Learner User Guide.
Redwood City, CA: Digital Promis

**MANIPULATING CONSTRAINTS TO LEARN VOLLEYBALL SKILLS WITH NOVICES: ANALYSIS OF A REAL SITUATION**

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INTRODUCTION

Sport skills acquisition requires an effective interaction with the environment. Constraints-Led Approach (CLA) suggests that constraints shape the emergence of coordinated action through self-organisation processes [1]. In this study, we implemented a Volleyball Unit following the Integrated Technique-Tactical Model [2] in regular lessons of a Physical Education (PE) program. Following CLA, practice was designed to afford certain specific actions highlighting its functional key elements [3]. The aim of this study was to investigate the effects of three task constraints manipulation in the learning of overhand and underhand pass in volleyball with novices, considering two different skill levels of mastery: emergence/exploration and refinement [4].
METHODS
Forty-eight subjects (26F; 10-11Y) with no prior experience in volleyball, divided into two natural school classes (C1 & C2), performed 6 PE lessons (50') aimed at the learning of basic technique and tactic elements. During practice, task constraints (serve direction and trajectory, and pass precision required) were altered to provoke the emergence and refinement of functional movement patterns. An adaptation of Game Performance Assessment Instrument [5] was used to assess learning through collection of effective or ineffective executions (E_EX & I_EX respectively). Assessment task (3 vs 3 match) was conducted and recorded in sessions 1, 4 and 6. Two-way RM ANOVAs and Bonferroni post-hoc tests were performed to analyse the intervention effects. Significance was set at $P<0.05$. A qualitative analysis was used to determine the parameters varied within each constraint, their effects on the subject, and if they were directed to the skill emergence or refinement.
RESULTS
The overall results displayed an increase in E_EX and I_EX at the end of the unit in C1 and C2. C1 showed significant increases in E_EX between baseline and intermediate assessment ($p<0.05$) and final assessment ($p<0.05$). C2 significantly increased E_EX and I_EX between baseline and intermediate assessment ($p<0.05$) and E_EX between baseline and final assessment ($p<0.05$). The qualitative analysis revealed three key parameters modified: a) serve ball initial and final position, b) performer initial position, c) level of precision required in the pass. They affected mainly the impact spot, orientation and intention of the subject. Tasks aiming technique emergence presented different parameter variations than tasks aiming skill refinement.
CONCLUSIONS
The findings of this study suggest that a unit of intervention implementing constraints manipulation was effective to promote learning of the overarm and underarm volleyball skills with novices. The qualitative results show that constraints were shaped differently depending on whether the goal was to provoke the emergence of the movement pattern or to refine it.
1. Davids et al. (2008) 2. López-Ros & Castejón (2005) 3. Orth et al. (2019) 4. Newell (1985) 5. Oslin et al. (1998)

**INCIDENTAL TEACHING STRATEGIES FOR LEARNING BASKETBALL THROUGH SMALL-SIDED GAMES**

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*CENTRO UNIVERSITARIO SAN ISIDORO*

INTRODUCTION: Introduction
In recent years there has been an increasing number of studies that have tried to find out whether incidental teaching strategies favor learning and performance more than deliberate strategies in team sports-related skills, or if not, whether they produce the same benefits. Many studies conclude that in this type of sports, such as basketball, characterized by high uncertainty, time limits and high stress, incidental or intuitive strategies reduce the possibility of performance degradation under pressure, as the amount of conscious information processed by the brain (cognitive load) decreases, thus freeing resources for other important processes, such as decision making. Reduced games seem to be an ideal learning environment where players can develop both types of processing, those that allow a more deliberate thinking, when there is time to think, and those that activate other more intuitive or incidental processing, when there is no time to think, as they represent an approximation to the real game that allows players to regulate their performance according to each of the specific situations they face and must solve. The aim of the present study is to analyze whether the manipulation of practice conditions in reduced game situations in basketball without the explicit external intervention of the coach can provoke learning in the players and reduce the possibilities of performance degradation under pressure conditions.
METHODS: Methods
An intrasubject design with repeated measures pretest and posttest was elaborated on a reduced situation of collective 3x3 basketball game with temporal and functional limitation (number of bounces). Twelve participants belonging to a male basketball team aged 15-16 years (M=15.32; ±1.26) with more than 5 years of basketball practice participated. Four groups were randomized: incidental group, incidental control group, explicit group and explicit control group.
RESULTS: Results
The incidental group showed the same performance as the explicit and control group when time was not limited. On the other hand, it showed higher performance when the time to perform the actions was shorter. In addition, the incidental group showed a progressive reduction in the use of the pot and an increase in its efficiency under time limit conditions, thus showing an improvement in the use of this skill, and therefore a better learning.
CONCLUSION: Discussion & Conclusion
In general, we can affirm that reduced game situations in basketball represent an effective learning environment for the use of incidental teaching strategies, as they reduce the possibility of degradation of the players performance in conditions of increased pressure, and can also favor the achievement of learning of different specific skills in a real environment, with the advantages that this entails.

# Oral presentations

## OP-MH03 Physical activity promotion

### MODERATING EFFECTS OF AGE AND INDIVIDUALIZATION ON MHEALTH INTERVENTIONS TO REDUCE PHYSICAL INACTIVITY AND SEDENTARY BEHAVIOR IN CHILDREN AND ADOLESCENTS

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INTRODUCTION: Children and adolescents increasingly do not meet physical activity (PA) recommendations. Hence, insufficient physical activity (IPA) and sedentary behavior (SB) among children and adolescents are relevant behavior change domains for using individualized mobile health (mHealth) interventions. The current review and meta-analysis investigates the effectiveness of mHealth interventions on IPA and SB with a special focus on age level of individualization.
METHODS: . The Review was preregistered on PROSPERO International Prospective Register of Systematic Reviews (CRD42020209417). PubMed, Scopus, Web of Science, SPORTDiscus, and Cochrane Library were searched for randomized controlled trials published between January 2000 and March 2021. mHealth interventions for primary prevention in children and adolescents addressing behavior change regarding IPA and SB were included. Included studies were compared for content characteristics as well as methodological quality and summarized narratively. In addition, a meta-analysis with a subsequent exploratory meta-regression examining the moderating effects of age and individualization on overall effectiveness was performed.
RESULTS: Based on inclusion criteria, 11 of the preliminary 825 identified studies were included for qualitative synthesis and 10 were included for the meta-analysis. Trials included a total of 1515 participants (Age (M, SD) = 11.69 ± 0.788; 65% male; 35% female) with self-reported (n = 4) or device-based measured (n = 7) health data on the duration of SB and IPA for an average of 9.3±5.6 weeks. Studies with high levels of individualization decreased insufficient PA levels significantly (d = 0.33; CI = 0.08, 0.58; z = 2.55; p = 0.01), whereas those with low levels of individualization (d = -0.06; CI = -0.32, 0.20; Z = 0.48; p = 0.63), or targeting SB (d = -0.11; CI = -0.01, 0.23; z = 1.73; p = 0.08) indicated no overall significant effect. Heterogeneity of the studies was moderate to low, and significant subgroup differences between trials with high and low levels of individualization ($\chi 2 = 4.04$; df = 1; p = 0.04; $I^2 = 75{,}2\%$) were found. Age as a moderator variable showed a small effect, but the results were not significant which might have been due to being underpowered.
CONCLUSION: Evidence suggests that mHealth interventions for children and adolescents can foster moderate reductions in IPA but not SB. Moreover, individualized mHealth interventions to reduce IPA seem more effective for adolescents than for children. Although to date only a few mHealth studies address inactive and sedentary young people and their quality of evidence is moderate, these findings indicate the relevance of individualization on the one hand and the difficulties in reducing SB using mHealth interventions on the other hand.

### EVALUATION OF THE FEASIBILITY, PSYCHOSOCIAL EFFECTS, INFLUENCE AND PERCEPTION OF ELASTIC BAND RESISTANCE BALANCE TRAINING IN OLDER ADULTS.

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INTRODUCTION: Physical activity (PA) interventions improve balance, strength and coordination, positively contributing to independence and quality of life reducing the risk of falls in older adults (OA). However, PA interventions often consider efficacy as the primary outcome measure, whilst failing to integrate older adults into the co-design and co-production to ensure internal validity and improve participant enjoyment, satisfaction and adherence [1]. Therefore, the aim of this study was to develop and justify a novel PA intervention using different elastic band exercise techniques attached to the hip or chest to challenge balance using qualitative variables (feedback/opinion and perceptions) to create a practically feasible, accessible and cost-effective intervention specifically designed for OA to reduce the risk of falls.
METHODS: Twenty-three active participants (age = 66.5 ± 8.3 y, height = 1.6 ± 0.1 m, mass = 83.2 ± 14.9 kg) volunteered for the study. The participants completed 8 exercises (8-12 repetitions) using elastic bands designed to challenge postural stability in two conditions (HIP and CHEST) by providing lateral resistance and instability. Conditions were performed 15 min apart in a randomised counterbalanced order. Heart rate (HR) and rate of perceived exertion (RPE) were measured throughout with an interview conducted after to investigate the preferences, comfort and difficulty of the exercises performed. Template analysis was conducted to examine participant feedback with two-way repeated measures ANOVAs used for quantitative data with statistical significance set at $P < 0.05$.
RESULTS: Similar significant increases in HR (baseline 83-85 bpm; mid 85-88 bpm; post 88-89 bpm) and RPE (baseline 8-9; mid 10; post 10-11) occurred during the HIP and CHEST conditions. Interviews revealed that participants thought the interventions challenged balance and they perceived the exercises to be beneficial for stability and balance, confirming that the exercises were suitable for themselves and others. Participants' reported a positive experience and confirmed they would perform the exercises again, preferably in a group with the band placed at either the hip or chest region due to individual preference and comfort.
CONCLUSION: Participants reported key preferences contributing to the design of a PA intervention using elastic bands confirming the use of these exercises as a feasible, accessible and appropriate PA intervention set at low-to-moderate intensity for OA These qualitative variables will inform intervention design and delivery in future studies with the potential to improve balance and stability in OA with further research required to confirm its efficacy for altering balance and sway patterns.
References
[1]. Boulton, E. R., Horne, M., & Todd, C. (2018). Multiple influences on participating in physical activity in older age: Developing a social ecological approach. Health Expectations, 21(1), 239-248.

### HIGH INTENSITY INTERVAL TRAINING IN SCHOOLS: METHODS FOR QUANTIFYING INTENSITY AND THE VALIDITY OF SESSION RATING OF PERCEIVED EXERTION

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INTRODUCTION: Few studies report the exercise intensity of high intensity interval training (HIIT) interventions in schools. When reported, heart rate (HR) is the most common measure, but the methods for quantification have not been consistent. Further, due to the setting, it will be important to understand the utility of quick, lost-cost measures when HR is not feasible. The aims of this study were to: 1) investigate the different methods used to quantify intensity via HR in school-based HIIT research and 2) assess the criterion validity of session rating of perceived exertion (sRPE) for quantifying the training load of school-based HIIT workouts.
METHODS: Ten-minute HIIT workouts were completed in 6 classes at 2 schools during health and physical education lessons for 8 weeks. HR (via Polar 10 monitors) and sRPE (via Children's Omnibus RPE scale) data were collected on average once per week during and immediately after HIIT workouts, respectively.
The following aspects were examined: 1) mean average and peak HR for all students and sessions combined; 2) percentage of time spent in various deciles (>80%, and >90% HRmax); 3) percentage of students with an average HR >80% and >90% HRmax; 4) variability within and between students; and 5) mean sRPE for all students and sessions combined. To assess criterion validity of session-RPE, a training impulse (TRIMP) for HR was calculated using the Edwards' method. To calculate sRPE (in arbitrary units), student's RPE was multiplied by the total duration (seconds) of the workout.
Means, standard deviations and frequencies were determined for HR and RPE quantification methods. Variability within and between students was examined using linear mixed models. Within-participant correlation (r) between TRIMP and session-RPE was calculated for validity of RPE.
RESULTS: In total, 761 measurements were collected from 132 students ($\bar{x}$ age 13.2 ± 0.6 years; 17 females) across 47 HIIT sessions. Mean average and peak HR were 79% ± 7% of HRmax and 92% ± 6% of HRmax, respectively. Students spent 38% ± 21% of time with a HR between 80-89% and 14% ± 20% of time with a HR of >90%. The mean percentage of students within a class with an average HR >80% was 53% ± 22%. The within person variation was 14.8 % points of HRmax for peak HR with a decrease of 0.42% per week ($p < 0.001$). Mean sRPE across all students and sessions was 5.9 ± 2.4 points. The within-person correlation between sRPE and TRIMP was 0.46 ($p < 0.001$).
CONCLUSION: Reporting intensity is necessary for understanding if the intervention was implemented as intended. Further, it is useful to report more than one outcome to showcase the variability in the data: across participants; throughout the session; and across the intervention timeline. Further work is needed to confirm our findings on the relationship between HR and RPE in a large, generalisable population of students, but results suggest the utility of using sRPE when HR is not a viable option.

### REPLACING SITTING WITH LIGHT-INTENSITY PHYSICAL ACTIVITY THROUGHOUT THE DAY VERSUS 1 BOUT OF VIGOROUS-INTENSITY EXERCISE: SIMILAR CARDIOMETABOLIC HEALTH EFFECTS IN MS

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*HASSELT UNIVERSITY*

INTRODUCTION: Persons with Multiple Sclerosis (PwMS) are physically inactive and spend more time in sedentary behaviours than healthy persons. Reduced physical activity increases the risk of developing cardiometabolic diseases. In this proof-of-concept study, the cardiometabolic health effects of replacing sitting with light-intensity physical activity (LIPA) and exercise (EX) were investigated.
METHODS: In a randomised crossover study, 28 mildly disabled PwMS performed four 4-day activity regimens in free-living conditions: (1) CONTROL: 9.7h sitting/day, (2) SIT: 13.3h sitting/day, (3) LIPA: 8.3h sitting, 4.7h standing and 2.7h self-perceived light-intensity walking/day and (4) EX: 11.6h sitting/day with 1.3h vigorous-intensity cycling. During LIPA and EX, perceived exertion was monitored daily. On day 5, following each regimen, plasma glucose and insulin during a 2-hour oral glucose tolerance test, plasma lipids, inflammation, resting heart rate, blood pressure and body weight were measured.
RESULTS: Compared to SIT, significant improvements ($p<0.001$) after LIPA and EX were found for insulin total area under the curve (-17019±5708 and -23303±7953pmol/L*min), insulin sensitivity (Matsuda index +1.8±0.3 and +1.9±0.4) and blood lipids (triglycerides: -0.4±0.1 and -0.5±0.1mmol/L; non-high density lipoprotein cholesterol: -0.3±0.1 and -0.5±0.1mmol/L), with no difference between LIPA and EX. Triglycerides were also lower after LIPA compared to CONTROL (-0.4±0.1mmol/L, $p=0.011$). Heart rate was lower after LIPA compared to SIT (-3±1bpm, $p=0.05$) and diastolic blood pressure after EX compared to SIT and LIPA (-5±1 and -4±1mm Hg, $p=0.044$). Perceived exertion was higher after EX compared to LIPA (Borg scale [6-20]: +2.6±3.3, $p=0.002$).
CONCLUSION: Replacing sitting with LIPA throughout the day is more feasible and exerts similar cardiometabolic health effects as one daily bout of vigorous-intensity exercise in PwMS.

### THE EFFECT OF DOMAIN-SPECIFIC EXERCISE INTENSITY PRESCRIPTION ON MAXIMAL AEROBIC CAPACITY IN YOUNG HEALTHY INDIVIDUALS: A RANDOMIZED CONTROLLED TRIAL

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INTRODUCTION: Exercise intensity is a key-factor modulating the magnitude of health- and performance-related improvements in response to exercise training. Despite this, the true contribution of exercise intensity to these changes remains elusive. This is because current exercise prescription methods, such as those based on percentage of maximal oxygen uptake (VO2max) or its surrogates (e.g., maximal heart rate), ignore differences in the position of individual-specific intensity thresholds (i.e., the exercise intensity domain schema) and consequently do not ensure a homogenous metabolic stimulus across individuals. Thus, this study assessed the effect of exercise intensity through individualized, domain-based exercise prescription on changes in VO2max. We hypothesized that domain-specific prescription, matched for total work, would elicit distinct improvements in VO2max that are proportional to the level of exercise intensity.
METHODS: Eighty-four young healthy participants (42 F, 42 M) were randomly assigned to six different groups (5 exercise, 1 control (CT); 14 participants per group). The exercise interventions consisted of three continuous cycling groups in the 1) moderate (MOD)-, 2) lower heavy (HVY1)-, and 3) upper heavy intensity (HVY2)- domain and two interval cycling groups including 4) high-intensity interval training (HIIT) in the severe-intensity domain and 5) sprint-interval training (SIT) in the extreme-intensity domain. All training groups, except SIT, were work-matched. Training participants completed three training sessions per week for six weeks with physiological evaluations performed before (PRE) and after (POST) intervention.

RESULTS: At PRE, there were no significant differences in relative (p=0.866) VO2max between groups. All training groups, except for MOD (+1.8 ± 2.7 ml/kg/min), had a significant increase in VO2max at POST compared to CT (+0.1 ± 1.2 ml/kg/min). HIIT demonstrated the highest increase in VO2max (+6.2 ± 2.8 ml/kg/min) followed by HVY2 (+5.4 ± 2.3 ml/kg/min), SIT (+4.7 ± 2.3 ml/kg/min) and HVY1 (+3.3 ± 2.4 ml/kg/min). The VO2max increases observed in HVY2, HIIT and SIT were all greater than MOD (p<0.05) while HIIT was significantly greater than HVY1 (p<0.05).
CONCLUSION: These results demonstrate that work-matched exercise training at well-defined exercise intensities elicit distinct improvements in VO2max. Specifically, the magnitude of these changes was greater with exercise intensities from the lower heavy- to the extreme-intensity domain when compared to that observed in the moderate-intensity domain and the control condition. Therefore, this study exemplifies the importance of exercise intensity for improving maximal aerobic capacity and supports the implementation of individualized, domain-based exercise intensity prescription to accurately deliver the desired metabolic stimulus and its associated adaptations across individuals.

## 13:45 - 15:00

## Oral presentations

### OP-PN01 Amino acids and proteins

#### COLLAGEN PEPTIDE SUPPLEMENTATION DURING RESISTANCE EXERCISE TRAINING DOES NOT INCREASE MYOFIBRILLAR AND MUSCLE CONNECTIVE TISSUE PROTEIN SYNTHESIS RATES

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INTRODUCTION: Exercise has been reported to increase myofibrillar and muscle connective protein synthesis rates. Protein ingestion during recovery from exercise further increases myofibrillar protein synthesis rates and is typically applied by athletes to support the skeletal muscle adaptive response to prolonged resistance exercise training. The post-exercise increase in muscle connective tissue protein synthesis rates does not seem to be modulated by post-exercise protein ingestion. However, the latter may be attributed to the type of protein consumed. Due to the greater glycine and proline content of connective tissue, it has been hypothesized that collagen peptide ingestion may be (more) effective in stimulating muscle connective tissue protein synthesis rates. The present study assessed the impact of daily collagen peptide ingestion on myofibrillar and muscle connective tissue protein synthesis rates during one week of resistance exercise training.
METHODS: A double-blind parallel group design was used. Twenty-five male recreational athletes (24±3 y, 1.82±0.05 m, 76.9±6.4 kg) were selected to perform one week of resistance type exercise training (daily whole-body resistance exercises, drop jumps, and rope skipping) with (COL) and without (PLA) collagen peptide supplementation. Subjects were randomly assigned into a group receiving 15 g collagen peptides or a non-caloric placebo twice daily. Deuterium labeled water was applied throughout the intervention, with blood and muscle biopsies collected prior to and after the training period to assess both myofibrillar and muscle connective tissue protein synthesis rates. Welch´s t-test for independent groups was used to compare protein synthesis rates and a 2-way ANOVA was used to compare plasma amino acid profiles concentrations, daily food intake, and trainings loads between the groups.
RESULTS: Myofibrillar and muscle connective tissue protein synthesis rates averaged 1.34±0.19 and 1.97±0.47 %/d (COL) and 1.34±0.27 and 2.00±0.27 %d (PLA), respectively, with no differences between treatments. Muscle connective tissue protein synthesis rates were higher than myofibrillar protein synthesis rates (1.99±0.38 vs 1.34±0.23 %/d, respectively; p<0.001). No differences were observed in food intake and training load between treatments.
CONCLUSION: Muscle connective protein synthesis rates are higher than myofibrillar protein synthesis rates during one week of intense resistance exercise training in male recreational athletes. Collagen peptide supplementation (15 g twice daily) does not further increase myofibrillar or muscle connective protein synthesis rates during one week of intense resistance exercise training.

#### QUARK INGESTION INCREASES MUSCLE PROTEIN SYNTHESIS RATES AT REST AND DURING RECOVERY FROM EXERCISE IN HEALTHY, YOUNG AND OLDER MALES.

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*1. MAASTRICHT UNIVERSITY; 2. FRIESLANDCAMPINA*

INTRODUCTION: Ingestion of protein concentrates and isolates increases muscle protein synthesis rates, with exercise further augmenting the anabolic response to feeding. However, far less information is available on the muscle protein synthetic response following ingestion of (dairy) wholefoods. Our objective was to assess the impact of ingesting 30 g protein provided as quark on in vivo muscle protein synthesis rates at rest and during recovery from exercise in both young and older males.
METHODS: In this parallel-group intervention trial, fourteen healthy, young (24±5 y; BMI 24.0±3.5 kg/m2) and fifteen healthy, older (73±3 y; BMI 24.2±2.4 kg/m2) males ingested 291 g quark (30 g protein, 693 kJ) following a single-legged bout of resistance-type exercise on leg press (6 sets) and leg extension machines (6 sets). Primed, continuous intravenous L-[ring-13C6]-phenylalanine infusions were combined with the collection of blood and muscle tissue samples to assess both postabsorptive and 4-h postprandial muscle protein synthesis rates at rest and during recovery from exercise. Data were analyzed using repeated measures ANOVA with time and leg as within-subjects factors and age group as between-subjects factor, with an α level of 0.05, and appropriate post-hoc testing in case of significant interactions. Data represent means±SD; η2 was used for effect size.
RESULTS: Plasma leucine and total amino acid concentrations increased following quark ingestion, peaked at t= 1 h in both groups and returned to postabsorptive concentrations at t= 4 h (Time: P<0.001; η2>0.8), with no differences between groups (Time x Group: P>0.1; η2<0.1). In the rested leg, muscle protein synthesis rates increased following quark ingestion in both the young and older males from 0.030±0.011 to 0.051±0.011 %/h and from 0.036±0.011 to 0.062±0.013 %/h, respectively (Time: P<0.001). In the exercised leg, muscle

protein synthesis rates increased even further following quark ingestion in both the young and older males from 0.030±0.012 to 0.071±0.023 %/h and from 0.042±0.015 to 0.078±0.019 %/h, respectively (Time: P<0.001; Time x Leg: P=0.003; η2>0.3). No differences in postprandial muscle protein synthesis rates were observed between age groups (all Time x Group: P>0.3; η2<0.03).
CONCLUSION: Quark ingestion increases muscle protein synthesis rates at rest and during recovery from exercise in both young and older males. The muscle protein synthetic response following fermented dairy ingestion does not differ between healthy, young and older males when ample amounts of protein (30 g) are ingested.
This collaboration project is co-funded by FrieslandCampina BV, and the PPP Allowance made available by Health-Holland, Top Sector Life Sciences & Health, to stimulate public-private partnerships.

### PRE-SLEEP PROTEIN INGESTION STIMULATES MITOCHONDRIAL PROTEIN SYNTHESIS RATES DURING POSTEXERCISE OVERNIGHT RECOVERY

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INTRODUCTION: Protein ingestion prior to sleep has been shown to stimulate myofibrillar protein synthesis rates during overnight recovery from exercise. Whether pre-sleep protein ingestion can also be applied to augment mitochondrial protein synthesis rates remains to be established. Furthermore, the impact of the type of protein to modulate overnight myofibrillar or mitochondrial protein synthesis rates has not yet been addressed.
The purpose of this study is to assess the impact of pre-sleep casein and whey protein ingestion on myofibrillar and mitochondrial protein synthesis rates during overnight recovery from a bout of endurance exercise.
METHODS: Thirty-six healthy, young men performed a single bout of endurance-type exercise in the evening (19:45 h) after a full day of dietary standardization. Thirty min prior to sleep (23:30 h), subjects ingested 45 g casein protein, 45 g whey protein, or a noncaloric placebo. Continuous intravenous L-[ring-13C6]-phenylalanine infusions were applied, with blood and muscle tissue samples being collected to assess overnight mitochondrial and myofibrillar protein synthesis rates. Overnight muscle protein synthesis rates were compared between treatments with a one-way ANOVA with a Bonferroni correction.
RESULTS: Protein ingestion resulted in higher mitochondrial (0.087±0.020 vs 0.067±0.016 %·h-1, P=0.005) and myofibrillar (0.060±0.014 vs 0.047±0.011 %·h-1, P=0.012) protein synthesis rates when compared to placebo. Casein and whey protein ingestion did not differ in their capacity to stimulate mitochondrial (0.082±0.019 vs 0.092±0.020 %·h-1, P=0.690) and myofibrillar (0.056±0.009 vs 0.064±0.018 %·h-1, P=0.440) protein synthesis rates.
CONCLUSION: Protein ingestion prior to sleep stimulates both mitochondrial and myofibrillar protein synthesis rates during overnight recovery from endurance exercise. There is no apparent difference in the capacity of pre-sleep whey or casein protein ingestion on overnight muscle protein synthesis rates.

### BONE TURNOVER FOLLOWING HIGH-IMPACT EXERCISE IS NOT MODULATED BY COLLAGEN SUPPLEMENTATION IN YOUNG MEN

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*HAN UNIVERSITY OF APPLIED SCIENCES*

INTRODUCTION: High-impact exercise can increase bone formation, although the optimal frequency of such exercise has not been established. Furthermore, it has been suggested that collagen supplementation can further augment the positive effect of high-impact exercise on bone turnover. In the present study, we assessed whether collagen supplementation augments the effects of high-impact exercise on bone turnover and whether a higher exercise frequency is accompanied by a greater impact on bone metabolism.
METHODS: In this randomized, cross-over trial, 14 healthy males (age 24±4, BMI 22.0±2.1) performed once (COL1 and PLA) or twice daily (COL2) 5-min high-impact exercise during a 3-day intervention period. One hour before every exercise bout participants ingested 20 g hydrolyzed collagen (COL1 and COL2) or a placebo control (PLA). Blood markers of bone formation (P1NP) and resorption (CTX-I) were assessed in the fasted state before the ingestion of the initial test drink and 24, 48, and 72 h following the first exercise session. In PLA and COL1, additional blood samples were collected in the postprandial state at 0, 1, 2, 3, 4, and 12 h after the first exercise session. Two-factor repeated measures ANOVA were applied to assess whether bone turnover following exercise and test drink ingestion differed between conditions. Data are presented as mean±SD.
RESULTS: Over the first 4 hours following exercise P1NP decreased marginally from 98.6±37.2 to 93.2±33.1 ng/mL in COL1, and from 96.8±32.4 to 91.7±31.3 ng/mL in PLA, although this time-effect did not reach statistical significance (P=0.053). Serum levels had returned to baseline after 12 hours (COL1: 100.7±38.3 ng/mL, PLA: 99.1±40.6 ng/mL). Moreover, no differences in P1NP concentrations between COL1 and PLA were observed in the postprandial state (time x treatment, P=0.58). CTX showed a ~50% decline (time, P<0.001) in the postprandial state in COL1 (0.9±0.3 to 0.4±0.2 ng/mL) and PLA (0.9±0.3 to 0.4±0.2 ng/mL), without differences between conditions (time x treatment, P=0.17). Interestingly, fasted P1NP concentrations increased ~8% by daily jumping exercise (time-effect, P<0.01), without differences between conditions (time x treatment, P=0.71). Fasting CTX were stable over time (time effect, P=0.41), without differences between conditions (time x treatment, P=0.58).
CONCLUSION: Short, once-daily high-impact exercise in the morning is effective in stimulating bone formation, as indicated by an increase in fasted P1NP concentrations. The exercise induced stimulation of bone formation is not further increased by collagen supplementation or by increasing exercise frequency. Bone resorption does not seem to be affected by high-impact exercise with or without collagen supplementation.

## Invited symposia

### IS-AP03 Towards optimal force plate use in sport: theoretical underpinnings and practical recommendations for training prescription and return to sport

#### FUTURE CONSIDERATIONS FOR CONTEXTUALISING FORCE PLATE TEST RESULTS IN PROFESSIONAL FOOTBALL

MCMAHON, J.

*UNIVERSITY OF SALFORD*

Commercial force plate (FP) systems are now common in professional football codes and are often used daily to assess athletes. Practitioners, such as sport scientists and physiotherapists, are responsible for administering FP tests, but there are few quality resources and published studies available to guide their interpretation of the results. As professional football clubs are private companies, they are solely responsible for tests conducted with their athletes, without industry-wide performance standards or regulations to abide by. Various FP tests (mainly vertical jump and multi-joint isometric tests) are broadly applied in football for benchmarking athletes' performance, informing and evaluating exercise interventions, monitoring neuromuscular (NM) fatigue, and guiding injured athletes' return to play.
Jump height is mostly reported as the primary outcome measure for vertical jump tests, but it may mask subtle acute and chronic alterations in NM strategies which variables derived from FP measurements can illuminate. Also, jump height is biased towards lighter athletes and may not be a fair metric for comparing athletes' performances when there are large variations in body mass, such as is in rugby. Jump height alone will also not reflect any changes in body mass that occur between testing occasions, which is especially relevant for maturing youth athletes or adult athletes who complete a hypertrophy-focussed training programme. Additionally, youth athletes who grow in height between testing occasions will be afforded with a greater distance over which to apply force to their mass, which may alter their NM strategy and/or their jump height score. In multi-joint isometric tests, the peak forces attained may require scaling to body mass depending on the football code, position and intended application. Thus, there is a requirement to better contextualise popular FP test results in football to inform practitioner decision making.
The presentation will include key results from several ongoing FP studies that have been funded either by a leading commercial FP company or the English Football Association. A comprehensive FP testing battery has been completed for 200 professional football athletes across the domestic season and international tournaments. The data is contextualised to facilitate quick and accurate decision making via a variety of statistical approaches (e.g., standardised scores) and data visualisation tools (e.g., traffic light systems). The results highlight future considerations using FPs in football for benchmarking athletes' performances, seasonal monitoring to inform supercompensation and/or chronic fatigue, and acute fatigue monitoring both pre- and post-match and when fixture congestion is high. The target audience is sport science and medicine practitioners and researchers who routinely assess athletes with FPs, particularly footballers, and any delegate who is interested in conducting physical performance tests in sport.

#### UNDERSTANDING BIOMECHANICAL VARIABLES TO ANALYSE ISOMETRIC AND DYNAMIC TESTS: THE IMPORTANCE OF VERBAL CUES AND IMPULSE

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Athlete performance assessments are commonly conducted in several sports. An athlete's ability to apply force is one of the most frequent capacities evaluated by sport scientists. Force plates are widely used for this purpose because they are well accepted and yield good reliability and validity. Force plates measure the force that an athlete applies when they perform an action on its surface. Force plates can even register force production when the athlete remains static. For that reason, both isometric and dynamic tests are measured by force plates and the software used can automatically calculate many force variables, trying to simplify the analysis of the executions performed by participants. However, it is important to pay attention to how we measure and analyse the force data because most information is typically limited, and important variables are often discarded, which could lead to misinterpretation of the data.
When isometric or dynamic tests are performed, the researchers and coaches have to instruct how athletes must execute the tests. The verbal cues utilised modify the test results and most of the biomechanical variables that are relevant to explain the performance obtained by athletes. Most commercial force plate software can provide the most common discrete variables for standardised tests. However, discrete variables represent just a single point within a test and it is important to analyse more than one variable to provide information of the test performed by athletes. In addition, variables including information about the whole test performance are relevant to understand how athletes apply the force during the allotted time. Net impulse is a variable that is underutilised when evaluating isometric and dynamic tests with athletes. It is frequent to observe that test performance is evaluated by the maximum force applied or the maximum velocity obtained but to understand how this performance is achieved, it is necessary to understand how the impulse was produced by athletes. Furthermore, in current research articles, there is an increased use of continuous analysis to avoid discarding data from the executions performed by athletes. In that sense, statistical parametric mapping (SPM) is one of the most powerful analyses to compare force-time curves.
The presentation will include results from several studies showing how verbal cues affect the measures obtained from force plate tests and how sports scientists need to consider the proper instruction depending on the purpose of the test. Then, investigations will be presented comparing the use of impulse and discrete force variables, highlighting the importance of the variables selected to facilitate correct interpretations. Finally, investigations and the results of force plate tests carried out on athletes, with different verbal cues and evaluated through the SPM, will be presented, including an explanation of how to interpret the results.

#### ALTERED FORCE PRODUCTION STRATEGIES IN COUNTERMOVEMENT JUMPING FOLLOWING SEVERE LOWER LIMB INJURY

BAYNE, H.

*UNIVERSITY OF PRETORIA*

The measurement of vertical ground reaction force during jumping tasks is becoming commonplace in sports medicine and athletic performance centres and continues to gain popularity as the accessibility of equipment and software improve. The countermovement jump (CMJ) is one of the most widely used tests. Processing of the CMJ force-time data involves the calculation of acceleration and impulse from

the raw signal. Velocity, displacement and power are then calculated, and key events are identified to subdivide the jump into functionally relevant phases. Typically, these are the unweighting, braking, propulsion, flight and landing phases. Standard analysis relies on metrics such as phase-specific minimum, maximum or mean values, phase durations, and calculated ratios. When dual force plate systems are used, inter-limb asymmetry is also calculated. These metrics are used in profiling athletes, monitoring performance changes over time, and assessing rehabilitation progress to guide return to sport following injury.
While these metrics are important and useful to practitioners for evaluating jump performance, meaningful information may be lost by excluding large portions of the force-time curve. A variety of different propulsion phase force-time curve shapes have been observed which reflect different jump strategies. Researchers have categorised these as unimodal or bimodal based on the number of distinct force peaks, however, the evidence for practical implications of these two jump strategies has been mixed. Further subcategories of force-time curve shape have been proposed based on the relative magnitude and timing of propulsion phase force peaks, with some evidence for an association between an earlier peak and jump performance. This categorisation approach, however, still does not account for variation at each data point along the force-time series. A functional data analysis method, such as statistical parametric mapping, is needed to investigate between-athlete, within-athlete and between-limb differences across the entire time-series curve.
The presentation will include a summary and critique of force-time curve modality categorisations, with implications for practice. Novel research findings from investigations that apply a statistical parametric mapping approach to assess CMJ performance in athletes recovering from severe lower limb injury will be presented and discussed. The target audience would include sport science and clinical practitioners who are interested in objective measurements of performance to inform training prescription and rehabilitation, as well as researchers that collect biomechanical time-series data. The topic is of relevance to improve data-informed decision making in sport, in particular with regards to rehabilitation following serious injury. It will also enhance the awareness of methodological approaches to better understand the data that researchers and practitioners work regularly with.

## Oral presentations

### OP-BM03 Neuromuscular Physiology

#### H-REFLEX MODULATION BETWEEN SEATING AND STANDING IS NOT ASSOCIATED WITH POSTURAL CONTROL IN FALLERS AND NON-FALLERS

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INTRODUCTION: Previous work reported a greater decrease in the Hoffmann (H) reflex amplitude from seated to standing in older compared with young adults (1). This specific modulation likely reflects an age-related change in the neural control of upright standing (2). This may cope with the increase in postural instability (3), which is one of the strongest risk factors for falls (4). This study investigated the relation between postural control and the H-reflex modulation from seated to standing in older adults with (fallers) and without (non-fallers) a history of falls during the last 12 months. We hypothesised a lesser H-reflex modulation in individuals with poor postural control, especially in fallers.
METHODS: The path length of the centre of pressure (CoP-path) was measured (40-s epoch) in 9 fallers [mean (SD); 69 (4) yrs] and 13 non-fallers [69 (5) yrs] when standing on a force platform with eyes open. The maximal amplitude of the soleus H reflex (Hmax) was recorded in seated and standing postures and normalised to the M-wave maximal amplitude (Mmax). Correlations between the change in H reflex from seated to standing postures and CoP-path were investigated for each group.
RESULTS: The CoP-path was greater for fallers [318 (83) mm] than non-fallers [234 (44) mm, p=0.006]. The Hmax was lesser in fallers than non-fallers when seated [22.0 (10.1) vs 35.3 (13.7) %Mmax] and standing [17.1 (10.9) vs 26.5 (12.9) %Mmax; p=0.032]. The decrease in Hmax from seated to standing was similar between groups [-26% vs -21%; p=0.64], and no association was observed between the change in Hmax and the CoP-path ($r^2 < 0.13$).
CONCLUSION: As evidenced by the smaller Hmax in the two positions in fallers, the H-reflex pathway undergoes greater age-related changes in fallers than in non-fallers. However, these modifications do not seem specific to upright standing and postural control. In contrast with our hypothesis, Hmax was modulated similarly in both groups, and the extent of the modulation from seated to standing was not associated with CoP-path. Thus, the risk of falls may not be associated with the modulation of the H-reflex pathway.
1. Baudry et al. 2015. Exp Gerontol, 69, 62-69.
2. Katz et al. 1988. Brain, 111 ( Pt 2), 417-437.
3. Abrahamova & Hlavacka. 2008. Physiol Res, 57, 957-964.
4. Ambrose et al. 2013. Maturitas, 75, 51-61.

#### EXPERTS VERSUS NOVICES: STIFFNESS REGULATION DURING VARIOUS STRETCH LOADS

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INTRODUCTION: High neuromuscular activity before and during ground contact (GC) are the prerequisites to benefit from energy saving mechanisms during stretch-shortening type actions (1). Especially time critical disciplines such as long jump (2) require immediate transition from eccentric to concentric muscle action (1). To meet such criteria athletes are highly involved in plyometric training. Therefore they have an exclusive neuromuscular control and stiffness regulation during the eccentric phase (3). During excessive stretch loads the eccentric activity is negatively affected possibly due to inhibitory influences (2,4). By directly comparing experts and novices the present study investigate the effect of expertise on the neuromuscular control and leg spring behavior in vertical jumps.
METHODS: By combining 3D motion capture system with electromyography of the shank and thigh muscles differences in biomechanical and neuromuscular control were elaborated between 13 professional youth elite track and field athletes and 13 sportive novices. All participants performed bipedal drop jumps from 25, 37, 49 and 61 cm. The seven trials with the highest reactive strength index (RSI) were selected for statistical analysis. Two-way Mixed-ANOVA (group x condition) was performed.

RESULTS: Significant interaction effect reveal higher RSI and leg stiffness in experts compared to novices. In both groups RSI is significantly reduced in 61 cm. Experts realize highest leg stiffness during low stretch loads; leg stiffness in novices remains constant. Overall experts demonstrate significant lower ankle and knee joint flexion compared to novices; both groups increase ankle and knee flexion with increasing stretch load. Significant interaction is evident for soleus (SOL), gastrocnemius medialis (GM) and vastus medialis (VM) with overall higher pre-activity in experts. During GC SOL activity is significant higher in experts; activity diminishes with increasing stretch load only in experts. During GC GM and TA activity is similar in both groups; GM activity diminishes whereas TA and VM activity increases with increasing stretch load. Further analysis revealed that RSI is positively correlated with leg stiffness ($r = .57$, $p < .01$) and eccentric SOL activity ($r = .51$, $p < .01$).
CONCLUSION: Our results reveal higher neuromuscular activity before GC in experts to achieve an immediate transition and high ballistic performance (2). Compared to previous experiments higher eccentric activity in experts is only evident for SOL (4). Although both groups compensate highest stretch loads by increasing joint flexion and VM activity, experts are able to achieve high stiffness which is associated with RSI. Immediate eccentric-concentric transition is more dominant in low stretch loads.
1) Seyfarth et al., J Biomech, 1999
2) Komi & Gollhofer, J Appl Biomech, 1997
3) Viitasalo et al., Eur J Appl Physiol, 1998
4) Taube et al., Exerc Sport Sci Rev, 2012

## DEGENERATION OF NEUROMUSCULAR CONTROL IN HUMANS IS DETECTABLE AFTER 10 DAYS OF LIMB SUSPENSION AND IS COMPLETELY RECOVERED AFTER A 21 DAYS TRAINING INTERVENTION

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INTRODUCTION: The multiple effects of disuse on skeletal muscle health have been described in several studies but limited literature exists about its consequences on neuromuscular control. In addition, neuromuscular control after disuse has been investigated only by invasive needle electromyography (EMG) and considering small hand muscles [1, 2]. Recently, the introduction of the high-density EMG (HD-EMG) allowed for non-invasive investigation of the MUs properties in vivo. Therefore, in the present study, HD-EMG was used to investigate how disuse affects neuromuscular control in the vastus lateralis, a large muscle with key functional implications. Moreover, we also tested whether and how the neuromuscular control is restored following a reconditioning training period.
METHODS: Eleven young male participants (22.1 ± 2.9 years, 22.87 ± 2.07 kg/m2) underwent 10 days of unilateral lower limb suspension (ULLS) followed by 21 days of moderate-intensity resistance training. Maximum voluntary isometric force (MViF), force steadiness and motor units (MUs) properties were measured at baseline, immediately after ULLS and after the training period. MUs were detected with HD-EMG during the execution of trapezoidal isometric contractions at 10, 25 and 50% MViF and tracked longitudinally across the intervention. Repeated measures ANOVA was performed to detect differences in MViF and steadiness while MUs properties were analysed with linear models.
RESULTS: MUs recruitment/derecruitment thresholds were reduced after ULLS at all contraction intensities, and the changes between the two variables were strongly correlated. After ULLS, MUs discharge rate (DR) was reduced at 10 and 25% but not at 50% MViF. The slope of the regression line representing the rate of change of MUs DR as a function of the rate of change of force (i.e., motoneuron input/output relation (I/O)) was increased after ULLS while the intercept was reduced. After resistance training, all the impairments were recovered and force steadiness even improved compared to baseline.
CONCLUSION: 10 days of ULLS can induce deterioration of neuromuscular control by affecting predominantly the DR modulation, while the strategies of MUs recruitment/derecruitment seem to be preserved. The motoneuron I/O after ULLS, and the different DR modulation at 50% vs 10 and 25% MViF, suggest a different motoneuron response depending on the level of presynaptic input . 21 days of resistance training were sufficient to restore, and slightly improve, the original neuromuscular control.

## CHANGES IN NEUROMUSCULAR JUNCTION TRANSMISSION STABILITY, MOTOR UNIT PROPERTIES AND RELATED GENE EXPRESSION WITH SHORT-TERM UNLOADING AND RETRAINING

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INTRODUCTION: While there is convincing evidence that neuromuscular junction (NMJ) integrity is affected by unloading, whether NMJ transmission stability is also impaired is currently unknown. Moreover, electrophysiological alterations in motor units potential (MUP) properties and related molecular mechanisms are poorly understood. With this study, we aimed to investigate the neuromuscular changes in response to a short period of unloading and retraining (RT) in humans with a particular focus on NMJ function and MUP properties.
METHODS: Eleven healthy males volunteered for a 10-day unilateral lower limb suspension (ULLS) period, followed by 3-week RT based on resistance exercise. At baseline, after the unloading period and after RT, quadriceps femoris (QF) muscle size and knee-extensors maximum voluntary contraction (MVC) were evaluated by ultrasonography and isometric dynamometry, respectively. Activation capacity (AC) was assessed with the interpolated twitch technique. Intramuscular electromyography recordings were collected from vastus lateralis (VL) during submaximal contractions at 10% and 25% of the MVC. The NMJ transmission stability and MUP properties were assessed using decomposition-based quantitative electromyography. Blood samples and VL muscle biopsies were collected for the evaluation of NMJ damage (via c-terminal agrin fragment concentration, CAF), fibre type, diameter and muscle biomarkers of denervation (fibre type grouping, presence of flat-shaped/angulated and neonatal myosin positive fibres). RNA sequencing was also performed to study changes in the expression of gene pathways involved in the NMJ and ion channels regulation.
RESULTS: The ULLS induced QF muscle atrophy (4.5%) and impairments in MVC (29.3%) and AC (6.0%). Evidence of NMJ molecular instability (5.4% increase in CAF) was found with unloading, together with changes in the expression of many NMJ-related genes, including upregulation of acetylcholine receptors subunits and downregulation of Homer proteins. However, NMJ transmission stability, evaluated through the assessment of near fibre Jiggle and segmented Jitter, was unchanged, while alterations in MUP properties (decreased firing rate, MUP complexity and increased near fibre duration) were found after ULLS. A possible explanation for these electrophysiological alterations is skeletal muscle ion channels remodelling (as suggested by an overall downregulation of the related gene set), rather than marked innervation/reinnervation processes. The RT period restored most of these neuromuscular degenerations.

CONCLUSION: We showed that the human NMJ is destabilized at molecular level but remains functionally robust in response to short-term unloading. However, we observed alterations in MUP properties occurring after ULLS, possibly due to alterations in skeletal muscle ion channels dynamics. These maladaptations are reversed by three-week resistance training.
Funding by ASI, MARS-PRE Project, n. DC-VUM-2017-006

**FASCICLE BEHAVIOUR, KINEMATICS, AND ELECTROMYOGRAPHY OF THREE NORDIC HAMSTRING EXERCISE VARIATIONS**

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INTRODUCTION: Bicep femoris (BF) fascicle length (FL) is extremely adaptable to training, which is important for the reduction of hamstring strain injury risk [1]. The Nordic hamstring exercise (NHE) should be performed supra-maximally, with progressive overload resulting in a greater adaptive response [2]. Popular regressions using elastic bands or other devices can result in submaximal performance. Performing the NHE on an incline or decline surface could alter the force required for any given knee angle. The aims of the present study were to determine the effects of performing the NHE at different inclinations and the influence on the kinematics, hamstring EMG and BF fascicle dynamics.
METHODS: 13 physically active individuals (24.7±3.7 years, 79.56±7.89 kg, 177.40±12.54 cm) performed three repetitions of the NHE performed on neutral (0°), incline (20°) and decline (20°) surfaces. Three-dimensional lower limb data, ultrasound (US) videos of the BF, and EMG activity of BF and medial hamstrings (MH) were captured. Onset was identified when participants moved >5° of knee extension, breakpoint was identified with a knee angular velocity of ≥20°.s-1. Relative BF muscle tendon unit (MTU) length was calculated [3]. Raw EMG signals were analysed with an RMS filter and US videos were analysed using Ultratrack. Between-trial reliability was assessed using ICCs and CMCs. Peak measures (BF MTU length, BF and MH EMG and absolute BF FL) were compared between NHE variations using a series of RMANOVAs with Bonferroni post-hoc analysis, the same measures were time normalised (onset to breakpoint) and compared between NHE variations.
RESULTS: Peak and time-series data demonstrated moderate-good reliability (ICCs = 0.62-0.84; CMCs = 0.68-0.82). A significant main effect was observed for peak kinematic and fascicle dynamics ($p<0.001$). Pairwise comparisons revealed greater peak MTU length (1.00±0.04 & 0.91±0.02, $p=0.006$) and peak BF FL (7.34±0.18 cm & 6.91±0.16 cm, $p=0.013$) during the incline versus the decline NHE. There were no differences ($p>0.05$) in peak EMG between inclinations. EMG time normalised curves showed the incline NHE favoured BF, in comparison to the neutral and decline NHE favouring the MH. Time-normalised curves revealed peak EMG occurred between 65-89%, whereas peak MTU length and BF FL occurred between 98-100%. BF FL initially shortened for up to 38-40%.
CONCLUSION: The NHE performance angle manipulates the lever arm through which the centre of mass is acting. The incline NHE results in greater MTU length and BF FL, which could result in enhancement in resting BF FL via training, until athletes can perform the entire range of motion where additional overload will be required [2]. The differences in performance angle resulted in a change in the neuromuscular contributions of the BF and the MH, favouring BF for incline variations despite no differences between peak EMG.
1.Bourne et al., SportsMed, 2018
2.Pollard et al., Scand J Med SciSports, 2019
3.Hawkins & Hull, J Biomech, 1990

## Oral presentations

### OP-PN31 Ketone ingestion and fat diet

**THE ACUTE EFFECT OF KETONE MONOESTER INGESTION ON CARDIAC FUNCTION AT REST AND DURING EXERCISE IN PEOPLE WITH TYPE 2 DIABETES MELLITUS.**

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INTRODUCTION: Type 2 diabetes mellitus (T2DM) is a chronic progressive metabolic disease associated with an increased prevalence of cardiovascular events [1]. Insulin resistance impairs the body's ability to utilise glucose and leads to an increased reliance on the metabolism of less efficient fuel sources which ultimately leads to increased cardiac burden [2]. Recent evidence in people with heart failure, suggests that infused ketone bodies (β-hydroxybutyrate; βHB) leads to increased cardiac output and stroke volume [3]. Oral ingestion of ketone monoesters (Kme) has been shown to provide a rapid increase in blood ßHb levels within 30 min in healthy humans [4]. The aim of this study was to examine the acute effect of oral consumption of Kme on cardiac function in people with T2DM at rest and during incremental exercise.
METHODS: In a double blind, randomised, crossover design study, 13 people with T2DM (age, 66±9 yrs.; body weight, 90.3 ±15.2; HbA1c, 54±7 mmol/mol) attended the lab in 2 separate visits during which they ingested either a Kme drink (0.115 g/kg (R)-3-hydroxybutyl (R)-3-hydroxybutyrate) or a placebo drink. After 30 min from ingestion, participants underwent measurements of cardiac output (CO) and stroke volume index (SVi) via thoracic impedance cardiography and circulating [ßHb] at rest and during incremental cycling exercise.
RESULTS: Circulating [ßHb] was higher at rest (mean diff. 1.51 mM, 95%CI 0.68 to 2.12, $P=0.016$) and during exercise (mean diff. 1.38 mM; 95%CI 0.85 to 2.1, $P=0.001$) compared to placebo. Resting SVi (mean diff. 10.58 ml/m²; 95C%CI 3.85 to 20.3, $P=0.016$) and resting CO (mean diff. 1.38 L/min; 95%CI 0.28 to 2.48, $P=0.018$) were higher after Kme ingestion compared to placebo. Similarly, SVi (mean diff. 16.32 ml/m²; 95C%CI 5.28 to 27.3, $P=0.001$) and CO (mean diff. 3.34 L/min; 95C%CI 2.18 to 4.47, $P=0.001$) were higher during incremental cycling exercise after Kme ingestion compared to placebo. No significant HR differences ($P>0.05$) were observed at rest or during exercise between the two drinks.
CONCLUSION: Ingestion of Kme acutely improves cardiac function at rest and during incremental exercise in people with T2DM. Large scale chronic interventions are needed to establish whether Kme can be used as an adjunct treatment for improving cardiac health in people with T2DM.

1. Type 2 Diabetes: National Clinical Guideline for Management in Primary and Secondary Care (Update). 2008, London: Royal College of Physicians of London.
2. Reusch, J.E.B., M. Bridenstine, and J.G. Regensteiner, Type 2 diabetes mellitus and exercise impairment. Reviews in endocrine & metabolic disorders, 2013. 14(1): p. 77-86.
3. Nielsen, R., et al., Cardiovascular Effects of Treatment With the Ketone Body 3-Hydroxybutyrate in Chronic Heart Failure Patients. Circulation, 2019. 139(18): p. 2129-2141.
4. Cox, P.J., et al., Nutritional Ketosis Alters Fuel Preference and Thereby Endurance Performance in Athletes. Cell Metab, 2016. 24(2): p. 256-68.

**EXOGENOUS KETOSIS SUPPRESSES DIURESIS AND ATRIAL NATRIURETIC PEPTIDE DURING EXERCISE**

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*KU LEUVEN*

INTRODUCTION: We have previously demonstrated that exogenous ketosis reduces urine production during exercise. However, the underlying physiological mechanism of this anti-diuretic effect remained unclear. Therefore, we investigated whether acute exogenous ketosis by oral ingestion of ketone ester (KE) during a simulated cycling race (RACE) affects the hormonal pathways implicated in fluid balance regulation during exercise.
METHODS: In a double-blind crossover design, 11 well-trained male cyclists participated in RACE consisting of a 3-h submaximal intermittent cycling (IMT180') bout followed by a 15-minute time trial (TT15') in an environmental chamber set at 28 °C and 60 % relative humidity. Fluid intake was adjusted to maintain euhydration. Before and during RACE, the subjects received either a control drink (CON) or the ketone ester (R)-3-hydroxybutyl (R)-3-hydroxybutyrate (KE), which elevated blood β-hydroxybutyrate to ~2-4 mM during RACE.
RESULTS: Compared with CON, N-terminal pro-atrial natriuretic peptide (NT-pro ANP) concentration during RACE was ~20% lower in KE ($p < 0.05$). KE also raised plasma noradrenaline concentrations during RACE. Performance in TT15' was similar between CON and KE.
CONCLUSION: Our current findings demonstrate exogenous ketosis to suppress diuresis during prolonged exercise. The underlying physiological mechanism remains, however, unclear. Interestingly, we also for the first time demonstrate ketone ester ingestion to suppress ANP secretion. Such effect could contribute to explain the previously reported effect of exogenous ketosis to lower circulating non-esterified fatty acid levels during exercise.

**SUPERCOMPENSATION CURVED KETO-ADAPTATION: NUTRITION AS QUICK-FIX OR STIMULUS FOR ADAPTATION?**

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INTRODUCTION: The supercompensation time-course of adaptation to training as stimulus is well-known (i.e., initial decline precedes physiological adaptation, resulting in enhanced performance). While the term keto-adaptation frames the ketogenic diet (KD) as a physiological stimulus, the supercompensation phenomenon has, to my knowledge, not been accepted in response to a nutritional intervention.
METHODS: To depict the time-course of metabolic keto-adaptations in energy system contributions, and changes in intermittent sprint fatigue, this study employed a time-series design. 15 Recreationally active participants (7 men, 8 women) performed cycle ergometer intermittent sprints (6 x 10 s separated by 2 min rest), while metabolic data were collected for the calculation of energy system contributions. Participants were tested prior to the KD intervention on their habitual diet (HD: 35% CHO, 45% fat, 20% protein) and subsequently every two weeks over a 6-week KD intervention (7% CHO, 66% fat, 28% protein).
RESULTS: While the anaerobic glycolytic energy contribution decreased at KD week 2 (-14.4 ± 28.16 Joule; P = 0.031; ES = -0.10) and remained suppressed throughout the 6-week KD, the phosphocreatine contribution gradually increased until it reached statistical significance at KD week 6 (+22.0 ± 43.15 Joule; P = 0.019; ES = 0.47). Intermittent sprint fatigue initially increased from HD at KD week 2 (8.8 ± 5.12% vs. 7.4 ± 3.92%; P = 0.720; ES = 0.31; CI = -0.42; 1.02), whereafter a very large decrease in fatigue occurred from KD week 2 to 6 (8.8 ± 5.12% vs. 5.7 ± 2.64; P = 0.066; ES = -1.17; CI = -1.91; -0.36) resulting in a net moderate decrease over the 6-week KD (HD vs. KD week 6; 7.4 ± 3.92% vs. 5.7 ± 2.64; P = 0.332; ES = -0.50; CI = -1.21; 0.24).
CONCLUSION: Collectively, steady upregulation of phosphocreatine energy metabolism over the 6-week KD, gradually compensated for lowered glycolytic energy, which aligns with the decline and subsequent supercompensation in intermittent sprint fatigue. Although the net decrease in fatigue at KD week 6 was not yet statistically significant, the phosphocreatine adaptations also did not plateau, suggesting further adaptation can be expected with longer KD interventions.

**EFFECT OF ACUTE KETONE BODY SUPPLEMENTATION ON CARDIORESPIRATORY EXERCISE RESPONSES AND THE INFLUENCE OF BLOOD ACIDOSIS: A RANDOMIZED, CROSSOVER TRIAL**

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*MCMASTER UNIVERSITY*

INTRODUCTION: Acute ketone monoester supplementation (KE) induces hyperketonemia and blood acidosis; both can affect exercise responses but the relative influence of each is unclear. We previously found that ingestion of 0.6 g/kg body mass KE increased heart rate (HR) and ventilation (VE) during cycling at ventilatory threshold (VT) compared to placebo (1). The present study used the same protocol (1) to examine the effect of KE on exercise cardiac output (Q) and the influence of blood acidosis. We hypothesized that KE vs placebo would increase Q and co-ingestion of a pH buffer would mitigate this effect.
METHODS: A sample size estimate (G*Power) determined n=12 provided 80% power to detect a change in Q (effect size f=0.4, alpha=0.05) with repeated measures analysis of variance (ANOVA). Trained adults (11 males, 4 females; VO2peak = 60±9 mL/kg/min) completed 3 trials in random order. Participants ingested 1 g/kg carbohydrate and 400 mL water 2 h before exercise, followed by either 0.20 g/kg body mass of sodium bicarbonate or a salt placebo 60 min pre-exercise, and a 0.6 g/kg bolus of KE or ketone-free placebo in 500 mL of fluid 30 min pre-exercise. This yielded 3 conditions: low blood ketone bodies and neutral pH [control (CON)], hyperketonemia and lowered pH (KE), and hyperketonemia and neutral pH (KE+BIC). Venous blood was sampled before and during exercise. Participants cycled for 30 min at VT intensity. Q was measured in duplicate over the last ~5 min using inert gas rebreathing (Innocor). After a 10-min rest, VO2peak and peak Q were determined. Data were analyzed using ANOVA and a Tukey post hoc test as appropriate with alpha=0.05.
RESULTS: Blood concentration of the major ketone body beta-hydroxybutyrate differed between conditions (CON: 0.1±0.0, KE: 3.5±0.1, KE+BIC: 4.4±0.2 mM, $P \leq 0.001$ for all). Blood pH was lower in KE vs CON (7.30±0.01 vs 7.34±0.01, $p<0.001$) and KE+BIC (7.35±0.01, $p<0.001$).

Q during VT exercise was not different between conditions (CON: 18.2±3.6, KE: 17.7±3.7, KE+BIC: 18.1±3.5 L/min, p=0.4). HR was higher in KE (153±9 beats/min) and KE+BIC (154±9) vs CON (150±9, p<0.02 for both). VE was higher in KE vs CON (81±16 vs 74±17 L/min, p<0.0001) and KE+BIC (77±16, p<0.01). VO2peak was not different between conditions (CON: 4.55±1.05, KE: 4.34±0.94, KE+BIC: 4.39±0.91 L/min; p=0.2). Peak Q was also not different (CON: 21.8±3.8, KE: 21.5±3.7, KE+BIC: 21.1±3.9 L/min; p=0.3). Peak power output was lower in KE (359±61 W) and KE+BIC (363±63) vs CON (375±64, p<0.02). Peak HR was lower in KE vs CON (179±9 vs 181±9 beats/min, p=0.03) and KE+BIC (182±9, p=0.03).
CONCLUSION: KE increased submaximal exercise HR independent of acidosis and thus was seemingly affected by hyperketonemia. Q was not different between conditions despite differences in HR, which suggests stroke volume may have been altered. The higher cardiorespiratory stress after KE may have lowered exercise capacity such that peak power output at VO2peak was reduced.
1. McCarthy et al. (2021) DOI: 10.1139/apnm-2020-09

# Oral presentations

## OP-AP01 Power and strength

### THE INFLUENCE OF TRAINING TWO OR THREE TIMES PER WEEK ON HYPERTROPHY AND STRENGTH ADAPTATIONS IN INDIVIDUAL LEG MUSCLES AFTER 10 WEEKS OF RESISTANCE TRAINING TO FAILURE

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*GHENT UNIVERSITY*

INTRODUCTION: The influence of resistance training (RT) variables (e.g. training frequency) on muscle hypertrophy and strength gains has been extensively researched (1). The majority of analyses on hypertrophy effects focused on measuring whole muscle groups, rather than on responses on the individual muscle level. The American College of Sports Medicine guidelines recommend training 2 to 3x/week for novices (2). However, an additional training may not be beneficial for every individual muscle considering their heterogeneity (e.g. muscle typology). Therefore, this study aimed at investigating the difference between training 2 and 3x/week on RT-induced adaptations in individual muscles.
METHODS: Twenty-one untrained individuals (22.06±2.18yrs, 11 men and 10 women) performed a 10 week resistance training program. A within-subject design was used in which leg A and leg B were randomly assigned to either training 2x/week (>=72h recovery) or 3x/week (>=48h recovery). Every training session included a leg extension and leg curl exercise performed to failure (3 or 4 sets/exercise, 60% 1RM). Changes in dynamic strength were assessed by measuring 1RM. Magnetic Resonance Imaging (MRI; Siemens 3T) was performed and muscle volumes were calculated by an artificial intelligence-based 3D rendering technique (Springbok Analytics). Paired Samples T-tests were used to detect differences between training 2x and 3x/week.
RESULTS: Dynamic strength and muscle volume increased significantly in all trained muscle groups and individual muscles (p<0.005). No significant differences were found in mean strength increases between training 2x and 3x/week, neither for the leg extension (2x: 18.76%, 3x: 22.07%, p=0.25), nor for the leg curl (2x: 26.36%, 3x: 30.38%, p=0.173). No significant difference in mean hypertrophy was found between training 2x and 3x/week for the hamstrings (2x: 9.18%, 3x: 11.26%, p=0.056) on muscle group level and for semimembranosus (2x: 4.42%, 3x: 3.86%), rectus femoris (2x: 6.23%, 3x: 7.76%), vastus lateralis (2x: 5.74%, 3x: 7.22%), medialis (2x: 3.08%, 3x: 4.82%) and intermedius (2x: 4.83%, 3x: 7.05%) on individual muscle level. However, hypertrophy was significantly higher when training 3x/week compared to 2x/week for the quadriceps (2x: 4.94%, 3x: 6.58%, p=0.018) on muscle group level and for biceps femoris (2x: 8.86%, 3x: 12.18%, p=0.012) and semitendinosus (2x: 15.62%, 3x: 19.31%, p=0.045) on individual muscle level.
CONCLUSION: Training 2 or 3x/week causes similar strength gains in leg muscles of previously untrained individuals. However, with regard to hypertrophy, specific individual muscles (biceps femoris and semitendinosus) benefit more from training 3x/week. These muscles were found to have higher mean percentual increases in muscle volume, indicating that muscles that are more prone to hypertrophy may benefit more from an additional training session.
1. Grgic et al. (2019). J of Sci and Med in Sport, 22(3), 361–370.
2. ACSM (2009). Med and Sci in Sports and Exerc, 41(3), 687–708.

### PHYSICAL ACTIVITY INTENSITY DOES MATTER FOR RELATIVE MUSCLE POWER: THE TOLEDO STUDY FOR HEALTHY AGING IN MIDDLE AGE

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INTRODUCTION: Preserving adequate muscle power during senescence has already been associated with sedentary behavior (SB) and moderate-to-vigorous physical activity (1). The decline of muscle power in older adults often leads to a deterioration of functional capacity and loss of independence. It is therefore of great importance to be able to anticipate this problem in earlier stages such as middle-age adulthood. However, there are hardly any studies that have analyzed how lifestyle components related to SB and physical activity are associated with muscle power in this population. Therefore, the aim of this study was to investigate the association of SB and physical activity with relative muscle power in middle-aged adults.
METHODS: A total of 138 individuals (53.91 ± 1.46 years; 58% women) from the Toledo Study for Healthy Aging in Middle Age (TSHA-ma) were included. Relative muscle power was assessed using the 30-second Sit-to-Stand Muscle Power Test, while SB and physical activity were monitored for 7 days using GENEActiv (Kimbolton, UK) accelerometer devices placed on the non-dominant wrist. Multiple linear regression analyses were performed with relative muscle power as the dependent variable, while SB, light physical activity (LPA), moderate physical activity (MPA), and vigorous physical activity (VPA) were independent variables. The model was adjusted for sex, age, educational level, and number of valid accelerometry days.

RESULTS: Multiple linear regression analysis showed no association between SB (β: 0.000; 95%CI: -0.003, 0.003; p = 0.926), LPA (β: -0.001; 95%CI: -0.009, 0.008; p = 0.900) and MPA (β: 0.004; 95%CI: -0.005, 0.012; p = 0.388) with relative muscle power. Only VPA (β: 0.039; 95%CI: 0.009, 0.069; p < 0.05) significantly explained relative muscle power in middle-aged adults.
CONCLUSION: This study suggests that VPA appears to be the only physical activity component to be associated with increased relative muscle power in middle-aged adults. Conversely, neither the SB nor the LPA or the MPA appeared to be related. Therefore, future strategies focused on preventing relative muscle power loss in middle-aged adults should encourage the increase of VPA, as it may attenuate functional decline or loss of independence in old age. However, future experimental studies should confirm this hypothesis.
REFERENCES:
1. Ramsey KA, Rojer AGM, DAndrea L, Otten RHJ, Heymans MW, Trappenburg MC, et al. The association of objectively measured physical activity and sedentary behavior with skeletal muscle strength and muscle power in older adults: A systematic review and meta-analysis. Ageing Res Rev. 2021;67:101266.

## MONITORING TRUNK INCLINATION IS ESSENTIAL TO DETERMINE MECHANICAL POWER OUTPUT DURING FIELD-BASED WHEELCHAIR PROPULSION

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INTRODUCTION: Over the last decades, the abilities to monitor wheelchair sport performance have increased significantly. One important performance determinant in wheelchair sports is the mechanical power exchanged between the wheelchair athlete and the environment. However, a feasible method to determine power in the field is not yet developed. The aim of current study was to determine the mechanical power based on full-body kinematics during wheelchair propulsion on a treadmill. Subsequently, this power was compared to power estimated from two inertial sensors (at the trunk and at the wheelchair) and to a commonly used approach which uses only one inertial sensor at the wheelchair.
METHODS: Twenty-five healthy participants performed five different 120s-trials at 1.2 m/s in an instrumented sports wheelchair on a treadmill. The five trials differed with respect to mass (+0, +5 or +15 kg) or tire pressure (1.75, 3.5, 5.25 bar). Before each trial, body mass inertial parameters were obtained and wheel friction coefficients were determined based on drag tests. During the trials, inertial sensors were attached to the participants' trunk (thorax) and wheelchair (wheel), upper body kinematics were monitored using an optical motion capture system. Participants were instructed to maintain a constant push frequency induced by a metronome during the entire session, which consisted of 60s normal wheelchair propulsion and 60s wheelchair propulsion without trunk motion.
Based on the calculated instantaneous rolling friction and instantaneous center of mass (COM) kinematics and power per push were determined. The resulted power was compared to power predicted using more simplified approaches that used one and two inertial sensors, respectively. In addition, we assessed the influence of trunk motion on these comparisons.
RESULTS: Mechanical power output increased significantly with added mass and decreased tire pressure. Although power estimated from one inertial sensor differed significantly from power based on all kinematics, no significant difference was found for the method that used two inertial sensors. Trunk motion increased when rolling friction increased and was positively related to the difference in power between the methods. For the parts without trunk motion, differences between methods were negligible.
CONCLUSION: During wheelchair propulsion, the trunk moves considerably within each push cycle. As a result, the COM of the wheelchair-user system moves relative to the wheelchair. Also, rolling friction changes with mass distribution due to the differences between castor and rear wheels. In this way, trunk motion influences power output. Therefore, to be able to determine power during straight-line wheelchair propulsion in the field, at least wheelchair and trunk kinematics should be obtained, implying the use of two inertial sensors. Power based on wheelchair kinematics only is likely to be underestimated with trunk motion, leading to unfair comparisons between athletes with different abilities.

## RESISTANCE TRAINING CAN AFFECT MUSCLE STRENGTH, FAT MASS AND TESTOSTERONE LEVELS IN HYPOGONADAL MEN WITHOUT HORMONE REPLACEMENT THERAPY

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INTRODUCTION: Male hypogonadism is a clinical syndrome manifesting with low testosterone (TT) including symptoms like decline in lean mass, muscle strength, increased adiposity, visceral obesity and incidence of insulin resistance and metabolic syndrome. There are only few studies dealing with effect of physical activity on hypogonadal males [1]. The aim of the study was to examine the effect of 12-week strength training program on muscle strength, body composition and selected biochemical parameters in hypogonadal men without hormone replacement therapy.
METHODS: The effect of resistance training (RT) on hypogonadal patients without hormonal therapy (HP, n=6, 48.41±6.38 yrs, TT= 7.9±1.75 nmol/L) and control group of eugonadal males (EM, n=8, 49.31±5.84 yrs, TT= 15.81±3.99 nmol/L) was studied. The subjects performed RT twice a week, the training program consisted of 6 exercises at an intensity from 60-80% of 1RM. Muscle strength was assessed by predicted dynamic leg press 1RM from multiple repetition maximum. Body composition, more specifically relative body fat mass was measured by DXA, Fasting morning venous blood samples were collected. The blood serum parameters included glucose, total testosterone, SHBG and cortisol.
RESULTS: Subjects from both the HP and EM groups significantly decreased relative fat mass by 6.2 % and 4.91% ($p>0.05$ and $p<0.01$, respectively). Muscle strength of lower extremities increased in both group ($p<0,01$), from 148 ± 16 kg to 211 ± 20 kg and from 183 ± 17 kg to 224 ± 19 kg in HP and EM, respectively. When both groups were merger, a negative correlation between TT and fat mass ($p<0.01$) and TT and body mass ($p<0.01$) was found before and after the intervention in both groups. Correlation between SHBG and TT pre-training ($r = 0.52$, $P < 0.05$) and post-training ($r = 0.75$, $P < 0.01$) was also observed. Interestingly, TT level was significantly increased in HP from 7.90 ± 2.90 nmol/L to 9.6 nmol/L ($p<0.05$) and unchanged in HM. Resistance training also influenced glucose, when effect size with Cohen D was calculated (d= -0.54).
CONCLUSION: Resistance training protocol of 3-month duration significantly improved muscle strength and reduced body fat regardless of the total testosterone levels. A significant increase in circulating levels of TT after resistance training in the groups of hypogonadal men could be of high clinical relevance in male hypogonadism treatment when testosterone-replacement therapy is contraindicated.

Aknowledgments The study was funded by the VEGA no. 1/0714/16. Trial registration: ClinicalTrials.gov: NCT03282682
References:
1. Hildreth et al. The Journal of Clinical Endocrinology and Metabolism 2013; 98(5), 1891–1900

**THE IMPACT OF TRUNK STRENGTH IN TEMPORAL AND KINETIC VARIABLES DURING VERTICAL JUMPING**

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INTRODUCTION: The purpose of this study was to examine the relationship of trunk strength with kinetic and temporal measures of a countermovement vertical jump (CMJ). It was assumed that higher trunk strength will be associated with better performance in vertical jump. We also hypothesized that trunk strength will affect eccentric and concentric phases of the jump similarly, and the effectiveness of the elastic energy recoil from the eccentric to the concentric phase.
METHODS: N=45 male handball and basketball players participated in this study (mean age=17.4±0.3 years) performing CMJ on a force platform (HUR labs) and trunk strength testing. From force-velocity-time data we divided the jump into eccentric and concentric phases registering the time duration (Tecc and Tcon) and the average force (Fecc and Fcon) values for each phase. We calculated the average rate of force development during the eccentric phase (RFDecc) from the moment ground reaction force exceeded body weight. Trunk strength was measured with an isokinetic dynamometer (BioniX Sim3 Pro) at 30º/s angular velocity. Participants performed left/right trunk rotation (Rot), trunk flexion (Fl), extension (Ext), and left/right trunk flexion (Lat Fl). Maximal peak torque from the best attempt (out of three) was used in further analysis. Left and right sides were averaged. Data were analysed using multiple linear regression and Pearson-type correlation in SPSS 25.0.
RESULTS: The relationship of trunk strength with CMJ performance was from trivial to small (r=.017 to .028; p>.05). Using the trunk movements as predictors and CMJ measures as dependent variables, the regression analysis showed that trunk strength explained the 24.7% of the total variance for rel. Fecc (F=3.12; p<.05), 33.1% for rel. RFDecc (F=4.70; p<.05), and 9.9% for rel. Fcon (F=1.05; p>.05). Besides Fl, the rest movements had a moderate, but significant negative correlation with Tecc, while Tcon had slightly lower negative correlation with Ext and Lat Fl. Rel RFDecc showed large correlations with Lat Fl (r=.53; p<.01) and Ext (r=.50; p<.01) and moderate correlation with Rot (r=.41; p<.01). Fcon correlated only with Lat Fl (r=.35; p<.05).
CONCLUSION: Performance in CMJ was not related to trunk strength, nevertheless the latter seems to have a significant contribution during the two subphases of the jump. During CMJ, trunk muscles stabilize the upper body improving movement optimization and in consequence performance. This contribution was larger for the eccentric phase compared to the concentric, indicating that trunk strength contributes to a more rapid execution of the countermovement and a higher eccentric force and RDF. The higher (and more explosive) eccentric force may increase the stored elastic energy, which potentially may increase concentric force production. However, based on our results, we could not confirm the connection of trunk muscles with a more efficient strain energy recoil from the eccentric to the concentric phase.

## Oral presentations

### OP-PN06 Pulmonary and respiratory physiology

**DYSANAPSIS AS A DETERMINANT OF EXPIRATORY FLOW LIMITATION DURING PHYSICAL EXERCISE IN MASTER ATHLETES**

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INTRODUCTION: In older highly trained populations or master athletes, the decline in pulmonary function might play a role in limiting high-intensity endurance exercise performance. Increased airway resistance with aging can be associated during exercise with expiratory flow limitation (EFL), defined as the inability to increase expiratory flow despite increased transpulmonary pressure. EFL can lead to hyperinflation, lower inspiratory reserve volume, greater respiratory muscles work / effort, and therefore exercise intolerance. For a given lung size, the reduction of airway size increases airflow turbulence and resistance and might increase the prevalence and severity of EFL. The aim of this study is to determine how the uncoupling between lung and airway size, termed dysanapsis, determines EFL in master athletes during maximal exercise.
METHODS: Ten male master athletes, (mean ± SD; age, 68.5±5.7 years; VO2MAX, 51.9±7.7 mL.min-1.kg-1) performed a maximal and graded test to exhaustion on a cycle ergometer. The maximal flow-volume (MFV) curve was determined based on flow and volume measured at the mouth from maneuvers performed prior and after exercise. To determine operational lung volumes, participants performed inspiratory capacity (IC) maneuvers during each stage of the test. The end expiratory lung volume (EELV) was calculated by subtracting the IC volume from the forced vital capacity (FVC) volume. EFL was defined as the percentage of the tidal volume that intersected the MFV curve during expiration. Subjects were flow limited when the severity of EFL was >5%. Dysanapsis was estimated using the ratio (DR) between forced expiratory flow at 50% of vital capacity (FEF50) and the product of FVC and static recoil pressure at 50% of FVC (Pst50), [i.e. DR=FEF50/(FVC* Pst50)].
RESULTS: During the exercise test (peak power output (PPO): 256±33.7 W), all participants experienced EFL at workloads (WEFL) ranging from 50% to 100% of PPO (average: 70.2 ± 20.2%). EFL severity reached 48.3 ± 16.6% at the highest workloads. DR was significantly correlated to WEFL (r=0.72, p=0.02) and participants who experienced EFL at lower workload (LOW) had a significantly lower DR than participants who experienced EFL at higher workloads (HIGH) (0.31±0.03 vs. 0.43±0.08, p=0.01, respectively). At maximum exercise, the LOW group also had a significantly higher EELV relative to FVC compared to the HIGH group (38.1±8%FVC vs. 32.4±6%FVC, p< 0.05, respectively).
CONCLUSION: All master athletes experienced EFL during exercise and EFL was related to airway dysanapsis. A lower DR was associated with both an EFL occurring at lower relative exercise intensities and with a higher EELV at maximal exercise. These findings thus suggest that dysanapsis (uncoupling between lung and airway size) is an important determinant of flow limitation in male master athletes during exercise.

**FREEZING HYPOXIA AND EXERCISE: HOW DO THEY AFFECT LUNG FUNCTION AND RESPIRATORY MUSCLE FATIGUE?**

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INTRODUCTION: Cold temperatures (<-15°C) increase exercise-induced bronchoconstriction (EIB) [1], whilst cold and hypoxic environments exacerbate respiratory muscle fatigue (RMF) development during prolonged sub-maximal exercise [2]. The aim of this study was to determine the independent and combined effects of cold and hypoxia on lung function (LF) and RMF development after strenuous exercise.
METHODS: 12 trained male subjects (age 27±3; VO2max: 64±5 mL/kg/min) randomly performed a maximal cardiopulmonary exercise test (CPET) followed by an 8-min bronchoconstriction test (8-BT), under four environmental conditions: Normothermic Normoxia (NN: 18°C, 20.9% FiO2), Normothermic Hypoxia (NH; 18°C, 13.5% FiO2), Cold Normoxia (CN: -20°C, 20.9% FiO2) and Cold Hypoxia (CH: -20°C, 13.5% FiO2). Maximal workload (WL), ventilation (VE), respiratory frequency (Rf) and tidal volume (VT) were measured during exercise; maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were evaluated before and immediately after the CPET, whereas LF (forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), forced expiratory flow at 25%-75% (FEF25-75) and forced expiratory flow at 50% (FEF50)) was evaluated at baseline and 1,3, 6, 10 and 15min post the 8-BT.
RESULTS: Cold and hypoxia decreased maximal workload (both p<0.001), VE (p<0.001, p=0.017, respectively) and VT (p<0.001, p=0.004, respectively) at the end of CPET, whereas cold only decreased VE (p<0.001) and VT (p=0.003) at the end of the 8-BT. A time effect (p=0.025) was seen in MEP (Δ% pre to post exercise, NN:-6.8±11.9%; NH:-3.38±10.1%; CN: -8.14±16.7%; CH: -10.2±16.4%), independently from environmental condition. Cold*time interactions (p<0.01) were found in FEV1 (Δ% pre to post exercise, NN: -3.4±6.7%, NH: 3.9±6.3%, CN: -7.7±6.0%, CH: -8.2±7.1%), FEF 25-75% (NN: 3.2±11.5%, NH: 0.11±10.1%, CN: -12.9±8.7%, CH: -8.12±13.8%) and FEF50% (NN: 2.1±12.4%, NH: -0.4±11.6%, CN: -11.2±9.7%, CH: -13.3±17.1%). Multiple correlation analysis showed that lower peak ventilatory responses during both CPET and 8-BT were associated with a higher decrease (Δ %) in LF parameters (all p<0.001, descriptor: moderate (0.35 CONCLUSION: These data showed greater LF impairment after strenuous exercise in the cold with no additional hypoxic effect. On the other hand, RMF development after maximal CPET seemed to be independent from environmental condition. Further studies are needed to clarify the relationship between LF impairment and the reduced ventilatory responses in the cold.
1. Kennedy MD, Faulhaber M. Respiratory function and symptoms post cold air exercise in female high and low ventilation sport athletes. Allergy, Asthma Immunol Res. 2018;10(1):43-51.
2. Hinde K, Low C, Lloyd R, Cooke C. Interaction between ambient temperature, Hypoxia, and load carriage on respiratory muscle fatigue. Aerosp Med Hum Perform. 2018;89(11):952-960.

**ASTHMA PREVALENCE IN NORWEGIAN ELITE ATHLETES**

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INTRODUCTION: Asthma is a common problem among elite athletes and represents a health risk interfering with the athlete's performance status. This study aimed to evaluate the asthma prevalence in Norwegian summer and winter elite athletes and asthma prevalence across sport categories. We also aimed to examine if bronchial hyperresponsiveness (BHR), lung function, fraction of exhaled nitric oxide (FENO) and allergy differed between asthmatic and non-asthmatic elite athletes.
METHODS: We included Norwegian athletes qualifying for the Beijing Olympic Summer games 2008 (n=80) and the Vancouver Olympic Winter Games 2010 (n=55). The athletes performed clinical respiratory examination including lung function measurement, methacholine bronchial challenge for assessment of BHR, FENO and allergy assessed with skin prick test. Asthma was diagnosed based on respiratory symptoms and clinical examination including objective measurements.
RESULTS: Asthma was more prevalent among winter athletes (50%) than summer athletes (20%). Thirty-three (52%) endurance athletes, 3 (6%) team sport athletes and 7 (33%) technical sport athletes had doctor diagnosed asthma. Significantly lower lung function (p<0,001) and significantly higher prevalence of severe BHR (p<0,001) were shown in asthmatic athletes compared to non-asthmatic athletes. Allergy and FENO did not differ between asthmatic and non-asthmatic athletes.
CONCLUSION: Asthma prevalence is high in Norwegian elite athletes, with winter athletes and endurance athletes showing the highest prevalence. Asthmatic athletes were characterized by lower lung function and more severe BHR compared to non-asthmatic athletes. The high asthma prevalence in winter sport athletes and endurance athletes demonstrate a need for increased attention to prevent and reduce the prevalence of asthma among those athletes.
Athletes, medical staff, and coaches should be aware of the high asthma prevalence among athletes training in unfavourable environmental conditions such as cold and dry air, polluted air and in swimming pools with high concentration of chlorine combined with poor ventilation. However, it is still unclear if asthma, BHR and reduced lung function are persistent in elite athletes after retirement from elite sport and if respiratory health may be a limitation for physical activity and exercise after career end. Follow up studies are needed to evaluate how athletes' respiratory health are over time, and if the asthma diagnosis is reversible.

**EFFECT OF REPEATED SPRINT TRAINING WITH VOLUNTARY HYPOVENTILATION ON PERFORMANCE AND MUSCLE OXYGENATION**

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INTRODUCTION: Repeated sprint training in hypoxic condition has been shown to improve repeated sprint ability. Moreover, repeated sprint training with voluntary hypoventilation at low lung volume (VHL) is growing attention as an alternative procedure for establishing hypoxic environment in the body. The training with VHL previously demonstrated further increase in repeated sprint ability compared with the same training with normal breath [1]. However, no direct comparison has not been conducted between "repeated sprint training in hypoxia" and "repeated sprint training with VHL". The purpose of this study was to compare the training adaptations between repeated sprint training with VHL and the same training in hypoxia.
METHODS: Twenty-four healthy physically active males (age, 21.9 ± 0.4 years; height, 172.9 ± 1.2 cm; weight, 71.0 ± 21.9 kg) performed repeated cycling sprints twice per week for three weeks (six sessions in total). All participants were randomly assigned to one of three different groups, (1) normoxia with normal breathing (NOR group; 23°C, FiO2 = 20.9%), (2) hypoxia with normal breathing (HYP group; 23°C, FiO2 = 16.4%), or (3) normoxia with breath holding (VHL group; 23°C, FiO2 = 20.9%). The repeated sprint ability (12 × 6-s maximal

sprint with 24-s rest periods between sprints) and maximal oxygen uptake (VO2max) were determined before and after the training periods. Power output, systemic oxygen uptake, and cardiac function were monitored during the repeated sprint test. Muscle oxygenation in vastus lateralis and respiratory muscle was also evaluated using near infrared spectroscopy.
RESULTS: Power output was significantly increased in VHL and HYP during the repeated sprint test (VHL, 575±21 W vs. 659±30 W, $p < 0.05$; HYP, 604±26 W vs. 671±35 W, $p < 0.05$), whereas NOR group did not show significant change after training period (592±32 W vs. 623±30 W, $p > 0.05$). After the training period, muscle oxygen saturation in vastus lateralis during the repeated sprint test was significantly decreased in VHL ($p < 0.05$) but not in HYP and NOR ($p > 0.05$). In addition, muscle oxygen saturation in respiratory muscle was slightly decreased in HYP ($p = 0.1$) but not in VHL and NOR ($p > 0.05$). VO2max significantly increased in VHL after the training period (46.2±1.3 mL/kg/min vs. 47.2±1.4 mL/kg/min, $p < 0.05$), but HYP and NOR did not show significant change (HYP, 47.0±1.5 mL/kg/min vs. 49.6±1.6 mL/kg/min, $p > 0.05$; NOR, 46.2±1.3 mL/kg/min vs. 48.7±2.6 mL/kg/min, $p > 0.05$).
CONCLUSION: Three weeks of repeated sprint training with VHL and same training in hypoxia further enhanced power output during repeated sprint test compared with the training with normal breath in normoxia. In addition, the training with VHL presented different tendency of muscle tissue oxygenation in vastus lateralis and respiratory muscle compared with the training in hypoxia.
1. Woorons et al. (2019)

## Oral presentations

### OP-AP21 Endurance

#### BAYESIAN MULTILEVEL REGION-SPECIFIC INVESTIGATION OF RISK FACTORS FOR ELIMINATION FROM FÉDÉRATION ÉQUESTRE INTERNATIONALE ENDURANCE RIDES DUE TO IRREGULAR GAIT AND METABOLIC PROBLEMS (2012–2019)

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INTRODUCTION: Endurance is a popular equestrian sport with the second largest number of events among all Fédération Équestre Internationale (FEI) disciplines. At the international level, horse and rider combinations race over distances of 80 to 160 km, which puts a significant load on equine and human athletes' musculoskeletal systems and metabolism and gives rise to the risk of injuries and other issues. The sport is practised and regulated globally and organised within eight FEI Regional Groups (RGs). Despite common regulation, the sport's specifics vary among RGs, with RG7 - North Africa/Middle East hosting significantly faster and larger competitions, with a younger, predominantly male rider population and lower proportion of completed rides. To date, risk factors for the two most prevalent adverse outcomes, elimination due to irregular gait (FTQ-GA) or metabolic problems (FTQ-ME), have been investigated using global models or models for one or more countries across RGs. Such models, however, allow limited examination of RG-specific factors. This study focused on RG7 and aimed to identify regional risk factors for FTQ-GA and FTQ-ME, which may be specific or more important to rides in this area, and which have thus not been detected or investigated in detail in global or national models.
METHODS: This retrospective cohort study used data from the FEI's Global Endurance Database. The study included 30,138 starts made by 11,119 horses ridden by 4,649 riders in 568 one-day international competitions held in 10 RG7 countries. This represents 94% of all starts made in RG7 from July 2012 to December 2019. Bayesian Generalised Additive Multilevel Models were fit to investigate associations between the outcomes and 61 potential risk factors identified based on earlier studies and a priori hypotheses. Modelling accounted for clustering at horse, rider, trainer, competition, and venue level, nonlinear shapes of associations, and biologically plausible interactions.
RESULTS: The study identified multiple risk factors including horse and rider sex, age, eliminations history, competition frequency and progression. Fast riding speed was associated with a sharp increase in the likelihood of FTQ-GA (ELPD diff. 269.2, SE diff. 21.5), and the curve of the association was, on average, steeper for higher- compared to lower-level rides. Experience was associated with a decrease in the odds of FTQ-GA in both riders (38.6, 9.4) and horses (33.3, 8.7). Female riders were less likely to end with FTQ-GA (OR 0.84, 95% CI 0.73–0.98) and FTQ-ME (0.63, 0.49–0.80) than male riders, and junior rides were more likely to result in FTQ-ME than non-junior ones (2.16, 1.52–3.10).
CONCLUSION: Identified modifiable factors, including high riding speed and frequency, can be mitigated by appropriate rules, and considered by athletes when planning competition schedules or during the ride itself. Other factors can aid officials at in-ride inspections as additional inputs when assessing combinations' fitness to continue in the ride.

#### EFFORT DISTRIBUTION AND TACTICAL BEHAVIOUR ON THE MEN'S 1500 METRES AT THE WORLD ATHLETICS INDOOR CHAMPIONSHIPS BELGRADE 2022

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INTRODUCTION: The 1500 meters is a middle-distance discipline. Due the distance of the race, tactic behaviour is important to achieve a good performance. Placing yourself in the first positions at the start of the race can be overrated since the medallists are usually decided in the last laps due the final "kick"(Sandford, Day & Rogers, 2019) or also to the lower loss of speed in the last 200 meters (Hanley, Stellingwerff & Hettinga, 2019). The aim of this study is to analyse the distribution of effort and tactical behaviour during the high-level mens 1500-meter race.
METHODS: The men's 1500 metres competition of the 2022 World Athletics Indoor Championships Belgrade was analysed. Have been included all the athletes participating in the final (n=12). Official data has been obtained from the official results of the World Athletics Federation. The temporal and spatial variables analysed are final time (s), time of each 100 m. partial (s), partial time of every split (100,200,300,400,500,600,700,800,900,1000,1100,1200,1300,1400,1500) (s), number of splits in first position (n), number of 100 m. splits in first position (n) and position every 100 metres (n). Correlations between final time or final position and time of each 100 m. split (s), time of every split (s), number of changes in position during the race (n), position every 100 metres (n) and number of 100 m. splits in first position (n) were performed. Shapiro-Wilk test was performed for checking the sample normality. All data was analysed with JASP (0.16.1.0).

RESULTS: Mean final time was 3'41"79±12"31. Significant differences were found between a better split time in every 100 m. (s) and the final time in 100-200 (ρ 0,629,p<.05), 300-400 (ρ 0.895, p<.001), 1000-1100 (ρ 0.825, p<.01), 1100-1200 (ρ 0,736, p<.01), 1200-1300 (ρ 0,666,p<.05), 1300-1400 (ρ 0,695,p<.05) and 1400-1500 (R 0,601,p<.05).
No significant differences were found between final position or final time and number of changes in position during the race. On the other hand, inversely significance has been found between the number of 100 m. splits in first position (n) and the final position (n) (R -0,604,p<.05).
CONCLUSION: The last third of the race seems to be the most decisive for the final performance. The changes of position or the number of times in first position during the race do not seem to be determining for performance, so take the firsts positions towards the end of the race seems to be the best tactical behaviour.
REFERENCES
Hanley, B., Stellingwerff, T. & Hettinga, F. (2019). Successful Pacing Profiles of Olympic and IAAF World Championship Middle-Distance Runners Across Qualifying Rounds and Finals. International journal of sports physiology and performance. 14. 894-901. 10.1123/ijspp.2018-0742.
Sandford, G. N., Day, B. T., & Rogers, S. A. (2019). Racing Fast and Slow: Defining the Tactical Behavior That Differentiates Medalists in Elite Mens 1,500 m Championship Racing. Frontiers in sports and active living, 1, 43. https://doi.org/10.3389/fspor.2019.00043

## CHANGES IN VO2MAX AND MAXIMAL AEROBIC PERFORMANCE FOLLOWING 3H RUNNING VS CYCLING EXERCISE MATCHED FOR INTENSITY

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INTRODUCTION: The variables that determine endurance exercise performance are often assessed in non-fatigued state. It has been previously shown that some endurance performance determinants, such as running economy or critical power, decrease following endurance exercise. However, it is unclear whether maximal oxygen uptake (VO2max) is negatively affected by previous endurance exercise, and if exercise modality plays a role in the magnitude of change. The purpose of this study was to assess whether VO2max decreases following 3h of endurance exercise, and to assess the differences in cycling vs running.
METHODS: Recreational athletes trained in both running and cycling (N = 17, 33 ± 8 yrs, 72.1 ± 5.3 kg, 178 ± 6 cm) visited the lab in four occasions. On visits 1 and 2 they performed a 30-s step incremental test to determine VO2max, gas exchange threshold (GET) and peak test performance (PTP, measured as average power output or speed during the last 30 s of the test). Heart rate (HR) and peak blood lactate concentration were also measured during each test. On visits 3 and 4 subjects cycled or ran during 3 h at 105% of GET after which the incremental test was repeated, and the same variables were measured. Only 11 subjects were able to perform both incremental tests on visits 3 and 4, the remaining 6 not completing them due to injury or pain. PTP data was normalized to the mean of the corresponding variable measured at pre to compare power and speed data. The changes in all variables at rest vs following the 3 h test were assessed using a two-way repeated measures ANOVA with two factors, time and modality. Data are expressed as mean ± SD.
RESULTS: There was a time × modality interaction effect for VO2max (p=0.004), with a significant decrease for running compared to baseline (4.28 ± 0.40 vs 3.92 ± 0.39 L/min, p=0.031) but no significant change for cycling (4.28 ± 0.50 vs 4.20 ± 0.58 L/min, p=0.859). There was a significant effect of time for PTP (p<0.001) but no modality or interaction effects. Specifically, PTP decreased significantly for running from 20.5 ± 1.2 to 17.9 ± 1.7 km/h (p <0.001) and for cycling from 407 ± 51 to 366 ± 52 W (p <0.001). Furthermore, there was no effect of time in maximal HR (p=0.115). There was a significant effect of time on peak blood lactate concentration (p<0.001), which decreased following both running (from 12.0 ± 2.4 t 6.3 ± 2.1 mmol/L, p<0.001) and cycling (from 14.0 ± 1.9 to 8.9 ± 3.6 mmol/L, p<0.001), but there was no interaction for this variable.
CONCLUSION: The main finding of this study was that running exercise lasting 3 hours at 105% of the GET has a negative effect on VO2max, but cycling exercise of the same duration and intensity does not lead to a similar VO2max reduction despite the reduction in test performance not being significantly different between exercise modalities. It is possible that a greater loss of efficiency in cycling may lead to the greater decrease in PTP relative to the smaller change in VO2max.

## CAN VIDEO- AND SENSOR-BASED FEEDBACK BY IMPLEMENTING A TERRAIN-SPECIFIC MICRO-PACING STRATEGY IMPROVE PERFORMANCE IN CROSS-COUNTRY SKIING?

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INTRODUCTION: Cross-country (XC) skiers employ a variable pacing pattern with higher metabolic rates and power production during uphill than flat and downhill sections. To improve performance, refining XC skiers' micro-pacing strategy through adjustments of speed in specific parts of flat and downhill terrain sections can be beneficial. Therefore, the aim of this study was to investigate performance-effects of video- and sensor-based feedback by implementing a terrain-specific micro-pacing strategy in XC skiing.
METHODS: Following a simulated 10-km skating time-trial (Race1) on snow, 26 national-level male XC skiers were randomly allocated into either an intervention (INT, n=14) or control group (CON, n=12), before repeating the race (Race2) two days later. Between races, INT received video- and sensor-based feedback through a theoretical lecture and a practical training session aiming to implement a terrain-specific micro pacing strategy focusing on active power production over designated hilltops to save time in the subsequent downhill. CON only received their overall results and performed a training session with matched training load. During the races the skiers were equipped with wearable sensors (GNSS, IMUs, heart rate), and prior to the field test, performance and physiological measures were collected in the laboratory.
RESULTS: From Race1 to Race2, INT increased the total variation of chest acceleration on all hilltops (p<.001) and reduced the time spent in a specifically targeted downhill segment (mean group difference: -0.55 s, CI95[-0.9,-0.19 s], p=.003), as well as the overall time spent in downhill (-14.4 [-21.4,-7.4] s, p<.001) and flat terrain (-6.5 [-11.0,-1,9] s; p=.006) compared to CON. The increased speed in the specifically targeted downhill segment did not correlate with the skiers' laboratory measures or a 20-m on-snow speed test, implying that the increase in performance occurred independent of the skiers' physical capacities. However, there were an association between the skier's speed on the hilltop in Race1 with improved speed on the hilltop from Race1 to Race2 (R=-0.57, p=.036) and reduced time in the following downhill segment (R=-0.68, p=.007). This means that the skiers with lower speed on the hilltop in Race1 improved more than the skiers with higher

speed. There was also an association between race-time in Race1 and improvement in race-time, so that skiers with longer race-time in Race1 improved more than the faster skiers (R=0.86, p= <.001). No between-group differences were found for overall time spent in uphill terrain (-9.3 [-31.2,13.2] s, p=0.426) or total race-time (-32.2 [-100.2,35.9] s, p=.339).
CONCLUSION: Targeted training combined with video- and sensor-based feedback led to successful implementation of a terrain-specific micro-pacing strategy in XC skiing, which induced reduced time spent in downhill and flat terrain for INT compared to CON. However, no change in overall performance were observed between the two groups of XC skiers.

**THE FLYING RABBIT: THE USE OF A DRONE TO IMPACT PACING BEHAVIOUR IN 1500M RUNNING.**

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INTRODUCTION: In middle-distance time-trial sports events, like 1500-m runs, pacing is a determining factor for performance [1]. Pacing is the decision-making process regarding the distribution of effort over the duration of the race [2]. The development of adequate pacing behaviour during adolescence is thought to be an important factor for future performance [3]. Currently, very few technologies are available to assist athletes with optimal pacing behaviour on the track. This study explores the use of a drone as a tool to help junior runners to better approximate their pacing plan in a 1500-m race.
METHODS: Eleven well-trained junior athletes (Male: n = 7, Female: n = 5; mean age, 17.4 years, SD = 2.4) performed four 1500-m races, while they tried to best approximate their personal pacing plan. The pacing plan described the 400m lap times and the 1500m finish time. The participants first ran two races as part of the familiarisation phase followed by two races as part of the experiment phase. All races took place on different days. In both phases, one race was self-paced (SP) by the athletes, the other was drone-paced (DP); a drone accompanied them on the track flying at the pace of the athlete's pacing plan. For all races, split times, finish times and rate of perceived exertion (RPE) scores were recorded. The deviation from the pacing plan and differences in RPE scores were compared between the SP and DP of the experiment phase.
RESULTS: Participants deviated less from the pacing plan in DP (M = 1.17, SD = 1.20) than in the SP (M = 3.05, SD = 3.34) ($F(1,86) = 12.30$, $p < 0.001$). The average deviation of the four set lap times from the planned lap times were compared, participants deviated on average less from the split times planned in the pacing plan in DP (M = 0.74, SD = 0.35) than in the SP (M = 1.23, SD = 0.65) ($F(1, 86) = 19.41$, $p < 0.001$). No significant difference was found between the RPE scores.
CONCLUSION: A drone can alter the pacing performance of youth athletes on the 1500m. Athletes adhered better to their pacing plan in the presence of a drone, while perceived exertion scores were unaffected. This leads to the conclusion that a drone can potentially be used to support the development of pacing and performance of junior runners. The introduction of a drone as a pace-setter is novel within the academic context, and is worth further exploration for potential application in athletic talent development programs.
1. Edwards, A. M., & Polman, R. C. J. (2013).
2. Menting, S. G., Hendry, D. T., Schiphof-Godart, L., Elferink-Gemser, M. T., & Hettinga, F. J. (2019).
3. Elferink-Gemser, M. T., & Hettinga, F. J. (2017).

## Oral presentations

### OP-AP16 Monitoring recovery

**COMPARISON BETWEEN DIFFERENT AFTER EXERCISE RECOVERY STRATEGIES–AN UMBRELLA REVIEW**

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INTRODUCTION: Numerous overview studies for individual recovery strategies, like for massage or active recovery, have been conducted in the field of sports sciences. However, only a few studies compared different types of recovery strategies or have a narrative rather than a systematic approach. Thus, the purpose of this study was to use an umbrella review to compare various types of post-exercise recovery strategies and provide a bird's view on the effectiveness of recovery strategies.
METHODS: Electronic searches of the PubMed, Cochrane Database of Systematic Reviews, and Web of Science databases were conducted for studies published up to April 2021 under the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement. Additionally, the AMSTAR 2 tool was used to assess the methodological quality of the identified studies.
RESULTS: Twenty reviews (nine systematic reviews and eleven meta-analyses) were fully reviewed out of the 130 identified. Methodological quality assessment via AMSTAR 2 revealed that two reviews had high quality, and eighteen had moderate to low quality. According to the outcome variables, we classified the various recovery metrics in physiological, psychological, and performance metrics following quantitative and qualitative synthesis. The included passive recovery methods (massage, nutrition, and foam rolling) indicated that carbohydrate, curcumin, and pomegranate supplementas provided a positive effect mostly on performance variables. Massage had a negligible or no effect on the recovery process. Regarding active recovery strategies (cryotherapy, varying combinations of submaximal activities), cryotherapy showed mixed results of effectiveness. Active recovery lasting 6-10 minutes improves performance. The effect of compression garments was the only strategy with beneficial effects (marginal to large) within proactive recovery (compression garments, alcohol consumption).
CONCLUSION: According to the criteria used in the current umbrella review, the majority of recovery studies have low methodological quality in terms of systematic reviews and meta-analyses. Most of the systematic reviews included in this umbrella review demonstrated that the recovery findings lacked adequate evidence, meaning that the majority of strategies are not helpful. Future original research on this subject should focus on improving experimental studies' methodological quality and design. Also, researchers should agree on standard outcome measures in the field of recovery to allow for a more objective assessment within and between the different types of recovery.

## INFLUENCE OF SECOND-GENERATION ORAL CONTRACEPTIVE USE ON MUSCLE RECOVERY FOLLOWING REPEATED BOUTS OF RESISTANCE EXERCISE IN TRAINED WOMEN

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INTRODUCTION: Oral contraceptives (OCs) are the preferred type of contraception used by female athletes. The exogenous sex hormones from OCs suppress the endogenous secretion of sex hormones and thereby change the sex hormonal profile. Limited evidence suggests that the female sex hormone estrogen may have a protective role against muscle damage. However, the role of the exogenous administered sex hormones is still uncertain. In untrained women, the use of OCs is associated with delayed strength recovery and greater increases in markers of muscle damage after muscle-damaging exercise when compared to non-users of OCs in a few, but not all studies. Therefore, there is a need for a well-controlled study comparing muscle recovery in trained OC-users and non-users of OCs before any conclusions can be drawn. Thus, the aim of the present study was to investigate if OC use influences muscle recovery following repeated bouts of resistance exercise in trained women.
METHODS: Trained OC-users and - non-users of OC were recruited to perform three strenuous resistance exercise bouts within a 24-hour period. Before, and 3, 24, and 48 hours after the resistance exercise sessions, the participants completed measurements of maximal voluntary isometric (MVIC) and dynamic contraction (MVDC), vertical jump height, and Wingate power performance. All participants were provided with an energy-macronutrient balanced diet during the experimental period.
RESULTS: Results from eight OC-users and six non-users of OCs demonstrated that MVIC, MVDC, jump height, jump power, Wingate peak and average power were all significantly reduced following resistance exercise ($p < 0.05$). However, in OC-users a significantly greater reduction in MVDC was observed 24 hours after the last exercise session compared to non-users of OCs (interaction: $p < 0.05$). No other significant interactions were observed.
CONCLUSION: The results indicate that OC-users experience a greater deterioration of maximal dynamic strength compared to non-users of OCs following repeated bouts of resistance exercise. However, no significant difference was observed in the other performance parameters. To enhance the statistical power, further 26 subjects are recruited. The test period is scheduled to end in June 2022. The full data set will be presented at the conference.

## ASSOCIATION BETWEEN SLEEP QUALITY PERCEPTION AND FATIGUE, MENTAL, STRESS AND MUSCLE SORENESS IN HANDBALL ATHLETES BEFORE PRE-OLYMPIC GAMES

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INTRODUCTION: According to recent research, sleep is directly related to the individual's sports performance, which means that better sleep quality is an important element contributing to a better physical and emotional recovery for the athlete. However, stress and traveling may be factors that lead to poor sleep quantity and quality, which can be the cause of decrements in performance and increased risk of illness.
The aim of this study was to compare the sleep quality perception in handball players to their stress levels, fatigue, mental and muscle soreness perception.
METHODS: Twenty-four male Portuguese handball athletes completed a questionnaire based on the Hooper Scale, to assess the quality of the previous night's sleep, stress levels, fatigue levels and perceived muscle damage, during handball training before pre-Olympic games. This questionnaire consists of 5 self-rated items and each question is individually scored on a scale from 1 ("Very, very low or good") to 5 ("Very, very high or bad"). This relation was evaluated by Pearson correlation, statistical level of $p<0.05$ was accepted.
RESULTS: 24 athletes, in average, reported that sleep quality perception was 3.4±0.8, which 90,5% had a "good sleep". Fatigue level was 3.9±0.6; mental state was 4.5±0.8 and energy perception was 4.0±0.8. Athletes with better perception of sleep quality felt significantly less fatigue ($r = 0.465$; $p = 0.034$), felt psychological better ($r = 0.609$, $p = 0.003$), and reported a significantly higher level of energy ($r = 0.484$, $p = 0.026$) and nonphysical muscle soreness. Athletes with a that felt less fatigue had a significantly higher level of psychological state ($r = 0.726$, $p <0.001$) and energy perception ($r = 0.804$, $p = 0.000$). Athletes with higher psychological state had a significantly higher energy perception ($r = 0.822$, $p <0.001$).
CONCLUSION: Handball athletes, before pre-Olympic games, who report a good quality of sleep have a positive mental state, more energy perception, less level of fatigue physical and less muscle soreness. The process of monitoring will help prescribe the correct dosage of training in order to maximize athlete performance and to implement the appropriate recovery protocols (rest, nutrition, and others).

## MUSCLE OXYGEN SATURATION CONTRIBUTES TO DETERMINING THE RECOVERY TIME INTERVALS IN MAXIMAL STRENGTH TRAINING. CONTRIBUTION TO UNDERSTANDING THE TRAINING PROCESS OPTIMIZATION

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INTRODUCTION: Training for maximum strength is commonly based on manipulating great magnitude external resistances (80% to 100% of the 1RM). The literature suggests long rest times to ensure a complete recovery between each set to optimize the training process. This study aimed to verify the relationship between muscle oxygen saturation ($SmO_2$) in the vastus lateralis muscle and the rest interval using the performance analysis over a training protocol to improve maximal force capacity in the back squat exercise.
METHODS: Six male subjects experienced in powerlifting practice (mean ± SD: age, 24.1 ± 2.68 years; height, 147 ±71.4 cm; body mass, 83.9 ± 8.93 kg) participated in the study. On two separate days, 48hours apart, athletes come to the weight room at the same time of the day (10:00 – 12:00 AM). Athletes underwent a training task to improve their capacity to produce maximum strength (5 sets of 3 repetitions at 83%RM). The training, nutrition, and hydration regime of 48 hours before the performance assessment were maintained.
In the first moment (PT1), the rest time between sets was timed in 8 minutes to assure the reduction of muscular acidity produced by the muscular exertion. A NIRS sensor (Humon muscle oxygen sensor) was placed at the medial part of the right vastus lateralis muscle to assess the SmO2 in the muscle. In the second moment (PT2), the rest time was individualized according to the time needed to reach the plateau of SmO2 (time delay) observed in PT1. A linear transducer Encoder was used to control the velocity of each repetition. Capillary blood samples were taken from the earlobe immediately after each set for Lactate assessment. Heart rate and RPE were also controlled during the experiment.

RESULTS: The rest time between sets was reduced by around 2' from PT1 to PT2. The mean recovery %SmO2 does not differ significantly between moments 79,7±7.55% and 76,3±5,33%, respectively. Additionally, the % of the concentric velocity loss also did not differ between PT1 (50.6±24,8%) and PT2 (42.2±14.2%).
CONCLUSION: The mean values of the %SmO2 observed after the rest period align with the literature and suggest that the rest times based on the $SmO_2$ values allowed for a complete recovery. The observed percentage of mean concentric velocity loss suggests that this indicator of neuromuscular fatigue was not affected by the reduced recovery time.
Our findings lead us to conclude that the recovery periods estimated through the %SmO2 allowed for complete recovery between sets in maximal strength training in powerlifters avoiding the detrimental effect of accumulated fatigue.

**THE EFFECT OF MUSCLE CONTRACTION TYPE ON MUSCLE OXYGEN SATURATION DURING DYNAMIC VERSUS ISOMETRIC BACK SQUAT**

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INTRODUCTION: Exercise monitoring is indispensable for improving performance and for achieving the defined objectives. Physiological variables such as heart rate, oxygen uptake, or blood lactate concentration are considered the most widely used as global parameters (1), and muscle oxygen saturation, through near-infrared spectroscopy, has been gaining emphasis as a local muscle parameter (2). This pilot study aimed to compare the effect of the type of muscle contraction in the back-squat exercise in muscle oxygen saturation (SmO2) and total hemoglobin (tHb) during a dynamic contractions protocol (DCP) and an isometric contractions protocol (ICP).
METHODS: Seven voluntary participants (age: 26.4±6.1 years old; height: 176.6±9.7 cm; body mass: 76.7±9.6 kg) with back-squat experience were recruited. They were physically active and reported no musculoskeletal injuries to exercise. Before the protocols, one-repetition maximum (1RM) was determined (114.29±38.45 kg) with standard methodology. The DCP comprised 3 sets of 16 repetitions at 50% of 1RM (57.14±19.23 kg), with a 120-second rest interval between sets and 2 seconds per cycle of movement. The ICP comprised 3 sets of 1 isometric contraction with the same load and set duration (32 seconds) of DCP. NIRS derived parameters, i.e., minimum SmO2 (SmO2min), mean SmO2, and SmO2deoxygenation (% change from baseline) were assessed in vastus lateralis, soleus, longissimus, and semitendinosus muscles. Statistical significance was set at $p \leq 0.05$ and the results are presented as means ± standard deviation.
RESULTS: Although paired sample t-tests revealed no significant differences in mean SmO2 in vastus lateralis, longissimus, and semitendinosus muscles, soleus muscle had lower values in DCP but only in the first set ($p=0.023$). Related to SmO2min, just the soleus muscle presented differences ($p \leq 0.05$) and lower values in the DCP compared with ICP regardless of the set (1st: 27.3±8.9 % vs 44.2±10.2 %; 2nd: 26.1±11.4 % vs 38.6±17.6 %; 3rd: 24.5±12.7 % vs 40.5±16.4%) and an interesting point was that the minimum values in the four muscles analysed were reached after the end of exercise in 78% of the cases. The SmO2deoxygenation showed no significant differences between protocols in all analysed muscles. No differences were seen in tHb between DCP and ICP.
CONCLUSION: These findings suggested that the variation in the type of muscle contraction with the same load and exercise duration promoted a lower SmO2 in the soleus muscle in DCP, probably due to a higher demand of specific muscle activation, reflecting a more pronounced gap between oxygen supply and consumption. The identical behaviour of tHb between the protocols and the decreasing pattern along sets might be due to the similar intramuscular pressure.
1) Thornton et al., Int J Sports Physiol Perform, 2019
2) Barstow, J Appl Physiol, 2019

## Oral presentations

### OP-PN15 Molecular Biology and Biochemistry I

**WEAK ASSOCIATIONS BETWEEN POLYGENIC RISK SCORE FOR PHYSICAL ACTIVITY AND AEROBIC CAPACITY IN HUNT 3 FITNESS STUDY**

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INTRODUCTION: Both physical activity (PA) behaviour and aerobic capacity are heritable phenotypes. Polygenic risk scores (PRSs) can be used to estimate the individual's genetic propensity for a trait that is explained by variation in thousands of genetic variants. We have previously shown that PRS for PA (PRS PA) accounted for statistically significant but overall small proportion of the variation in PA in the Finnish cohorts (1). The purpose of this study was to investigate if genetic inheritance of PA affects aerobic performance and to replicate our previous findings using a cohort representing different genetic ancestry.
METHODS: Genotyped participants of the HUNT 3 Fitness Study with directly measured maximal oxygen uptake (VO2max) measurements (age 19-89 years, 49% males, N = 4,521) were included in analysis. PRS PA was calculated for self-reported moderate to vigorous PA (MVPA) minutes per week using UK Biobank genome-wide association study summary statistics and SBayesR methodology (2). In HUNT, self-reported PA was estimated using Kurtze score. A treadmill protocol was conducted to estimate VO2max (ml/kg/min). Linear regression models adjusted for age, sex and genetic principal components of ancestry were used to assess if standardized PRS PA predicts PA and aerobic capacity.
RESULTS: In fully adjusted model high PRS PA predicted higher PA in HUNT 3 cohort (ß = 0.104 per one SD change in PRS PA, SE = 0.042, P = 0.013). PRS PA independently accounted 0.13% of the variation (R2) in the in the Kurtze score. PRS PA was not associated with VO2max (ß = 0.099, SE = 0.103, P = 0.338).
CONCLUSION: PRS PA explained a minor proportion of variation in PA among HUNT cohort. This is probably because of low predictive value of the used PRS PA or low correlations among PA methods (MVPA minutes vs. Kurtze score). The fact that no statistically significant association was observed between PRS PA and VO2max may be explained by low predictive value of PRSPA or that the variants included in PRS

PA are mainly related to PA behavior and not to physiological determinants of aerobic capacity but also to the unreliability inherent in the self-reported PA measurement.
References:
1. Kujala UM, et al., Med Sci Sports Exec. 2020
2. UK Biobank Web site, http://www.nealelab.is/blog/2017/7/19/rapid-gwas-of-thousands-of-phenotypes-for-337000-samples-in-the-uk-biobank

**TRANSCRIPTOMIC ANALYSIS OF MURINE SPLENIC CD3+ T CELLS AFTER ACUTE EXERCISE**

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INTRODUCTION: Exercise is a key factor that affects the immune functions. It is generally accepted that appropriate exercise could improve immune functions, while exhaustive exercise has been shown to impair the immune response. Acute exercise or overload exercise could cause an "open window" period (3 to 72 h after exercise) of weakened immune function[1], and the mechanism of exercise induced immunosuppression is still poorly understood. This study focused on the transcriptomic characterization of the effects of acute exercise on murine splenic CD3+ T cells by transcriptome sequencing (RNA sequencing, RNA-seq) technique.
METHODS: Mice were randomly assigned to the control, sedentary group, and the experimental groups, which performed a single bout of intensive and exhaustive treadmill exercise. Murine splenic lymphocytes were separated by density-gradient centrifugation after exercise.Cells were labeled with anti-CD3-PE antibody and sorted by a flow cytometry.The effect of exercise was evaluated by the immunological parameters (lymphocyte proliferation and cellular inflammatory factor secretion). The combination of flow cytometry and carboxyfluorescein succinimidyl ester labeling technique was used for determination of cell proliferation, and Th1/Th2 cytokines in the culture medium with cytometric bead array(CBA).Transcriptomic analysis of murine splenic CD3+ T cells was performed by RNA-seq technology, and differentially expressed genes were screened by the standard of |log 2 FC|>1 and P-adjust<0.05. Hierarchical cluster analysis was done for the screened differentially expressed genes, and gene ontology analysis (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG) pathway enrichment analysis were performed for the differentially expressed genes.Experimental validation of the screened key expressed genes was performed by qRT-PCR.
RESULTS: Compared with the control group, exercise significantly reduced Con A-induced proliferation of CD3+ cells in vitro ($p < 0.05$), and increased the levels of IL-6, IL-5, and IL-13 in the culture medium ($p < 0.001/0.001/0.05$, respectively), down-regulated the level of IL-2 ($p < 0.05$). KEGG pathway enrichment analysis showed the effect of exercise were significantly enriched to cytoskeletal proteins and signal transduction mechanisms.Compared with the control group, exercise significantly increased the transcription level of the factors (SERCA2B, PKCθ, Cav3.3, Bcl-xL and FADD) in CD3+ cells.
CONCLUSION: Acute exercise has immunosuppressive effects, and its mechanism could be related to the regulation of the gene expression from the calcium signaling pathway, providing a theoretical basis for the further research into the mechanisms of exercise immunity.

**THE EFFECT OF TNF-A INHIBITOR ON THE INFLAMMATORY RESPONSE AFTER ONE-OFF EXHAUSTIVE EXERCISE**

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INTRODUCTION: Acute inflammation caused by overtraining and insufficient rest can evolve into a chronic inflammatory response, leading to systemic immune response, inducing exercise fatigue, affecting performance and reducing athletic performance. TNF-α inhibitor (thalidomide) specifically inhibit TNF-α protein synthesis, acting by interfering with transcription, translation or affecting mRNA half-life. It is thus hypothesized that a reduction or inhibition of TNF-α contributes to a reduction in the validation response in exercise fatigue. In the present study, we investigate the effect of one-off exhaustive exercise on the TNF-α/NF-κB signaling pathway-mediated inflammatory response in skeletal muscle and the effect of TNF-α inhibitor intervention.
METHODS: Male 8-week-old Wistar rats were randomly divided into three groups: control group (EC group, n=10), exhaustive exercise group (EE group, n=10), and exhaustive exercise combined with TNF-α inhibitor intervention group (TEE group, n=10). The EE and TEE groups performed an exhaustive treadmill exercise at 16m/min with an incline of 0°after three days of acclimatization. The TEE group received 200mg/kg body weight of TNF-α inhibitor (thalidomide) by oral infusion 4h prior to each exercise. After 24 hours of exhaustive exercise, the serum CK, BUN, IL-1β and TNF-α were sampled and the expression of NF-κB, TNF-α and IL-1β was measured by western-blotting.
RESULTS: The exercise to exhaustion time was significantly increased in the TEE group compared with the EE group. Serum CK, BUN, IL-1β and TNF-α values were significantly higher in the EE group compared to the EC group, while serum BUN, IL-1β and TNF-α values were significantly lower in the TEE group compared to the EE group. The protein expression of NF-κB, TNF-α and IL-1β in the gastrocnemius muscle of rats was significantly higher in the EE group than in the EC and TEE groups.
CONCLUSION: TNF-α inhibitors reduced the TNF-α/NF-κB signaling pathway-mediated inflammatory response in rat skeletal muscle induced by one-off exhaustion exercise, prolonged the duration of exercise to exhaustion and improved the exercise capacity of rats.

**ASSOCIATION OF DAILY DIETARY INTAKE AND MYOKINES IN MARATHON RUNNERS**

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INTRODUCTION: Daily food intake is crucial to determine endogenous fuel to practice endurance exercise and consequently to maintain muscle mass. Chronic low nutrients availability has been demonstrated to be one of the main factors related to endocrine and metabolic dysfunction. Myokines are chemical messengers release by skeletal muscle tissue during contraction and have autocrine, paracrine and endocrine effects modulating muscle mass and function. The aim of this study was to associate daily dietary intake with myokines response in marathon runners.
METHODS: Participated in this study sixty-one Brazilian male amateurs runners (age, 41 ± 7 years; height, 1.7 ± 0.01 m, body mass, 74 ± 14 kg). Blood samples were collected 1 day before and after São Paulo International Marathon. The plasma levels of myokines were determined using the Human Magnetic bead Panel. Dietary intake was determined using a prospective method of three food records in the week before marathon race.

RESULTS: Before race, energy and carbohydrate intake was correlated positively with musclin ($p<0.05$, $r=0.28$ and 0.38, respectively) and myostatin ($p<0.05$, $r=0.33$ and 0.40, respectively); and sugar intake with musclin ($p<0.05$, $r=0.30$). Musclin concentration also had a positive correlation with the micronutrients manganese ($p<0.05$, $r=0.28$) and vitamin C daily intake ($p<0.001$, $r=0.43$) and myostatin levels with vitamins B1, C and iron intake ($p<0.05$, $r=0.27$-$0.30$) before race. BDNF, IL-15, apelin, irisin, apelin, FSTL, FGF-21 levels were not associated with daily dietary intake before race. After race, daily sugar intake was correlated positively with BDNF, FSTL, IL-6 and FGF-21 concentrations, which are crucial to muscle recovery ($p<0.05$, $r= 0.31$-$0.33$); fiber intake with musclin and myostatin ($p<0.05$, $r=0.29$); and vitamin C with IL-15 ($p<0.05$, $r=0.26$). Cholesterol intake was correlated negatively with apelin and irisin levels ($p<0.05$, $r=-0.32$ and -0.27, respectively), sodium intake with BDNF and FGF-21 levels ($p<0.05$, $r=-0.30$ and -0.37, respectively) and protein intake with BDNF and apelin levels ($p<0.05$, $r=-0.26$).
CONCLUSION: The results highlight the importance of carbohydrate and fiber consumption in runners for good muscle recovery and alert to the adequacy of sodium and cholesterol consumption due to its negative correlation with BDNF, apelin and irisin levels. The data also could contribute to elucidate the mechanisms of beneficial effects of adequate intake in runners. In conclusion, daily dietary intake may influence some myokineslevels responsible to maintenance of muscle mass, such as myostatin, musclin, apelin and irisin, and to recovery of muscle mass and function, such as BDNF, FSTL, IL-6 and FGF-21.

## Oral presentations

### OP-AP18 Relative age effect

#### NEURO-MUSCULAR DEVELOPMENT AND AGE-RELATED PROFILING IN ELITE YOUTH SOCCER PLAYERS: CONVENTIONAL STATISTICS AND CONTRIBUTIONS OF MACHINE LEARNING

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INTRODUCTION: From a neuromuscular perspective, soccer is characterized by the need to move ones own body mass at high speed. In addition, rapid changes of direction and quick responses to visual stimuli are needed. For these reasons, performance diagnostics often include jumping, tapping, balance and sprint tests and are supplemented by tests on changes of direction and visual information processing. However, little is known about the development of these skills in youth elite athletes. Therefore, this cross-sectional study investigated neuromuscular performance tests of elite youth soccer players across different age groups.
METHODS: 232 male elite youth soccer players (17.3±2.8 yrs) performed neuro-muscular tests including counter-movement jump (CMJ), squat jump (SJ), drop jump (DJ), star run (StR), chase next (CN), tapping (Tap), balance (Ba) and sprinting (Spr). For each athlete, 1-11 tests were carried out in a period of 4 years (number of tests: U15 = 88, U16 = 168, U17 = 263, U19 = 229, U23 = 192). The data were organized in a “data warehouse” and used for conventional statistics and machine learning, such as clustering and decision trees.
RESULTS: Conventional Statistics
There were significant differences between certain age groups (mean±SD) e.g. regarding CMJ, SJ, DJ, StR and Reactive Strength Index (RSI) as a key indicator for neuro-muscular reactivity. These differences, however, cannot statistically be related to biological age or age groups as the intraindividual or groupwise within variation is very high. So is the individual development in the context of soccer specific training. Thus an individual profiling is required.
Examples for groupwise results are: CMJ [cm]: U15 = 33.8±4.2, U16 = 36.6.1±4,6, U17 = 38.0±3.9, U19 = 40.6±4.5, U23 = 40.5±4.1. StR [s]: U15 = 18.4±1.2, U16 = 18.0.±1.1, U17 = 17.5±1.1, U19 = 17.3±1.2, U23 = 17.2±1.1). RSI [cm/ms]: U15 = 0.141±0.030, U16 = 0.148±0.033, U17 = 0.163±0.031, U19 = 0.182±0.035, U23 = 0.185±0.033).
Machine Learning
In order to obtain to gain a better understanding of complex key indicators a “dimension reduction” by means of factor-analyses with varimax-rotation was carried out. Two major factors with an explained variance of 39% were extracted, which can be associated with dominant reactive components (24%) and more coordinative features (15%).
CONCLUSION: The data show that neuromuscular performance differs between age groups, but that this difference is not simply a function of age. It is conceivable that the difference between and high variance within age groups is the result of individual training stimuli, causing some individuals to stand out from the rest over time. It turns out that the interindividual variance is primarily based on two factors that can be attributed to reactive or coordinative abilities. These results will help athletic trainers to understand the development of the neuromuscular performance in youth athletes, set appropriate priorities in training, and identify talent.

#### WHY ARE THEY ALWAYS OLDER AND STRONGER? RELATIVE AGE EFFECT AND TALENT IDENTIFICATION FACTORS IN YOUTH ELITE SOCCER PLAYERS.

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INTRODUCTION: Assessment of the players motor potential for soccer is multidimensional. In most cases, testing set dedicated to youth players take into account the anthropometric, linear or curve sprinting characteristics, jumping and agility testing and the ability to rapidly change direction. Nevertheless, interpretation of the obtained data is disturbed by the phenomenon of relative age effect (RAE) and different maturity statuses in youth soccer players. There is a lack of studies that investigated the relationship between anthropometric profile, body composition, results of motor tests, and different methods of maturity-based banding for the Talent Identification (TI) process in soccer. The aims of the study were: a) examination of anthropometrical and motor performance with traditional age-grouping by chronological age (CA) and Midway Point methods (MP) proposed by Helsen and colleagues (2021), and b) identify the birth-date distribution in elite polish youth soccer payers.
METHODS: Two hundred thirty-six (236) elite youth soccer players aged 12-14 selected by Polish Football Association to National Development Camp (NDC) completed a physical performance battery with anthropometric and body composition analysis. Players biological maturity status was assessed with the age at peak height velocity (APHV) method. All data were compared to growth charts and distribution of birth dates for the Polish Population. Homogeneity of variance was checked, and no violations were found. The $\chi 2$ test was used to deter-

mine the differences between the observed and expected frequencies of a birth-date quartile. Differences in body height and match statistics were analyzed with ANOVA and Tukey`s post hoc test. The calculations used a confidence interval of $p < 0.05$. An independent t-test was conducted to determine the differences in anthropometric characteristics and performance tests results between grouping methods and the first and fourth birth quarter.
RESULTS: Before relocation RAE was identify in each sub-group (U13, $\chi2=13,5$, p=0,0023, V=0,3; $\chi2=14,34$, p=0,0025, V=0,29; U15 $\chi2=17,65$, p<0,001, V=0,33). Analysis shows the quarterly significant differences for U13 grup for body mass (p<0,05), body height (p<0,01), total body water (p<0,01), total protein mass, skeletal muscle mass and power peak output for 30 meters sprint (p<0,05). No significant differences in jumping abilities (SJ, CMJ) and results of CODAT Test. In addition, the study shows the quarterly difference in APHV for U15 (p<0,01). After relocating players with MP guidelines, results show that only 34% of player was correctly banded by age-grouping and over 47 % was older than their CA age-group.
CONCLUSION: The results of this study show that maturity status and CA are crucial in the TI and selection process in youth soccer. The method proposed by Helsen and colleagues (2021) may lead to fewer dropouts and thus a larger talented player pool, which benefits, in turn, the talent identification process for soccer academies.

**PHYSICAL DEVELOPMENT OF YOUTH FOOTBALL PLAYERS**

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INTRODUCTION: Due to the frequent high intensity efforts in football, well developed physical qualities are necessary to perform at a high level (Bradley et al., 2009). During youth years, athletes progressively improve in physical characteristics concurrently with growth and maturation (Malina et al., 2004). However, due to varying timing and tempo of growth and maturation in individuals, interpretation of physical qualities among youth is challenging. Several studies have characterized physical qualities at different ages in boys, but studies including girls and studies comparing sexes are scarce. Therefore, the aim of this study was to compare physical performance characteristics between age groups and sexes in youth football players.
METHODS: In a cross-sectional study design, 141 football players, boys (n=83) and girls (n=58), from U14, U16, and U18 age groups were tested. The test battery consisted of 30 m sprint, change of direction ability (CoD), countermovement jump (CMJ) with a force plate and yoyo-intermittent recovery test level 1 (YYIR1). An independent t-test was used for differences between sexes for each test, and one-way ANOVA were used to calculate the significance level between the groups.
RESULTS: Boys performed significantly better than girls in all tests (p<0.001); 30 m sprint (5.03 vs. 4.71 sec), CoD (10.96 vs 10.20 sec), CMJ (27.5 vs 31.6 cm) and YYIR1 (590 vs 908 m). Boys were also significantly better at all ages, and the difference between sexes increased with age for both 30 m sprint (U14: -3.5% p=0.03; U16: -6.9%, p<0.001; U18: -11%, p<0.001) and CoD (U14: -4.1%, p=0,001; U16: -7.9%, p<0,001; U18: -9.1%, p<0,001). The same trend was shown for CMJ, but there was no difference between the sexes in the U14 group (U14 = 10.7%, p=0.151; U16 = 15.5%, p=0,006; U18 = 31.8%; p=0,004). Though there was a trend for increasing differences with age also for the YYIR1, only the U16 had significant sex differences (U16 = 71%, p=0.003).
CONCLUSION: This study shows that boys perform better than girls at a wide range of physical qualities during youth years and that these differences increases as they get older. These results adds to the fact that girl's plateau in physical development at an earlier stage than boys, that suggests that sex differences should be taken into account in training prescription. However, there is a need for more research looking into longitudinal development to confirm this.
Bradley, P. S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P., & Krustrup, P. (2009). High-intensity running in English FA Premier League soccer matches. Journal of Sports Sciences, 27(2), 159-168. https://doi.org/10.1080/02640410802512775
Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). Growth, Maturation, and Physical Activity. Human Kinetics. https://books.google.no/books?id=VqFcFsykj6EC

## Oral presentations

### OP-SH01 Psychology

**SELF-SELECTED VS. IMPOSED RUNNING INTENSITY AND THE ACUTE EFFECTS ON MOOD, COGNITION, AND BRAIN ACTIVITY**

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INTRODUCTION. People state to go for a run because it helps them to 'clear their mind'. Based on the self-determination theory (Deci & Ryan, 1985), perceived autonomy is considered as key factor for positive effects of exercise on mood (Ekkekakis, 2009). Here, we investigate how two identical bouts of exercise with differing degree of autonomy influence the psychological and electrocortical outcomes. Because neuroscientific investigations revealed inconsistent results previously, we focus on aperiodic brain dynamics (1/f), which – to the best of our knowledge – have not been considered in sports science, yet. As a decrease of 1/f activity is associated with more efficient neuronal communication (Voytek & Knight, 2015), we hypothesize that there will be a reduction after exercise going along with improvements in mood and cognitive performance.
METHODS. 29 experienced recreational runners (aged 22 ± 2.5 years, 14 females) completed two 30-minute runs. During the first intervention, the participants chose their individual feel-good intensity in a self-selected run (SR). Four weeks later, during an imposed run (IR) under blinded conditions, the same running speed was externally prescribed, which should influence the perception of autonomy. The acute effects on mood (Feeling Scale, Felt Arousal Scale, MoodMeter®) and cognition (d2-R, digit span test) were examined using t-tests and Wilcoxon tests, respectively. Brain activity in the electroencephalogram (slope, offset, 1/f-corrected alpha and beta band) was analyzed using cluster-based permutation tests with repeated measures ANOVA and Bonferroni post-hoc tests.
RESULTS. Both running interventions were equal in terms of duration, running speed, heart rate and lactate concentrations. Activation in the Felt Arousal Scale increased following both runs (SR: p< .001, d= 1.27; IR: p< .001, d= 1.54). No acute changes were found in the Feeling Scale or MoodMeter®, but slight improvements were indicated in several dimensions, such as motivation after the SR (p= .054, r= 0.36),

which were not present after the IR (p= .306, r= 0.19). Cognitive performance improved after both runs in the d2-R (p< .05, r> 0.48). The scores in the digit span test remained stable after the SR (p> .05), but decreased after the IR (p< .05, r> 0.39). Brain activity increased only after the SR in the 1/f-corrected alpha band (p< .05), whereas it was reduced after both runs in the beta band (SR: p< .01; IR: p< .05), slope (each p< .001), and offset (SR: p< .001; IR: p< .05).
CONCLUSION. The IR did not clearly affect mood or cognition directly after running, but there are indications for deteriorations even though the physical workload was the same as for the SR. This highlights the potential relevance of perceived autonomy in exercise. Reduced aperiodic brain activity could reflect exercise-induced behavioral effects facilitated by improved neural communication and provide a neurophysiological explanation that running 'clears the mind'.

**SELF-CONTROL EXERTION AND GOAL PRIMING: EFFECTS ON TIME-TO-EXHAUSTION CYCLING PERFORMANCE**

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INTRODUCTION
Prior self-control exertion has been shown to have a detrimental effect on subsequent physical performance (Hunte et al., 2021). However, interventions to attenuate these negative effects on physical performance are limited. The current study had two primary objectives: a) to investigate whether prior self-control exertion reduced subsequent performance on a time-to-exhaustion cycling task (TTE), b) to investigate if goal priming could help to attenuate the detrimental effects of self-control depletion on subsequent physical performance. In addition, the study examined the potential for any observed performance decrements to be explained by changes in perceptions of pain and motivation.
METHODS
Fourteen recreationally active males (22.9±3.1 y) completed three TTE cycling tasks at 80% VO2 max on an electromagnetically braked cycle ergometer (Lode Bike). Prior to each TTE participants completed a congruent Stroop task (non-self-control depletion condition) or an incongruent Stroop task (self-control depletion condition) for 4 min. During the TTE, participants were asked to watch a video on the screen in front of them. During this video participants were exposed to a goal priming sequence (intervention condition) or a random letter sequence (control condition). Participants' perceptions of pain and motivation were recorded every 3 min during the TTE task.
RESULTS
A one-way repeated measures ANOVA revealed that there was no significant difference in TTE task performance between all experimental conditions ($p = 0.28$). Furthermore, there were no significant changes in perceptions of pain ($p = 0.36$) or motivation ($p = 0.21$) throughout the TTE cycling task. However, a significant difference was demonstrated for participants cycling cadence ($p = 0.01$). Post hoc t-tests revealed that participants cycled at a statistically significant higher cadence in both the self-control depletion and goal priming intervention condition and non-self-control depletion and control condition when compared to the self-control depletion and control condition (both $p < 0.01$).
DISCUSSION
The findings indicate that prior self-control exertion does not negatively affect subsequent TTE cycling performance. In addition, the findings suggest that goal priming does not improve endurance performance or attenuate the effects of initial self-control exertion on subsequent physical task performance. However, participants cycled at a higher cadence when exposed to a goal prime related to self-control. Participant's perceptions of pain and motivation during the TTE task were not influenced by prior self-control exertion or a goal prime.
REFERENCES:
Hunte, R., Cooper, S. B., Taylor, I. M., Nevill, M. E., & Boat, R. (2021). The mechanisms underpinning the effects of self-control exertion on subsequent physical performance: A meta-analysis. International Review of Sport and Exercise Psychology. doi: 10.1080/1750984X.2021.2004610
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**FROM THE LAB TO THE FIELD: THE RELATIONSHIP BETWEEN INHIBITORY CONTROL AND SPORTS PERFORMANCE IN TAEKWONDO**

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INTRODUCTION
Inhibitory control has been shown to have to capacity the predict the success in sports. In terms of taekwondo, previous research has demonstrated the relationship between laboratory inhibitory control measures and taekwondo training experience. Despite this, the utility of field-based cognitive measures and on-field performance correlation remains unclear. To address this issue, the present study aimed to examine the associations of lab- and field-based inhibitory control measures with on-field performance.
METHOD
Twenty-five senior high school taekwondo athletes (aged 16.5 ± 1.5 years) with taekwondo experience of 8 ± 5 years were recruited to participate in this study. Lab-based inhibitory control was measured using a go/no-go task. A similar go/no-go task administered by a specific LED equipment was used to assess the field-based inhibitory control. On-field performance was evaluated using a 5-point Likert scale including six questions by two seventh dan grade and a fourth dan grade black belt certified by the World Taekwondo Headquarters. The correlations between lab and field-based inhibitory control and on-field performance measures were investigated using Pearson's Correlation analysis.
RESULTS
Results revealed a significant correlation between lab- and field-based inhibitory control evaluated by go/no-go task designs. Moreover, on-field performance was significantly correlated with inhibitory control selectively for the field-based measure but not for lab-based measure, indicating that a taekwondo athlete with a high level of sports performance also has better ability of field-based cognitive function than their low-level counterparts.
DISCUSSION
We observed that lab-based inhibitory control was related to the field-based, indicating that the validity and feasibility from the lab may copy to the real field by the medium (e.g., LED equipment). However, only the taekwondo athletes field-based inhibitory control correlates with the on-field performance by experts' ratings, indicating that field-based inhibitory control may be a more sensitive measure to reflect

real-world performance of taekwondo. In conclusion, the present findings provided a basis for field-based cognitive function applications in taekwondo.

**DOES IMPROVING PHYSICAL LITERACY LEAD TO ENHANCED FITNESS STATUS? A 12-WEEK INTERVENTION STUDY**

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INTRODUCTION: Physical literacy (PL) is believed to improve physical activity, physical fitness, and overall healthy lifestyle habits [1]. However, the concept of PL is not embraced in South-eastern European countries [2]. Thus, the goal of this research was to apply and evaluate the effectiveness of the specific 12-week intervention aimed at the improvement of PL (PL-intervention) among high school students in Croatia. The aim was to determine whether PL-intervention will lead to changes (improvement) in the physical fitness of adolescents.
METHODS: This research was conducted on 364 high school students (244 females), grouped into intervention group (n = 207), and control group (n = 157). The intervention group was educated on PL-related topics by online-educational materials for 12 weeks (3 min video-animated education delivered 3 times a week) as an addition to regular physical education classes (PE), while the control group participated in PE only. Variables included anthropometric indices (body mass, body height, and body mass index), and physical fitness tests (standing broad jump, sit-and-reach test, sit-ups, and multilevel endurance test). Two-way ANOVA for repeated measures (group × time) was calculated to determine the effects of PL-intervention.
RESULTS: Significant group × time ANOVA effects were evidenced for body mass index ($F=3.94$, $p<0.05$) with negative changes in the intervention group (i.e., decreased body mass index), and the multilevel endurance test ($F=23.71$, $p<0.001$), with positive changes in the intervention group.
CONCLUSION: A 12-week PL-intervention induced positive changes in indicators of cardiovascular and metabolic health. It is important to emphasize that PL-intervention was relatively short, not time-consuming, and conducted during the COVID-19 pandemic, a crisis of unprecedented scale. Thus, similar interventions should be applied as online education both during the normal and crisis situation and can be embedded in the PE curriculum to improve the physical fitness and general health of children and adolescents.
References
1. Cairney J, Dudley D, Kwan M, Bulten R, Kriellaars D. Physical Literacy, Physical Activity and Health: Toward an Evidence-Informed Conceptual Model. Sports Med. 2019;49(3):371-383.
2. Young L, O'Connor, J Alfrey, L Penney D. Assessing physical literacy in health and physical education. Curric Stud Health Phys Educ. 2021; 12(2):156–179.

**MOTIVATION, EXERCISE AND EATING BEHAVIOR ENTANGLEMENT: A 12-MONTH'S CROSS-LAGGED ANALYSIS**

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Purpose
A healthy lifestyle involves several behaviors, such as regular exercise and balanced eating. Do changes in motivation for one health behavior affect other health behaviors? Previous research showed spill-over effects from intrinsic exercise motivation to eating and exercise behaviors among Portuguese women with obesity (Mata et al., https://doi.org/10.1037/a0016764). The current study extends these findings by examining reciprocal relations between motivation and health behaviors over time in a European group of men and women from the NoHoW trial, which tested behavior change sustainability mechanisms of action after an initial weight loss. We hypothesize that cross-lagged effects occur between exercise motivation, eating motivation, eating behavior, and physical activity (steps) during the 12-month trial.
Methods
The NoHoW trial includes data from 1627 adults seeking weight loss maintenance from the UK, Denmark, and Portugal. The present study involved 753 participants with complete data (66.3% women, 45.8 +-11.1 y). Eating motivation (REBS), exercise motivation (BREQ3), and Eating Behavior (TFEQ - Restraint and Disinhibition) were measured with validated questionnaires. Physical activity was operationalized as daily average of steps (FitBit Charge 2) in the 14 days after the baseline, 6- and 12-months measurements. We ran four cross-lagged panel models with Mplus, including exercise and eating autonomous vs. controlled motivation, steps, and restraint vs. disinhibition as variables.
Results
The models presented a good fit (RMSEA .023-.065) with an explained variance between R2 =.34 and .78. We found cross-lagged effects between steps and exercise autonomous motivation as well as eating behavior and eating autonomous motivation, suggesting cyclic increases in the quality of motivation, steps, and eating behavior. In contrast, cross-lagged effects among eating and exercise controlled motivations favored cyclic detriments on the quality of motivation. Disinhibition predicted exercise and eating controlled motivation. Higher exercise autonomous motivation at 6 months spilled over to increasing eating autonomous motivation, steps, and restraint. In the autonomous motivation models, motivation predicts behavior (i.e., cross-lag as expected). In contrast, behavior seems to predict motivation in the controlled models.
Discussion
This study partially replicated Matas spill-over results, providing extra layers of evidence. The results show that autonomous motivation predicts behavior. The "Whys" of the behavior are coherent with the behavior itself, hence less attrition. Interestingly, higher controlled motivation leads to a low-quality motivation spiral. In addition, disinhibition is predicting controlled motivation. Therefore, one can speculate that controlled motivations represent excuses for not being able to eat healthily instead of driving healthy behaviors. We will discuss results in light of behavior change maintenance theories

## Oral presentations

### OP-SH04 Learning in PE II

#### THE EFFECT OF THE AMOUNTS OF STUDENTS VERBAL COMMUNICATION IN JUNIOR HIGH SCHOOL PHYSICAL EDUCATION CLASSES ON LEARNING OUTCOMES

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INTRODUCTION: In Japan, physical education classes are required to " To enable students to improve physical fitness and harmonious development of both body and mind through engaging in physical activities appropriately. " (1). Previous studies have argued that increasing time for verbal communication in physical education classes is related to the learning of skills (2). In this research, we investigated the relationship between the amounts of students verbal communication and changes in students thinking.
METHODS: The target was one physical education teacher working in K junior high school and 27 students in one class (17 boys and 10 girls) in charge of the teacher. In addition, one physical education teacher working in N junior high school and 35 students in one class (20 boys and 15 girls) in charge of the teacher were the target too. The two physical education teachers are those who are in a leadership position and have sufficient experience.
One unit (8 hours) of dance lessons was given in K junior high school, and one unit (9 hours) of volleyball lessons was given in N junior high school. Each lesson, the amounts of students verbal communication was measured with a business microscope of Hitachi, Ltd. It can measure verbal communications by body movements. The amounts of students verbal communication in all lessons was individually averaged and divided by quartiles, with the top 25 percent in the top group and the bottom 25 percent in the bottom group. Changes in students thinking read by worksheets in each lesson, and we compared the top group to the bottom group.
Results and discussion:
In K junior high school, students in both groups looked back on their own dances and described the joy of dancing with a number of people in worksheet in the seventh and eighth hours. In addition, the top group touched on variations of dance in the fifth and sixth hours and development of performances by communicating with others in the seventh and eighth hours.
In N junior high school, the teacher promoted students verbal communication. So students in both groups looked back their verbal communication in worksheet in the final. But, Compared to the bottom group, the top group specifically described what kind of communication produced what kind of results.
From these two results, it is considered that the difference in the amounts of students verbal communication in the physical education class influence the learning outcomes such as the changes in students thinking.
References:
1) Ministry of education (2017). an education guideline.
2) M. Takahashi, T. Nakajima, T. Kawamoto, I. Kambayashi (2019). Relationship between students' verbal communication, and acquisition of
motor skills in junior high school physical education classes.
–Comparison with qualitative and quantitative data of athletics（Sprint running）–Hokkaido Journal of Physical Education, Health and Sport Sciences, 54, 101-111.

#### PHYSICALLY ACTIVE LEARNING AS A WAY TO MOVE BODY AND KNOWLEDGE IN SECONDARY SCHOOL STUDENTS?

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INTRODUCTION: Schools have been identified as a key setting to promote and implement more physical activity. Physically active learning (PAL) has become a popular approach where the curriculum is combined and/or integrated with physical activity in subject lessons [1]. Research about PAL is limited in secondary school, and it is unclear how physically active students are in such learning activities. This study aimed to examine students' physical activity in PAL activities in secondary school and explore their teacher's reflections on the use of PAL to fuller understand how PAL may or may not contribute to more physical activity in lessons.
METHODS: This study has a concurrent mixed methods design [2]. The participant group was one 10th grade class with 24 students and their teacher (male, 42 yrs.). Data were collected at four different times when students were taught Norwegian. Data collected in PAL activities: 1) Students' physical activity levels measured with accelerometers, 2) semi-structured observation of PAL activities, and 3) interview with the teacher post PAL activity.
RESULTS: During a 20-minute PAL lesson, the students spent on average 2.7 minutes in moderate to vigorous physical activity, 3.8 minutes in light activity, and 13.4 minutes in sedentary time. Girls were significantly more sedentary than boys ($p = 0.004$). In contrast, researchers evaluated the students' participation and engagement with the activities to be high, with positive energy and good moods based on the semi-structured observations. First, the teacher experienced PAL activities as a resource for teaching language and a valuable tool to create variation and interrupt sedentary time during school hours, even though those students have different needs, skills, and motivations. Second, the teacher expressed that his motivation for PAL is for the students to have fun. Thus, PAL is viewed as a way to "spice up" subjects' perceived as uninteresting by the students. The teacher's focus was on the activities themselves and less on the learning outcomes. Third, the teacher recognized that PAL could make some students feel both academic and physical performance pressure.
CONCLUSION: The PAL led to surprisingly low levels of executed physical activity compared to what was perceived by the researchers' observation. Further, knowledge on how to increase physical activity levels in general and for both genders and how to integrate the subject learning outcomes with physical activities is an important goal for future research in PAL.
References:
1. Daly-Smith, A., Quarmby, T., Archbold, V. S., Routen, A. C., Morris, J. L., Gammon, C., Bartholomew, J. B., Resaland, G. K., Llewellyn, B., & Allman, R. (2020). Implementing physically active learning: Future directions for research, policy, and practice. Journal of Sport and Health Science, 9(1), 41-49.
2. Andrew, & Halcomb, E. J. (2009). Mixed Methods Research for Nursing and the Health Sciences. John Wiley & Sons, Inc.

**PHYSICAL EDUCATION: AN EMBODIED APPROACH TO IMPROVE CHILDREN'S MATHS ACHIEVEMENT**

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*UNIVERSITÀ CATTOLICA DEL SACRO CUORE*

INTRODUCTION: The viewpoint of embodied cognition holds that cognitive processes are rooted in the body's interactions with the world aimed at gathering and collecting as much information as possible: cognition is situated, body based and for action1. Therefore, embodied education research may have important implications for education because it highlights an approach to learning through whole-body engagement2. To date, there has been little agreement on the positive effect of classroom-based lessons integrating mathematics/geometry and physical activity3,4. The aim of this research was to examine the effect of embodied education on mathematical achievement and physical fitness (PF) level.
METHODS: The study was designed as a school-based controlled trial targeting primary school children and was carried out between October 2020 and May 2021. Pupils were divided into the experimental group (EG) and the control group (CG), involving 82 children in the first and 39 in the second group. The intervention lasted 8 months, with two 50-min lessons per week, for a total amount of 30 lessons, carried out in the gym or in an open space. The CG did traditional physical education (PE) lessons, whereas EG, through practical activities during curricula PE lessons, learned geometrical and mathematical concepts. The assessments, performed twice, at the beginning and at the end of the project comprised: a mathematical achievement evaluation with the "Test for the evaluation of calculating and problem solving abilities" (AC-MT 6-11)5; three PF measurements by the six min walking test (6MWT)6, the 4x10m shuttle run test (4X10m SRT) and the standing broad jump test (SBJ)7.
RESULTS: Mathematical skills significantly improved throughout the sample with a greater achievement in the EG compared with CG (EG: $X2=27.88$; $p<0.05$; CG: $X2=12.11$; $p<0.05$). Children in the EG were significantly more successful in problem solving ability in maths than the CG ($p=0.0120$). Children in both groups significantly ($p=0.0210$) improved their 6MWT distance (EG: 538±66 and 564±55m; CG: 550±62 and 562±47m), however no significant intervention effect on 4x10m SRT (EG: 15.8±2.2 and 15.7±2.2s; CG: 15.9±2.3 and 15.9±2.3s) and SBJ (EG: 111.0±19.8 and 116.5±18.3cm; CG: 116.1±18.9 and 118.5±17.8cm) was observed.
CONCLUSION: To the best of our knowledge, this study investigated innovative aspects of the embodied education, not yet deepened by the recent literature. Participation in a 8-month PE intervention improved math achievement among elementary school children. This research confirms previous findings4 and contributes to the understanding of the close relationship between perception and action, mind and body.
References:
1Wilson, 2002,9(4):625-36
2Gallagher, 2015,27(3):391-404
3van den Berg, 2019,10;16(14):2452
4Have, 2018,13(12):e0208787
5Cornoldi, 2012,Gruppo MT,Erickson
6Li, 2005,25(6):1057-60
7Ruiz, 2011,45(6):518-24

**EFFECTS OF SCHOOL-BASED PHYSICAL ACTIVITY INTERVENTIONS ON LANGUAGE SKILLS: A SYSTEMATIC REVIEW AND META-ANALYSIS OF RANDOMIZED CONTROLLED TRIALS**

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INTRODUCTION
School seems to be an ideal context for the promotion of physical activity (PA), particularly given that children spend most of their school time sedentary [1]. School-based PA interventions appear as an overall beneficial strategy for the improvement of cognitive performance, general academic achievement or mathematical skills, but the evidence on their benefits on language skills remains unclear. Recent research proposes that language and action are both linked through the neural overlap between mirror neuron system for action and Broca´s area for speech articulation [2], [3]. We aimed to assess the effects of school-based PA interventions on language skills in children and adolescents.
METHODS: Relevant articles were systematically searched in PubMed, PsycINFO and Scopus from inception to December 2020. We included randomized controlled trials (RCTs) that performed a school-based PA intervention in children and adolescents (aged 3-18) and that assessed at least one outcome related to language skills (i.e., reading, spelling, vocabulary, verbal fluency and comprehension) or language academic achievement (i.e., school grades). A meta-analysis was conducted to determine the differences between groups (expressed as standardized mean difference [SMD] along with 95% confidence intervals [95%CI]) when ≥3 interventions assessed the same outcome.
RESULTS
Twenty-nine studies (14600 participants) were included, of which 16 performed an integrated PA intervention (i.e., performing PA along with the academic content), 10 a non-integrated one (e.g., extra physical education lessons), and three a combination thereof. Methodological quality of the studies was overall high. Significant benefits were observed for reading (SMD: 0.18; 95%CI: 0.09, 0.27), vocabulary (SMD: 0.65; 95%CI: 0.09, 1.21) and language school grades (SMD: 0.74; 95%CI: 0.23, 1.25), but no effects were observed for spelling, comprehension or verbal fluency (all $p>0.05$). No consistent differences were observed between integrated and non-integrated PA interventions, although sub-analyses were not possible for some outcomes.
CONCLUSIONS
School-based PA interventions appear as an effective strategy for improving different language-related skills and overall language school grades, although further research is needed to determine how interventions' and children's characteristics moderate these effects.
Key words: exercise; sedentarism; education; embodied learning; cognition.
REFERENCES:
[1] Egan, C. A. et al. Sedentary Time and Behavior during School: A Systematic Review and Meta-Analysis. Am. J. Heal. Educ. 50, 283–290 (2019).
[2] Casado, P. et al. When syntax meets action: Brain potential evidence of overlapping between language and motor sequencing. Cortex 100, 40–51 (2018).
[3] Glenberg, A. M. & Gallese, V. Action-based language: A theory of language acquisition, comprehension, and production. Cortex 48, 905–922 (2012).

# Oral presentations

## OP-AP26 High intensity interval training

### HIGH INTENSITY INTERVAL TRAINING PRACTICES IN COMPETITIVE FIELD-BASED INVASION TEAM SPORTS

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*TECHNOLOGICAL UNIVERSITY OF THE SHANNON: MIDLANDS MIDWEST, ATHLONE CAMPUS*

INTRODUCTION: High intensity interval training (HIIT) can be defined as alternating bouts of short duration exercise (e.g., 5s to 10 min) at near maximal or maximal intensities separated by complete rest or low intensity activity (1). Competitive field-based invasion team sports (FITS) such as rugby, soccer and Gaelic games demand high fitness levels in order to complement technical and tactical aspects of performance. Despite the high profile nature of FITS there remains a paucity of scientific literature examining training prescription practices of FITS coaches [2]. Given the potential of HIIT to elicit positive physiological adaptations and replicate match demands, the aim of this study is to investigate HIIT practices in FITS.
METHODS: A self-administered online survey consisting of 14 sections was developed to investigate coaches HIIT practices. Sections included coaches background information, general HIIT practices and practices specific to short intervals (SI's), long intervals (LI's), sprint interval training (SIT) and repeated sprint training (RST). Content validity of the survey was carried out using the modified Delphi technique. Fixed response questions were evaluated using a frequency analysis, with open-ended questions analysed using a thematic-analysis approach
RESULTS: Ninety-two coaches working across 9 FITS participated with 57% of coaches having more than 5 years coaching experience. In total, 80% of coaches (n=74) prescribed HIIT. While HIIT was used during all stages of the season by 77% (n=57), 86% (n=51) of coaches varied their prescription depending on the time of the season. Fitness levels (74%), injury (69%) and number of days since a previous match (61%) were frequently cited reasons for coaches adapting their sessions for individuals in the squad. SI's (n=65) and SIT (n=47) were the two most commonly used methods of HIIT. However, LI's (n=35) and RST (n=38) were also frequently implemented by coaches.
CONCLUSION: This study provides insight into the use of HIIT in FITS and identified that coaches implemented HIIT due to its time efficient nature, its ease of implementation and its sport specificity. Although the specific content of HIIT sessions (number of reps, work-rest ratio, intensity) was highly variable between coaches, the results of this study can be a valuable resource to FITS coaches when prescribing various HIIT formats during various stages of the season. In particular, this information can be beneficial to coaches who do not implement HIIT as one of the most commonly cited reasons for coaches not implementing HIIT included a lack of knowledge.
References:
1. Laursen and Jenkins., Sports Med, 2002.
2. Jones et al., Journal of strength and conditioning research, 2016.

### EFFECTS OF INCLUDING HIGH-INTENSITY INTERVALS DURING REGULAR TRAINING ON MAXIMAL OXYGEN UPTAKE IN 12-YEAR OLD PHYSICALLY ACTIVE ADOLESCENTS - A RANDOMIZED CONTROLLED TRIAL.

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INTRODUCTION: Maximal oxygen uptake (V̇O2max) increases during puberty in parallel with the increase in fat-free mass (1, 2). If high-intensity training (HIT) adds to the effects of growth and maturation is controversial (3). Therefore, the aim of this study was to investigate if inclusion of HIT during an 8-weeks training period was superior to either strength and coordination training (SC), or minimal training, in young adolescents.
METHODS: Thirty-five adolescents from a cross-country ski club (age: 12.3 ± 0.3) were randomized into a HIT group (HITgr) (n=22, girls=15) and a SC group (SCgr) (n=12, girls=8), while also including a group of less active or sedentary school children (age: 12.3 ± 0.3) (C, n=29, girls=15). HITgr performed high-intensity intervals (≥ 10 min work period, target heart rate ≥ 90% of HRpeak) twice weekly, while SCgr conducted low-intensity SC training. Training volume was reported through a training log, and training intensity assessed with a HR monitor. Physical activity (PA) was monitored with an accelerometer for one week. Fat-free mass (FFM), V̇O2max and hemoglobin mass (Hbmass) were tested pre- and post-training. A one-way and two-way ANOVA analysis were performed to detect mean group differences and pre-post changes, respectively. Level of significance was set to $p<0.05$, and results are presented as mean ± SD
RESULTS: The number of training sessions per week during the training period were higher for HITgr (5.4 ± 1.7) and SCgr (4.5 ± 1.2) compared to C (1.7 ± 2.0) ($p<0.05$). HITgr had 1.9 ± 0.2 interval sessions per week, while SCgr and C had none. At baseline, there was no difference between groups in FFM (HITgr: 31.7 ± 4.7kg, SCgr: 32.3 ± 3.4kg, C:33.5 ± 5.9kg), but both HITgr and SCgr had significantly higher absolute V̇O2max (ml·min-1) and V̇O2max relative to FFM (HITgr: 73.2 ± 6.1 ml·kgFFM-1·min-1, SCgr: 75.1 ± 5.8 ml·kgFFM-1·min-1, C: 61.0 ± 5.9 ml·kgFFM-1·min-1) compared to C ($p<0.01$). There were no differences in total Hbmass (g) or Hbmass relative to FFM between HITgr (13.5 ± 0.7 g·kgFFM-1), SCgr (13.7 ± 1.0 g·kgFFM-1) or C (13.0 ± 1.6 g·kgFFM-1). The change in V̇O2max absolute values was 6% ± 6% for HITgr ($p<0.01$), 5% ± 7 for SCgr ($p=0.13$), and 5% ± 13% for C ($p=0.13$) with no differences between groups. V̇O2max relative to FFM did not change significantly for either HITgr (3% ± 6%), SCgr (3% ± 7%) or C (4% ± 14%), due to the similar increase in FFM for HITgr (3% ± 2%), SCgr (3% ± 2%) and C (2% ± 3%). There were no changes in Hbmass relative to FFM for either HITgr (-2% ± 4%), SCgr (-2% ± 4) or C (3% ± 5).
CONCLUSION: The change in V̇O2max was similar in all groups, which suggests that development of V̇O2max over a short-term training period in a group of physically active adolescents is not affected by HIT. Both V̇O2max and Hbmass seems to increase parallel to the increase in FFM.
1. Landgraff & Hallén (2020) 2. Landgraff et al. (2021) 3. Dotan (2017)

## OXYGEN UPTAKE AND HEART RATE BASED TIME-IN-ZONE ANALYSIS OF FOUR ISOCALORIC HIGH-INTENSITY INTERVAL TRAININGS WITH RESPECT TO FITNESS LEVEL AND SEX

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INTRODUCTION: Athletes use a variety of high-intensity interval training (HIIT) forms to improve endurance performance [1]. Maximizing time in the "high-intensity zone" (Z3) (≥90% maximal oxygen uptake (VO2max) or ≥90% maximal heart rate (HRmax)) is crucial for triggering positive adaptations [2]. Previous studies comparing different HIIT forms used mainly work-matched protocols with well-trained athletes [3,4]. To date, no study used an isocaloric approach (i.e., equal energy expenditure (EE)) to compare different forms of HIIT. Here, we compared the time-in-zone (TIZ) between four different isocaloric HIIT forms and the effects of fitness level and sex.
METHODS: Five untrained females (VO2max: 37.4±2.5 ml/min/kg.), 5 well-trained females (VO2max: 56.2±2.5 ml/min/kg), 5 untrained males (VO2max: 47.6±4.9 ml/min/kg) and 5 well-trained males (VO2max: 69.3±4.2 ml/min/kg) underwent a cycling ramp test to exhaustion to determine peak power output (Ppeak), VO2max, HRmax and lactate kinetics to set training intensities and zones (VO2Z3:≥90%VO2max, HRZ3:≥90%HRmax). Subsequently, three aerobic HIIT forms in counterbalanced order were performed using the EE of the first HIIT to ensure isocaloric EE for the following forms (1) "5x4"min at power output at 90%HRmax with 2.5min recovery at power output at 1.5mmol/L lactate (PLIT) (2) "30x30"s at 100%Ppeak with 30s recovery at PLIT (3) "15x1"min at 100%Ppeak with 1min recovery at PLIT and (4) speed endurance production (SEP) training with 40s intervals at 125%Ppeak and 4min 20s recovery at PLIT. There was at least 48 hours between all forms of HIIT. Breath-by-breath and HR data (Quark CPET, Cosmed, Italy) was measured continuously and resampled for one second values using linear interpolation. A two-factor repeated measures ANOVA was used to detect differences between programs as well as sex and fitness level. Effect sizes (ES) are expressed as partial eta-squared.
RESULTS: Mean VO2Z3 time was 179±298, 95±306, 91±162, 12±20s for 5x4, 30x30, 15x1 and SEP, respectively. No differences were found between forms (P=0.07, ES=0.391). Mean HRZ3 time was 793±406, 890±691, 927±588, 206±223s for 5x4, 30x30, 15x1 and SEP, respectively. Significant differences were revealed between forms (P<0.001, ES=0.871) with SEP achieving lower time compared with all other HIIT versions (P<0.001). No effects were observed for fitness level (P=0.81, ES=0.064) or sex (P=0.25, ES=0.248) on VO2Z3 time. Regarding HRZ3 time, a significant effect for sex (P=0.04, ES=0.447) with higher times in females compared with males but no significant effects for fitness level (P=0.54, ES=0.139) was observed.
CONCLUSION: Different isocaloric HIIT forms may lead to differences in TIZ parameters. TIZ regarding HR demonstrated a different pattern when compared with VO2. While sex had a significant effect on HRZ3, fitness level had no effect on either HRZ3 or VO2Z3.
1. Buchheit & Laursen (2013) 2. Wenger & Bell (1986) 3. Bossi et al. (2020) 4. (Rønnestad & Hansen (2016)

## TIME SPENT ABOVE 90% VO2MAX DURING UPHILL VS. HORIZONTAL RUNNING DURING HIGH INTENSITY INTERVAL TRAINING: POLARIZATION IMPLICATIONS FOR ENDURANCE TRAINING

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INTRODUCTION: Polarized training (POL) is an effective model of training intensity distribution (TID) for competitive distance runners to increase aerobic performance [1,2]. Thereby, less than 20% of the total weekly training sessions is high intensity training and spent above 90% of maximal oxygen uptake (VO2max). Athletes often spent less time than intended above 90% VO2max. Thus, real polarization seems partly violated as high intensities trend to threshold intensities. Compared to horizontal running, uphill running reduces the mechanical impact [3] and increases relative muscle activation [4]. However, comparative data on how and to which extend uphill running affects HIIT compared to horizontal HIIT running given as time spent above 90% VO2max is still lacking. Thus, the present study examined the effects of uphill versus horizontal HIIT on the relative percentage of VO2max.
METHODS: Nineteen well-trained distance runners (7 females, 9 males; 26 ± 7 y; VO2max: 62,4 ±4,6 ml/min/kg) had 4 randomly assigned lab visits in 4 weeks (one test each week) on a treadmill at uphill (8% incline) and horizontal (1 %): Prior to the HIIT protocols, an incremental exercise test were conducted to determine VO2max. Running speed associated with 90% VO2max and was applied. HIIT running comprised 4 x 5 min intervals, with 90 s rest in between while respiratory gas exchange was measured together with heart rates (HR), blood lactate concentrations and rate of perceived exertion (RPE). A repeated measures analyses of variances (rANOVA) was computed to detect interaction effects between the conditions and intervals (INT1-4). Bonferroni post-hoc tests were calculated in case of significant interaction effects.
RESULTS: Time spent running above 90% VO2max was significantly (p=0.001; SMD=0.95) higher for uphill HIIT (11.6 ± 2.9min) compared to horizontal HIIT (8.7 ± 2.5min). HR (p =0.17) and blood lactate (p =0.14) did not differ significantly. Interestingly, lower RPE levels (p =0.006, SMD=0.64) were observed for uphill HIIT (INT1: 13.6 ± 1.4; INT2: 14.8 ± 0.7; INT3: 16 ± 1.2; INT4: 16.9 ± 1) compared to horizontal HIIT (INT1: 13.9 ± 1.3; INT2: 15.6 ± 1.4; INT3: 17.5 ± 1.4; INT4: 18.6 ± 1.3).
CONCLUSION: Our findings indicate that uphill HIIT result in more time spent running at or above 90% VO2max at lower RPE with comparable HR and lactate levels. Thus, uphill HIIT can be seen as a valuable training approach fore successful training polarization at high VO2max levels and lower running impacts and mechanics.
1. Stöggl & Speerlich (2014) 2. Holfelder (2016) 3. Hoogkamer (2014) 4. Sloniger (1997)

## QUANTIFICATION OF IN-SEASON HIGH-INTENSITY RUNNING IN YOUNG SOCCER PLAYERS.

HIDALGO-DE MORA, J.1,2, LÓPEZ-SEGOVIA, M.1,3, CAMPOS-VÁZQUEZ, M.A.1,4, PAREJA-BLANCO, F.4

*CEU ANDALUCÍA UNIVERSITY, SEVILLA*

INTRODUCTION: During the past decade, high-intensity running has exponentially increased throughout soccer matches (1, 2), being considered a key factor in elite soccer (3). In this regard, elite soccer players spend longer times at low speeds across training sessions compared to those attained during matches (4, 5). Therefore, the aim of this study was to compare the training load and high-intensity running recorded during training sessions and official matches.
METHODS: On-field in-season training load during four training days was analyzed with respect to the number of days before or after a match (MD; MD+1; MD-4, MD-3 and MD-2) (5). A total of ten young soccer players from an U23 semi-professional team (22.4 years ± 2.0) and an U19 (17.9 years ± 0.6) elite team, having played at least 60 min during 14 matches, were included into this study. Running activity was collected with GPS (Catapult, EVO) and the following variables were analyzed: total distance covered (TD), distance covered between 19.9 and 25.2 km.h-1 (HID), distance covered at above 25.2 km.h-1 (SR) and peak speed achieved (PS).

RESULTS: Match demands were significantly higher to all training days in both teams ($p < 0.05$), except for PS which were not significantly different in MD-3, as well as SR for U23 team ($p = 1.000$). Multiple differences were found between teams, in particular, significant higher values of TD and HSR were observed during MD, MD+1, MD-4, MD-3 and MD-2 in U19 compared to U23. Moreover, no significant differences were found during MD-3 in SR and PS between teams ($p = 0.227$ and 0.195, respectively).
CONCLUSION: Our findings show that high-intensity running during training sessions are lower than those achieved during matches in young soccer players, regardless to their performance level. Moreover, MD-3 is the typical high-velocity training day, although it is not enough to stimulate the competitions demands in young elite teams.
1. Barnes et al. (2014) 2. Bradley et al. (2016) 3. Faude et al. (2012) 4. Martin-Garcia et al. (2018) 5. Akenhead et al. (2016)

## 15:30 - 16:45

## Invited symposia

### IS-MH03 Dimensions of health threats due to headers in soccer

#### BEHAVIORAL EFFECTS OF HEADER INDUCED HEAD IMPACTS IN SOCCER

HERMSDÖRFER, J.

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As behavioral assessments, still, are the most frequently used means to investigate potential header-related deficits, this presentation will first address the current evidence concerning behavioral impairments as a result of soccer heading and specifically focus on the most common methodological approaches. These typically rely on the administration of pre-specified test batteries (e.g., ANAM, CogState, etc.) to assess players' neuropsychological performance across several domains including attention, working memory, and executive functioning. Although performance decrements have been reported in active players after an acute bout of heading (Di Virgilio et al., 2016) as well as in retired soccer players (Prien et al., 2020), current systematic reviews argue that the empirical evidence for neuropsychological impairments as a result of to soccer heading remains inconclusive (Kontos et al., 2017; Tarnutzer et al., 2017).
In addition to these neuropsychological outcomes, we would like to emphasize the importance of expanding these behavioral assessments towards the inclusion of sensorimotor tests. While evaluation of sensorimotor performance across balance, gait or eye movement tasks revealed heading-related deficits in short-duration lab-tests (Caccese et al., 2021; Nowak et al., 2020), knowledge about potentially persisting sensorimotor deficits associated with soccer heading remains scarce due to the limited application of sensorimotor assessments in longer-term observational studies. However, as persisting motor deficits, such as impairments in fine motor control, have been commonly observed in contact sport athletes (e.g., American football players) following concussion (Pearce et al., 2015), they might also result from repetitive head impacts due to heading the ball.
Recently, we employed a prospective design to investigate the potential relationship between purposeful heading and behavioral changes in 22 female soccer players (mean age: 22.0 ± 3.9 years). Behavioral performance was assessed immediately before and after one competitive season by means of an extensive test battery consisting of neuropsychological as well as sensorimotor tests. Head impacts were registered using video recordings and miniaturized accelerometers affixed behind the players' ears. Multiple linear regression analysis revealed a statistically significant model with four factors ($R2adj = 0.65$, $p < 0.01$). A greater number of headers was associated with negative alterations in postural control ($ß = 0.49$, $p < 0.01$) and concomitant positive changes in working memory performance ($ß = 0.33$, $p = 0.03$) in a dual task as well as fine motor deficits in a writing task ($ß = 0.35$, $p = 0.02$ and $ß = -0.47$, $p < 0.01$). Our findings will be discussed in relation to the existing literature on neuropsychological and sensorimotor deficits due to soccer heading and with regard to further recommendations for the application of behavioral assessments in the context of head impact research.

#### STRUCTURAL AND FUNCTIONAL BRAIN CHANGES INDUCED BY HEADERS OVER 12-18 MONTHS

REINSBERGER, C.

*PADERBORN UNIVERSITY*

Heading the ball in soccer may be related to structural and functional brain changes as measured by (f)MRI. Regional brain volumes, cortical thickness and functional connectivity (FC) have been shown to be associated with repetitive head impacts (RHI), although causality, dose response relationships and clinical modifiers are still vividly debated. Most data have so far only been derived from cross-sectional studies and therefore contains some methodological flaws.
In this presentation data from a longitudinal study will be presented that included 14 active professional soccer players (mean age 20.36 ± 3.34 years). MRI scans (3T), neuropsychological and neurophysiological assessments were performed before and after an observation period of 12-18 months (median 17.2 months), during which each training session and game was recorded on video to allow characterization of each header performed by any player who participated in the study. Structural T1 images and resting state fMRI sequences were used to analyze changes in cortical thickness and functional connectivity between the two time points (controlled for age) with specific emphasis to the default mode network (medial prefrontal cortex, lateral parietal left and right, posterior cingulate cortex) representing the default mode network (DMN), as the DMN is one of the primary targets for RHI induced structural or functional brain changes. During the observation period between 146 and 943 (median 340.5) headers per player were recorded and used as a regressor for the imaging as well as neurophysiological and neuropsychological data. Cortical thickness measures in single clusters were higher before the observation, but no significant correlation with heading frequency was detected. FC changed significantly from pre- to post-observation in a cluster comprising the superior frontal gyrus and frontal pole bilaterally, but also without significantly correlating with heading frequency. Results will be discussed in relation to clinical, neuropsychological and neurophysiological data as well as characteristics of headers beyond frequency (e.g. playing situation, length of pass leading to header, header duel etc.) and clinical recommendations will be provided.

**PHYSIOLOGICAL BRAIN CHANGES AS A RESULT OF HEADER INDUCED HEAD IMPACTS IN SOCCER**

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*UNIVERSITY OF STIRLING*

INTRODUCTION: Across the sporting world there is growing concern about long-term consequences of sport-related head impact on brain health. To date, relatively little attention has been paid to understanding mechanisms by which these chronic effects arise. In principle, however, the origins of long-term damage must first be evident in acute brain changes. This presentation will therefore focus on the acute physiological brain alterations that occur following routine head impacts in soccer, and what this means for the current understanding of brain health in contact sport.
Our research was the first direct demonstration that soccer heading disrupts the brain. Critically, we examined the impact of the modern football, because any effects of heading on brain health have often been dismissed as an issue of the past (related to old leather footballs being heavy in wet conditions). This presentation will show the direct evidence for brain and brain-to-muscle changes following the routine impacts of a standard soccer heading drill, utilises the neuroimaging technique of Transcranial Magnetic Stimulation (TMS). In this lab-based research, soccer players headed a modern football 20 times, as is typical in training sessions. The ball was fired from a ball machine to simulate the pace and power of a corner kick. Before and after the heading sessions we measured brain inhibition using TMS, as well as assessing players' memory function. We found that soccer heading resulted in immediate and measurable disruption to brain function: increased inhibition in the brain was detected in 74% of participants, and cognitive tests revealed memory performance was also reduced by 41-67%. In this presentation, we will also examine further research on the physiological brain changes following a standard heading drill. It is currently not known how much impact is safe in contact sport. We therefore examine the dose-response relationship of soccer heading and physiological changes at a brain level. Also unknown are the mechanisms through which changes to brain health in contact sport arise. In this presentation, we therefore look at the relationship between changes in brain chemistry following soccer heading and the physiological brain response when learning and attending. We will also look at how, by combining different neuroscientific methods linked to the effects of soccer heading on blood biomarkers of brain injury, we can develop the understanding of what happens in the brain when players head the ball and reveal critical evidence on cause and effect of brain health in contact sport. Our findings and research approaches will be discussed in relation to the existing neuroscientific and brain health literature and with regards to recommendations around the safety of routine head impact in sport.

# Oral presentations

## OP-PN07 Dietary Supplements

**THE EFFECT OF SHORT-TERM DIETARY NITRATE SUPPLEMENTATION ON SKELETAL MUSCLE CALCIUM HANDLING AND HIGH-INTENSITY INTERMITTENT EXERCISE PERFORMANCE IN HEALTHY ADULTS**

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INTRODUCTION: Dietary supplementation with nitrate ($NO_3^-$), which can undergo a stepwise reduction to nitrite ($NO_2^-$) and then nitric oxide, has been reported to improve performance in a variety of exercise settings. The ergogenic effect of $NO_3^-$ supplementation has been attributed to improved skeletal muscle calcium ($Ca^{2+}$) handling, based on data from mouse muscle indicating improved sarcoplasmic reticulum (SR) $Ca^{2+}$ release or reuptake after $NO_3^-$ or $NO_2^-$ administration, but this has yet to be tested in human skeletal muscle. This study tested the hypothesis that $NO_3^-$ supplementation would improve high-intensity intermittent exercise (HIIE) performance and skeletal muscle SR vesicle (SRV) $Ca^{2+}$ release and reuptake.
METHODS: In a randomised, double-blind, cross-over study design, 16 recreationally active adults (23 ± 2 yrs) consumed $NO_3$rich (BR, 13 mmol of $NO_3^-$ ) or $NO_3$depleted (PL, <0.1 mmol of $NO_3^-$) beetroot juice for 7 consecutive days. Muscle biopsy (n=6) and blood samples were collected on day 7 of supplementation at rest and after attaining 80% of task failure during a HIIE test, which was established during a preliminary HIIE performance test. The HIIE protocol consisted of repeated 15 s cycle intervals at 160% of maximal aerobic power interspersed with 30 s recovery. After 20 min passive rest, the HIIE protocol was repeated and continued until task failure. A paired samples t-test was used to analyse HIIE performance, with plasma [$NO_3^-$] and muscle SRV $Ca^{2+}$ handling data analysed with two-way repeated-measures ANOVAs.
RESULTS: Resting plasma [$NO_3^-$] (381 ± 105 vs 44 ± 22 uM, $p<0.001$) and the number of repetitions completed in the HIIE protocol (13 ± 5 vs 12 ± 4, $P=0.04$) were higher after BR compared to PL supplementation. While SRV $Ca^{2+}$ release rate was lower after HIIE compared to rest in the PL condition (1.5 ± 0.3 vs 1.7 ± 0.4 µmol/gr prot/min, $p=0.03$), there was no main effect for supplement or no supplement x time interaction effect on SRV $Ca^{2+}$ release rate ($P>0.05$). There was a main effect for supplement and a supplement x time interaction effect on the rate of SRV $Ca^{2+}$ reuptake ($p<0.05$). Compared to rest, SRV $Ca^{2+}$ reuptake rate was slower after HIIE in PL (31.1 ± 7.1 vs 35.7 ± 7.3 s, $p<0.01$), but not BR (30.0 ± 7.3 vs 29.9 ± 8.3 s, $p>0.05$). There was no difference in SRV $Ca^{2+}$ reuptake between BR and PL at rest ($p>0.05$), but SRV $Ca^{2+}$ reuptake was faster after HIIE in BR compared to PL ($p<0.01$).
CONCLUSION: Short-term $NO_3^-$ supplementation improved performance and speeded skeletal muscle SRV $Ca^{2+}$ reuptake during HIIE in healthy adults. While SRV $Ca^{2+}$ release rate was impaired following HIIE, this was not alleviated by BR. These observations improve understanding of the physiological mechanisms by which $NO_3^-$ supplementation may enhance exercise performance.

**INTERMITTENT EXOGENOUS KETOSIS FACILITATES THE REHABILITATION OF MUSCLE DISUSE ATROPHY**

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*KU LEUVEN*

INTRODUCTION: Muscular disuse has debilitating effects on muscle mass and strength, and impairs functional capacity (1). Previous research indicated that elevated blood ketones can negate catabolic events during energy deficit (2). In addition, we recently showed ketone

ester ingestion to enhance the anabolic response post-exercise (3) as well as to stimulate exercise performance during endurance training overload (4). From this perspective, we hypothesized that ketone ester (KE) ingestion may be a potent strategy to attenuate the decline in muscle mass, strength, and functional capacity following muscle disuse as well as to stimulate subsequent rehabilitation.
METHODS: A randomized, double-blind trial was performed in young healthy volunteers (9 females and 15 males). Subjects underwent 2-weeks of immobilization of their dominant leg followed by a 4-week rehabilitation program involving unilateral resistance exercise (3 sessions/week). Half of the subjects received 3 x 20g of the ketone monoester (R)-3-hydroxybutyl (R)-3-hydroxybutyrate (KE) per day, whilst the others ingested a taste-matched, isocaloric placebo (CON). Before and after immobilization and after 2 and 4 weeks of rehabilitation, in both legs, muscle volume was assessed using a computed tomography scan, and maximal dynamic and isometric knee-extension torques were measured. Exercise capacity was evaluated by a graded exercise test on a cycling ergometer with the immobilized leg only. A two-way repeated-measures ANOVA was performed to evaluate differences between both groups and over time.
RESULTS: KE intake increased blood D-ß-hydroxybutyrate levels up to 2.9 ± 0.2 mM within 30 min, whereas in CON blood ketone levels remained at baseline (interaction effect, $p<0.001$). Immobilization decreased quadriceps muscle volume (~5%) and knee-extension torque (~15%) by the same magnitude in both groups. Compared with CON, KE intake stimulated the rehabilitation of muscle volume and isometric knee-extension torque by ~5% (interaction effects, $p < 0.05$). KE intake also gradually increased muscle volume in the contralateral leg (CON: +1.7 ± 0.8% vs. KE: +4.7 ± 0.7%, interaction effect, $p < 0.05$) without affecting knee-extension torque. Peak power output in the unilateral cycling test decreased upon immobilization in CON (pre: 133 ± 10W vs. post: 114 ± 9W) but not in KE (pre: 126 ± 12W vs. post: 121 ± 11W, interaction effect, $p < 0.05$).
CONCLUSION: These findings indicate that KE intake does not affect disuse muscle atrophy but attenuates the decline in functional capacity as well as facilitates rehabilitation of muscle mass and strength.
1. Vigelsø et al., J Physiol, 594, 2339-2358 (2016).
2. Pawan et al., Lancet, 594, 1983, 15-17 (1983).
3. Vandoorne et al., Front Physiol, 8, 1-12 (2017).
4. Poffé et al., J Physiol, 597, 3009-3027 (2019).

## MOUTH RINSING AND INGESTING SALTY OR BITTER SOLUTIONS AFTER HEAVY INTENSITY CYCLING DOES NOT INFLUENCE SPRINT PERFORMANCE OR NEUROMUSCULAR FUNCTION.

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INTRODUCTION: Previous research suggests that ingesting an unpleasant bitter tastant can enhance cycling sprint performance. However, the mechanisms facilitating changes in performance are unclear and it is not known if other unpleasant tastes could also be ergogenic. Therefore, the purpose of the present study was to explore the effect of unpleasant salty and bitter tastes on cycling sprint performance and neuromuscular function in different fatigue states.
METHODS: Eight trained male cyclists (age: 37 ± 9 years, weight: 82 ± 9 kg, VO2max: 55 ± 4 ml.kg-1.min-1) participated in five laboratory visits. In the first visit participants completed a cycling ramp test to determine VO2max and the respiratory compensation point (RCP). In the familiarisation and the three main trials participants cycled at 85% of RCP for 45 minutes and then, after a 5 minute rest, completed a maximal 1 minute cycling sprint. Neuromuscular function was assessed using two knee extensor maximal voluntary contractions (MVC) immediately before, between and after the cycling efforts. Participants mouth rinsed (5 s) and ingested a 25 ml test solution immediately before each MVC and the cycling sprint. Using a randomised cross-over design the test solution in the three main trials were salt (1 M), bitter (2 mM quinine) and a water control condition.
Differences between conditions in cycling performance were assessed using one-way repeated measures ANOVA. Differences in neuromuscular function were assessed using a time*condition repeated measures ANOVA. Bonferroni post-hoc comparisons located significant differences. Data are presented as mean ± SD.
RESULTS: Average and maximum power were not significantly different between conditions during the 1 minute cycling sprint (average: 512 ± 64 W, 513 ± 67 W, 515 ± 74 W, and 503 ± 80 W; maximum: 876 ± 86 W, 884 ± 136 W, 884 ± 145 W, 890 ± 108 W in the familiarisation, water, salt and bitter conditions, respectively). Additionally, there was no significant difference in average and maximum cadence during the sprint.
Maximal voluntary force and 100-200 ms impulse declined following exercise in all conditions, showing a significant main effect for time. However, for 0-50 ms and 0-100 ms impulse there was no significant main effect for time. Furthermore, there was no significant effect of condition or condition*time interaction for maximal voluntary force or any impulse variables.
CONCLUSION: Previous research has shown ingesting a bitter solution improves sprint performance when it is commenced without prior fatigue. However, the present study found no effect of a bitter taste on 1 minute cycling performance after heavy intensity cycling. Furthermore, the bitter taste had no influence on neuromuscular function at rest or in a fatigued state. Similarly, an unpleasant salty solution had no effect on cycling performance or neuromuscular function. Further research is required to determine if and how ingesting bitter, or other unpleasant tastes, may be beneficial for sprint performance.

## ARE THE ACUTE EFFECTS OF NEW ZEALAND BLACKCURRANT EXTRACT ENDURANCE PERFORMANCE-DEPENDENT IN TRAINED CYCLISTS: A HOME BASED STUDY.

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INTRODUCTION: Acute intake of blackcurrant anthocyanins improved vascular function (1) and reduced oxidative stress post-exercise (2). Responses seem to be dose-dependent reaching a plateau at 310 mg of anthocyanins (1). No data is available on exercise performance with intake of such a dose. In December 2019, a novel coronavirus, named COVID-19, became pandemic forcing people to stay at home. Therefore, this study presents a novel approach testing the acute effects of 900 mg of New Zealand blackcurrant (NZBC) extract (315 mg of anthocyanins) on endurance cycling performance in a home-based environment using an online software.
METHODS: A randomized, double-blind, placebo-controlled trial was implemented. Thirty-four cyclists [(26 males and 8 females, age: 38 ± 7 years, V O2max: 57 ± 5 ml/(kg·min)] completed four 16.1 km time trial (TT) (two full familiarizations and two experimental trials) in the morning connecting their turbo-trainers to an online simulator (ZWIFT). Females reported symptoms on a menstrual cycle questionnaire (MCQ) before starting. Capsules containing 900 mg of NZBC extract or an equivalent placebo (PLA) were consumed 1.5 h before the TT. Time, power, speed, distance, heart rate, and cadence were recorded. Data were analysed as a group and for evenly separated faster

(<1400 s) and slower riders (>1400 s). Differences between conditions were assessed with a t-test. A repeated-measures ANOVA was implemented to analyse differences between distance points (4, 8, 12 and 16.1 km). Coefficient of variation (CV), typical error (TE) of the model and 95% CI were calculated. Significance was set at p<0.05 and data reported as mean ± SD.
RESULTS: Consumption of NZBC extract resulted in a faster TT compared to PLA, close to significance (1414 ± 91 s vs 1422 ± 104 s; 95% CI [-0.53, 17.06], p=0.06) with a small effect size (d=0.3). No difference was observed for power, speed, HR, RPM and RPE. The slower group (n=17) average time to complete the 16.1 km TT was 20 s faster with NZBC extract compared to PLA (1479 ± 83 s vs 1499 ± 91 s; 95% CI [4.18, 34.52], d=0.65, p=0.01,). Power profile across the whole TT in the slow group was higher with data close to significance at 8 km (PLA: 234 ± 54 W, NZBC: 239 ± 54 W, p=0.06, d=0.4) and being different at 12 km (PLA: 232 ± 54 W, NZBC: 239 ± 51 W, p=0.02, d=0.6). Slower group CV was 1.3% with a TE=20 s. There was no difference between conditions for time, power, speed, HR and RPM in the faster group. No differences between conditions for MCQ symptoms were reported.
CONCLUSION: Acute consumption of 900 mg of NZBC extract improved 16.1 km cycling TT performance in the slower group (>1400 s) with no changes in the faster group. However, variation within the model showed a ~20 s TE which is within the improvement observed. The effectiveness of anthocyanin-rich supplementation seems to be cycling performance-dependent, but more research is warranted to confirm these preliminary results.
1. Rodriguez-Mateos et al., (2013)
2. Lyall et al., (2009)

**COMPARISON IN THE CONSUMPTION OF SPORTS SUPPLEMENTS ACCORDING TO COMPETITIVE LEVEL.**

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INTRODUCTION: Powerlifting is a sport based on lifting the maximum weight possible in three exercises: squat, bench press, and deadlift (1). The range of consumption of supplements in sports (SS) is very wide and, currently, we place it between 30-95% (2). This variation in consumption can depend on various variables, mainly the type of physical activity or sport (i), the level of performance or competition of the athlete (ii), gender (iii), and age (iv) (3). The studies that collect the consumption of SS in powerlifters are scarce. Knapik et al (4), Petkova et al (5), and Al Saffan et al (6) show a high prevalence of use in this discipline with a percentage of consumption of 85%, 100%, and 73.1%, respectively. Currently, there is no research that studies the prevalence and pattern of consumption based on the variables that determine it in powerlifters. Thus, the objective of this study was to analyze possible differences in performance and consumption of SS in powerlifters of the international level (INT) with respect to the national level (NAT).
METHODS: 32 male powerlifters (10 INT, 22 NAT) completed a 72-hour supplement diary (2 training days and 1 rest day), as well as a questionnaire regarding SS consumption. In addition, the best performance in squat, bench press, and deadlift during a competition in the month previous to the study was recorded.
RESULTS: INT level athletes reported a higher total performance (+20,1%; p<0,001; ES=1,46) and in each of the exercises: squat, bench press and deadlift (p<0,05; ES=0,99–1,29). The 100% of the sample consumed SS, the most consumed being creatine monohydrate (63%), whey protein (59%), vitamin complex (34%), caffeine (25%) and branched-chain amino acids (19%), there being only differences in the consumption of whey protein by INT level athletes (90% vs 45%; p=0,024; OR=1,75 [1,11–2,76]).
CONCLUSION: INT level athletes reported higher performance. However, there were no significant differences in overall SS consumption.
References:
1. International Powerlifting Federation (IPF). Reglamento Técnico IPF 2019. https://bit.ly/2NcmI74
2. Sánchez-Oliver, AJ, et al. A survey on dietary supplement consumption in amateur and professional rugby players. Foods 10.1 (2020): 7.
3. Mata, Fernando, et al. Analysis of the consumption of sports supplements in elite fencers according to sex and competitive level. BMC Sports Science, Medicine and Rehabilitation 13.1 (2021): 1-9.
4. Knapik A, Gallert-Kopyto W, Jendrysik K, Ziemianek P, Horodecki M, Mysliwiec A. The use of supplementation among people practicing powerlifting and its connections with their self – esteem and body value. Cent Eur J Sport Sci Med. 2019; 25(1): 35-42.
5. Petkova E, Ivanov K, Ivanova S, Gueorguiev S. The use of dietary supplements by professional athletes. Biomed Res. 2018; 29(9): 1953-1955.
6. Al Saffan A, Alshahry RM, Alrwissan SA, Aljanoubi ZA, Alswailem RA. The effect of sports on oral health in Riyadh city: A cross-sectional study. Saudi J Oral Sci. 2010; 7: 18-23.

## Oral presentations

### OP-PN08 The importance of Oxygen

**BOTH HIGH- AND LOW-FREQUENCY BLOOD-FLOW RESTRICTION WALK TRAINING INCREASE MAXIMAL AEROBIC CAPACITY INDEPENDENT OF BLOOD-VOLUME CHANGES**

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INTRODUCTION: At rest, the occlusion of leg blood flow (BFR) has been shown to cause an increase in sympathetic activity and circulating blood-volume regulating hormones. Given that fluctuations in blood pressure and ion concentrations affect blood-volume control, the perturbation of these regulating systems is likely amplified with the addition of exercise. Over time, repeated exposure to fluid retention hormones could lead to increases in total blood volume, which would explain how BFR exercise has repeatedly shown to improve maximal aerobic capacity (VO2max) in the absence of more localized muscular changes.
METHODS: To determine changes in serum copeptin and renin concentration, venous blood samples were collected from 23 subjects before and after an acute bout of BFR or time-matched walking exercise (5 sets x 3 min walking, separated by 1 min rest, 5% grade, 5km/hr, BFR condition used 100% of lowest occlusion pressure). Twenty of these subjects and an additional eight (n=28) were then divided into control (CON), high-frequency (BFRH) and low frequency (BFRL) training groups. CON and BFRH performed a twice daily walking protocol for 4 weeks, while BFRL performed a twice weekly walking protocol for 6 weeks. VO2max and blood volume (CO-rebreathe) were tested

at baseline (PRE) and following training (POST). Paired samples t-tests using changes in serum renin and copeptin concentrations (pre to post BFR/free-flow walking) were used to determine whether greater increases were observed following BFR walking. A repeated measures ANOVA was performed to compare changes in aerobic capacity and blood volume.
RESULTS: BFR walking resulted in significantly greater changes in serum copeptin (BFR: 5.5±2.9 to 57.8±99.4 pmol/L; free-flow: 6.3±3.8 to 6.7±4.0 pmol/L; p=0.02) and renin (BFR: 19.1±8.2 to 44.5±27.1 ng/L; free-flow: 19.41±7.2 to 28.5±15.1; p=0.001). Significant changes in maximal aerobic capacity were observed following training (p=0.03). Increases in VO2max were observed from PRE to POST for both BFRH (46.7±8.8 to 50.7±9.5 ml.kg-1.min-1, p=0.004) and BFRL (48.1±7.4 to 52.5±10.2 ml.kg-1.min-1, p=0.02) groups but not CON (48.8±9.4 to 49.2±8.6 ml.kg-1.min-1, p=0.6). No changes in blood volume were evident (BFRH: 83.4±12.3 to 82.0±10.5 ml.kg; BFRL: 76.6±12.8 to 78.2±13.9 ml.kg; CON: 77.3±9 to 78.4±8.7 ml.kg; p=0.7).
CONCLUSION: The current results support findings of improved maximal aerobic capacity following BFR exercise. Of note, mean improvements in VO2max were of a similar magnitude in both the high- (+9.6%) and low-frequency (+9.0%) BFR training groups. Despite large increases in circulating fluid retention hormones following an isolated bout of BFR exercise, blood volume over the training period did not increase in either group. The notable adaptations promoting greater endurance capacity with low intensity BFR exercise require further investigation to elucidate the mechanisms responsible.

### NRF2 AND NF-KB SIGNALLING, AND ANTIOXIDANT ENZYME ADAPTATIONS TO SPRINT INTERVAL TRAINING ARE POTENTIATED BY BRIEF ISCHAEMIA APPLICATION DURING THE RECOVERY PERIODS

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Reactive oxygen and nitrogen species (RONS) stimulate signalling pathways essential for the adaptative response to exercise. Nrf2 and NFkB transcription factors regulate over 150 genes involved in redox homeostasis, inflammation, and the antioxidant response. High-intensity exercise increases RONS and activates Nrf2, NFkB, and CaMKII signalling in human skeletal muscle (HSM), an effect potentiated by immediate ischaemia application (PMID: 32863217). It remains unknown how sprint interval training (SIT) modulates antioxidant enzyme expression and regulatory transcription factors. It is uncertain whether additional metabolic and RONS-mediated stress could further stimulate the adaptive response to SIT. We hypothesized that SIT would upregulate the basal and exercise-induced Nrf2 and NFkB signalling, with this effect being exacerbated by post-exercise ischaemia.
METHODS: Ten active subjects were tested before and after SIT (4-6 30s sprints, 4min recovery, 6 sessions in 2 weeks). Immediately after each sprint, the circulation of one leg was instantaneously occluded (300mmHg) for 30-50s. The main PRE and POST-training tests consisted of an incremental exercise to exhaustion (IE) followed by 90min rest and 6 bouts of supramaximal exercise to exhaustion at 120%VO2max (SPE) interspaced with 20s recovery, during which circulation of both legs was fully occluded. In addition, VL biopsies were taken at rest, 90 min after IE, and immediately after SPE unilaterally at PRE and bilaterally at POST from the leg training with free circulation (FCL) and the leg training with ischaemia (IS) for Western Blotting. Statistics: repeated-measures ANOVA
RESULTS: After SIT, basal protein levels of pSer536p65, IkBalpha, IkBbeta, pSer40Nrf2, Nrf2, Nrf2/Keap1 ratio, Catalase, SOD1, GR, pThr287CaMKII, and CaMKII were largely increased (∼2.3-fold) solely in IS ($p<0.05$). Besides, SIT increased basal protein levels significantly more in IS for pSer176/180IKK, p50, p65 (∼1.9-fold vs. FCL) ($p<0.05$). The acute upregulation following SPE observed at PRE and after SIT in FCL was blunted in IS ($p<0.05$) for pThr287CaMKII, IkBbeta, TrxR1, Nrf2, pSer40Nrf2, p65, pSer536p65, pSer176/180 IKK and pTyr705STAT3.
CONCLUSION: These findings show that Nrf2 and NFkB signalling and their downstream antioxidant enzymes are largely upregulated by additional time under oxidative stress during 2 weeks of SIT in HSM. Furthermore, we have shown that a marked elevation of the basal antioxidant response with training suppresses the acute exercise-induced activation of Nrf2 and NFkB signalling otherwise required in the non-trained state. This was achieved by employing a novel experimental approach where immediate ischaemia is applied after each bout in only one leg, exacerbating RONS and metabolite build-up, which may enhance the antioxidant capacity of HSM. Whether these adaptations are beneficial for performance or long-term adaptation to training remains to be evaluated.

### PREMATURITY AND MAXIMAL EXERCISE CAPACITY AT HIGH-ALTITUDE: EVIDENCE OF HYPOXIC PRECONDITIONING?

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INTRODUCTION: Premature birth induces several long-term sequelae on the pulmonary and cardiovascular systems that contribute to reduced exercise capacity. However, preliminary data suggest that prematurity might, at least in-part, protect against some altitude-induced physiological alterations. Accordingly, we aimed to investigate the cardiorespiratory and muscle oxygenation responses to incremental exercise to exhaustion performed at sea level and at altitude in preterm and full-term born adults, to clarify the mechanism(s) underpinning prematurity-related impairments in exercise capacity.
METHODS: Healthy preterm (n=17; age, 21±1 years; gestational age, 29±1 weeks) and age-matched full-term (n=17; gestational age, 40±0 weeks) adult men underwent a hypoxic sensitivity test (i.e., random 1 to 8 consecutive breaths with 100% N2) to assess the hypoxic ventilatory response (HVR) and two incremental exercises to exhaustion on a cycle ergometer – one at sea level and the other at altitude (3375 m). Gas exchange, hemodynamics, and muscle oxygenation were assessed continuously by metabolic cart, transthoracic impedance, and near-infrared spectroscopy, respectively. Intramuscular matching between O2 delivery and utilization was assessed by the presence of a deoxygenation (Δ[deoxy(Hb+Mb)]) overshoot in the transition from rest to exercise.
RESULTS: The HVR was comparable between preterm and full-term adults (0.383±0.061 vs. 0.270±0.029 L/min/%, p=0.11). In normoxia, preterm demonstrated lower peak power output (276±10 W vs. 312±12 W, p=0.04) compared to full-term adults, but not in hypoxia (248±10 vs. 279±10 W, p=0.07 and 2.62±0.11 vs. 2.84±0.09 L/min, p=0.47), despite similar peak O2 uptake in both normoxia (48.5±2.6 mL/kg/min vs. 51.9±1.9 mL/kg/min, p=0.36) and hypoxia (36.4±1.6 mL/kg/min vs. 37.9±1.1 mL/kg/min, p=0.87). At peak, stroke volume (116±6 vs. 138±5 mL, p=0.02) and cardiac output (21.7±1.2 vs. 26.0±1.0 L/min, p=0.01) were lower in preterm compared to full-term adults in normoxia, but not in hypoxia (113±7 vs. 122±5 mL, p=0.53 and 21.1±1.2 vs. 23.2±0.9 L/min, p=0.35). Peak Δ[deoxy(Hb+Mb)] was increased from normoxia to hypoxia in full-term (11.0±1.5 vs. 16.2±2.1 µM, p=0.04) but not in preterm (13.5±2.5 vs. 13.7±2.0 µM, p=0.84)

adults. Intramuscular matching between O2 delivery and utilization was improved by hypoxia relative to normoxia in the preterm (1.9±0.6 vs. 0.3±0.2 µM, p<0.01) but not in the full-term (1.1±0.4 vs. 0.2±0.2 µM, p=0.13) group.
CONCLUSION: These data suggest that prematurity reduces exercise capacity primarily via impaired convective, rather than diffusive, O2 transport. However, hypoxia-induced impairments in physiological responses to maximal exercise appear to be attenuated in healthy preterm adult men, compared to their full-term counterparts. These findings lend further support to the potential hypoxic preconditioning effect of premature birth and/or perinatal treatment that warrant further scrutiny.
Funding: SNSF grant n. 320030L_192073, ARRS grant n. N5-0152

**EXERCISE-COGNITION INTERACTION IN HYPEROXIA DURING APPLIED UNDERWATER FIN-SWIMMING IN SCUBA-DIVING**

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INTRODUCTION: Executive functions (EF) positively interact with moderate and severe exercise intensity in laboratory studies, but this interaction might be modulated by environmental factors, oxygen supply, and resulting changes in prefrontal and muscle oxygenation (1–3). These aspects are combined in the applied setting of SCUBA-diving, where hyperoxia occurs when breathing air at depth, and gas mixtures with elevated oxygen fractions are commonly used (4). Intact EFs enable higher-level processes like goal-directed behavior and problem-solving, which are highly relevant in the demanding underwater environment, and especially in critical situations or rescue scenarios where additional exercise stress occurs. It was hypothesized that (I) the positive interaction between exercise intensity and EF performance would be amplified by an increased inspiratory oxygen pressure and (II) that environmental impacts and increased physiological demands might attenuate this effect during severe exercise intensity.
METHODS: Based on a priori power analysis (f = 0.5; Power 1-β = 0.9), 15 experienced SCUBA-divers (age: 27 ± 6 years; 7 females) performed 3 × 8 min of underwater fin-swimming (UFS; 4 m depth) at individual work rate intensities of 20 % (low), 30 % (moderate), and 55 % (severe) heart rate reserve. HRmax was derived from an incremental UFS step test. Eriksen Flanker tasks for inhibition, which is considered a core EF, were performed directly after rest and exercise at the pools edge (100 stimuli). This scenario was repeated on three separate days with different oxygen fractions in the breathing gas (21 %, 40 %, 100 % O2; double-blind). ANOVAs with repeated measures on the factor intensity (rest, low, moderate, severe) and gas were performed for the normally distributed variables accuracy (ACC) and reaction times that required inhibitory control (RTincom).
RESULTS: RTincom showed a significant main effect for intensity ($P < 0.001$; $\eta p2 = 0.4$) but not for gas. Significantly faster RTs were observed after severe intensity exercise compared to rest ($P = 0.022$), low ($P < 0.001$), and moderate-intensity ($P < 0.001$). ACC showed no effects.
CONCLUSION: The results comply with superior EF performance after severe exercise from elevated lactate and serotonin levels (5,6). Cerebral oxygenation was possibly maintained during exercise (7) despite environmental and exercise-dependent competing physiological demands (8), which hyperoxia might have met. In summary, EF performance was slightly elevated and remained intact during hyperoxic exercise settings in SCUBA-diving.
1 - Sudo et al. (2017), 10.1007/s00421-017-3692-z 2 - Ando et al. (2009), 10.1007/s00421-009-0989-6
3 - Pontifex et al. (2019), 10.1016/j.psychsport.2018.08.015 4 - Bosco et al. (2018), 10.3389/fpsyg.2018.00072
5 - Zimmer et al. (2016), 10.1007/s00421-016-3456-1 6 - Hashimoto et al. (2018), 10.1096/fj.201700381RR
7 - Moreau et al. (2019), 10.1177/1745691619850568 8 - Tempest et al. (2017), 10.1016/j.bandc.2017.02.001.

**THE FRACTIONAL UTILIZATION OF VO2MAX IS HIGHER IN HYPOBARIC HYPOXIA EQUIVALENT TO 2800 M THAN NEAR SEA LEVEL**

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INTRODUCTION: The lower O2 availability at altitude leads to a 6% reduction in maximal oxygen uptake (VO2max) for every 1000 m of increasing altitude (1). In contrast, the decline in endurance performance with hypoxic exposure is variable, depending on the discipline and event duration. Typically, 800–10’000 m track and field performances are decreased by 0.4-2.4% at events above 1000 m of altitude (2), while time trial (TT) performances in cycling are also lowered at altitude but presumably to a lesser extent than VO2max (e.g. 3). Generally, a greater decline in VO2max than in endurance performance suggests a higher fractional utilization of VO2max (the VO2 over a given time or distance as a percentage of VO2max; %VO2max) at altitude, provided that anaerobic capacity and exercise economy are unaltered. Thus, it was hypothesized that the %VO2max is higher during a cycling TT in hypoxia than near sea level.
METHODS: Sixteen amateur cyclists (8 women, age: 31±7 years [mean±SD], body mass: 68±8 kg, VO2max: 60±8 ml.min-1.kg-1) underwent exercise testing in a hypobaric hypoxic chamber set to 300 m (976±2 hPa, 18.0±0.3 °C) or 2800 m (724±2 hPa, 17.9±0.3 °C). VO2max and maximal power output (Pmax) were assessed by an incremental test to exhaustion and average power output (Pavg) and average VO2 were determined during a 40 min all out cycling TT. The %VO2max was calculated as the average VO2 during the TT as a percentage of VO2max. All participants performed each exercise test at both altitudes.
RESULTS: VO2max and Pmax decreased from 4119±783 ml.min-1 and 349±49 W at 300 m to 3655±710 ml.min-1 and 313±44 W at 2800 m (-11.2±2.9%, p<0.001; -10.2±3.7%, p<0.001). Similarly, average VO2 and Pavg during the TT were lower at altitude, namely 3113±571 ml.min-1 and 223±39 W at 300 m and 2854±516 ml.min-1 and 199±34 W at 2800 m (-8.2±4.4%, p<0.001; -10.7±3.1%, p<0.001). The lower decline in VO2 than in Pavg suggests poorer cycling economy during the TT in hypoxia and indeed, VO2 per completed kJ was higher at 2800 m (+3.0±2.9%, p=0.001); all in all leading to an increased %VO2max at altitude (300 m: 76.0±4.5%, 2800 m: 78.4±4.2%, p=0.023).
CONCLUSION: As hypothesized, the %VO2max was higher during a 40 min cycling TT at altitude than near sea level. However, this was not explained by a lower decline in performance than in VO2max, but it is rather suggested that the poorer cycling economy during the TT is compensated by enhancing %VO2max at altitude. Future studies should address the mechanisms underlying the higher %VO2max with hypoxia.
REFERENCES:
(1) Wehrlin & Hallén. Eur J Appl Physiol. Mar;96(4):404-12 (2006).
(2) Hollings et al. Eur J Sport Sci. Aug; 12(3):201-206 (2012).
(3) Faulhaber et al. J Sports Sci. Mar;28(5):513-9

# Oral presentations

## OP-BM01 Biomechanics

### UPPER AND LOWER EXTREMITY CONTRIBUTIONS TO LOAD-VELOCITY PROFILES IN SEMI-TETHERED FRONT CRAWL SWIMMING

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INTRODUCTION: In swimming, maximum speed is achieved by generating high propulsive forces while minimizing resistance. Although upper and lower extremities contribute to propulsion in all swimming strokes, it has been assumed that in front crawl swimming the upper extremities provide most of the thrust (Toussaint & Beek, 1992). However, findings from laboratory ergometer and tethered swimming suggest that the contribution of the lower extremities may be greater than previously thought (Morouço et al., 2015). As both methods differ substantially from the biomechanics of free-swimming, we aimed to estimate extremity contributions to propulsive force and speed using load-velocity profiles during semi-tethered swimming.
METHODS: Nine male and seven female well-trained swimmers (18 ± 3 yrs; 180 ± 10 cm; 70 ± 7 kg) performed five 20-m all-out semi-tethered swimming trials with increasing loads in whole-body front crawl swimming (W), upper extremity movement only (A) or lower extremity movement only (L) in a randomized order. Starting from 1 kg, resistance was increased by 2 and 1 kg in W, by 1 and 0.5 kg in A and by 0.5 in L for male and female athletes, respectively. Load was applied and velocity was recorded at 333 Hz by a robotic resistance device (1080 Sprint; 1080 Motion AB, Lindingö, Sweden). Theoretical maximum velocities (V0) and loads (L0) were calculated from the linear regression between load and velocity ($R^2$ = 0.99 ± 0.01 in W, 0.98 ± 0.03 in A and 0.97 ± 0.04 in L). For both parameters, all values were normalized to the sum of the lower and upper extremity values (100%) to calculate percent force and speed deficits and contributions.
RESULTS: V0 was 1.90 ± 0.07 and 1.68 ± 0.04 m·s-1 in W, 1.59 ± 0.06 and 1.36 ± 0.06 m·s-1 in A and 1.15 ± 0.10 and 1.10 ± 0.05 m·s-1 in L in male and female swimmers, respectively. L0 was 19.0 ± 2.4 and 15.5 ± 2.1 kg in W, 11.9 ± 2.7 and 8.6 ± 2.3 kg in A and 6.6 ± 1.9 and 6.0 ± 0.9 kg in L in male and female swimmers, respectively. Upper and lower extremity contributions to V0 were 58 ± 2 and 42 ± 2% in male and 55 ± 2 and 45 ± 2% in female athletes. For L0, contributions were 64 ± 9 and 36 ± 9% in male and 58 ± 9 and 42 ± 9% in female athletes. A speed deficit of -30 ± 4 and -32 ± 2% was found for V0 ($p < 0.001$), while L0 in W was similar to the sum of A and L (+4 ± 15 and +8 ± 15%, $p > 0.05$) in male and female athletes, respectively.
CONCLUSION: Our data show that the lower extremities contribute significantly to maximal force and speed in semi-tethered front crawl swimming in male and female athletes. While force production in W was similar to the sum of A and L, we found a substantial speed deficit. These findings highlight the importance of minimizing speed deficit by more efficiently converting force into propulsion or improving whole-body coordination, which has the potential to maximize swimming speed even at high performance levels.

### TUNING BETWEEN MUSCLE ACTIVATION AND TENDON OPERATING LENGTH FACILITATES ENERGY OUTPUT IN TRICEPS SURAE MUSCLES DURING HIGH WALKING SPEEDS

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INTRODUCTION: Increased walking speed is associated with higher ankle joint moments (1), which suggest higher muscle force generation of the triceps-surae muscles (TSM). On the other hand, the generated TSM force is impaired due to its force-velocity relationship at walking speeds of ~2.0 m/s [2]. This indicates lower muscle forces at higher speeds. Our main purpose was to investigate experimentally the Achilles tendon (AT) force as a proxy of the TSM force generation and the mechanical work done at the ankle joint by the TSM with increasing walking speed. A secondary objective was to assess mechanics and energetics within the gastrocnemius medialis (GM) muscle-tendon unit (MTU). We hypothesized that decoupling between muscle and tendon regulated by an appropriate muscle activation would increase the muscular mechanical work despite lower muscle forces.
METHODS: In fifteen young adults, we measured the electromyographic activity (EMG) of the TSM during walking at speeds of 0.7 m/s (slow walking), 1.4 m/s (preferred walking), 2.0 m/s (transition walking) and maximum walking speed capacity (2.6±0.3 m/s) on a treadmill. Further, we measured the length of the AT tendon during walking with a combination of the ultrasound and motion capture systems and using the individual AT force-elongation relationship, we assessed AT force during the walking trials [3]. We calculated the moment generating at the ankle joint and the mechanical work done from all TSM. Finally, we investigated the mechanical work done by the GM-MTU, assuming a constant based on the physiological cross-sectional area contribution of GM muscle force.
RESULTS: We found a decrease ($p<0.05$) in the maximum AT force and AT strain energy recoil in the two higher speeds compared to the preferred one. With increasing speed, the net mechanical work done at the ankle joint from the TSM increased significantly ($p<0.001$, from -0.02±1.06 J to 7.63±0.36 J). In the transition and maximum velocity speed, a rapid increase in the EMG-activity of the TSM initiates muscular energy gain despite a continued elongation in AT. At the GM-MTU level, the rapid increase of the GM activity in the two higher speeds causes a shortening in the muscle belly while the tendon is elongated.
CONCLUSION: Our findings show for the first time that at walking speeds higher than the preferred, muscular work of the TSM provides a higher contribution than the AT energy recoil to the needed mechanical work. A rapid increase in the muscle activation at low tendon strain operating length introduces a decoupling between tendon and muscle belly resulting in an earlier muscular energy gain which increases the net muscle belly and MTU mechanical work. A part of this earlier muscular energy gain is transferred to the tendon despite the shortening of MTU and muscle belly.
REFERENCES:
1. De David et al., J. Sports Sci 2015
2. Farris and Sawicki, PANS. 2012
3. Kharazi et al., Sci. Rep. 2021

**EFFECTS OF FATIGUE ON PERCEPTION OF VELOCITY DURING BACK SQUAT**

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INTRODUCTION: The two necessary key components to prescribe velocity-based training are the percentage of loss of velocity (VL) and the mean concentric velocity (MCV) of the fastest repetition[1]. However, electronic devices are necessary and this is impractical when several athletes train at the same time. Recently a subjective perception of velocity scale has been validated showing a high correlation between real velocity (Vr) measured with encoders and perceived velocity (Vp)[2]. The purpose of the present study was to investigate whether perception of barbell velocity is affected by fatigue induced by two different training protocols with the hypothesis that Vp would be unaffected despite changes in Vr.
METHODS: Resistance trained participants were randomly divided in two groups: the 10% velocity loss group (VL10) (6 males, 5 females, age=29±8.23 years; 1RM=118.36±38.51 kg;) and repetitions to failure group (EX) (6-males, 5-females, age=24.3±3 years; 1RM=119.05±26.97 kg). Both protocols included 5 sets at 75%1RM but differed in the number of repetitions performed, using the 10% velocity-loss method in one case and repetitions to failure in the other. The accuracy in perceiving concentric velocity Vp was assessed during a test with 3 blinded loads (heavy: MCV ≥ 0.4 m·s−1, medium: 0.6-0.8 m·s−1, light: ≥ 1m·s−1), in the Back Squat exercise on 2 different days, in random order. One day rested (REST) and one day immediately following one of the two designated training protocols (VL10 or EX)). Vr was measured by a linear position transducer (Vitruve, SPEED4LIFTS S.L., Madrid-Spain) and at the same time the subjects reported their Vp. The accuracy of the Vp was analyzed by calculating the delta score (DS), (difference between Vp and Vr). Data are presented as median ± interquartile range. Mann-Whitney tests were used to compare DS and Vr between conditions in the 2 groups, and separately for the 3 loads. Bland-Altman plots were used to represent the agreement between Vp and Vr in the 3 loads.
RESULTS: Vr and DS did not change between REST and VL10 conditions (Vr: REST= 0.57 ± 0.55 m·s−1, VL10= 0.6 ± 0.57 m·s−1 ($p > 0.129$); DS: REST= 0.04 ± 0.11 m·s−1, VL10= 0.04 ± 0.08 m·s−1 ($p= 0.704$). In the EX-group a significant decrease in Vr was found (Vr: REST= 0.61 ± 0.51 m·s−1, EX= 0.55 ± 0.50 m·s−1 ($p< 0.05$), but no difference in DS. The EX-group showed a significant reduction in Vr at light and medium loads ($p< 0.05$) compared to REST with no differences in DS. The VL10-group showed no difference in Vr and DS, at all loads.
CONCLUSION: This is the first study that investigates the effects of two different training protocols on Vp. Vr changed after the EX-protocol only. However, in both cases the delta score (the accuracy of the Vp) did not change. These results, although preliminary, are comforting demonstrating that Vp is a stable parameter on which athletes can base their training.
REFERENCES:
1. Guerriero, A., et al., (2018)
2. Bautista, I.J., et al., (2016)

**THE EFFECT OF PELVIC STABILIZATION TRAINING ON DYNAMIC KNEE VALGU**

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INTRODUCTION: Pelvic instability is often associated with angular deviations of the lower limb and often causes valgus shift of the knee joint under load. In addition, non-contact ACL tears during sport activity are often caused by muscles weakness around the pelvis. Therefore, reinforcing the physiological function of the pelvic stabilizing muscles may counterbalance dynamic knee valves, hence decreasing ACL injury risk. The aim of this research is to increase the activity of the pelvic stabilizing muscles through a specific exercise program and to investigate its effect of dynamic knee valgus.
METHODS: Twenty-two subjects (male/female: 16/6) participated in the study. The aim of the six-week pelvic stabilization training was to strengthen the m. gluteus maximus, medius and m. vastus medialis obliquus and to harmonize the ratio of quadriceps and hamstring muscle strength. Before and after the training, dynamic knee valgus was determined on both sides using a Microsoft Kinect Azure camera and Dynaknee software. The software gives the medio-lateral displacement of the knee during single-leg squats as a function of leg length. The normality of the pre- and post-training knee displacement data was analyzed using the Shapiro-Wilk test and the difference was analyzed using Wilcoxons signed rank test.
RESULTS: Dynamic knee valgus decreased from 3.15 % to 1.03 % for the left knee and from 3.89 % to 1.26 % for the right knee. The magnitude of change was significant on both sides ($p<0.001$).
CONCLUSION: Strengthening the pelvic stabilisation muscles induced a substantial improvement in knee valgus, and thus reduced the risk of developing cruciate ligament injuries. This study provides a direct link between an easy diagnosed predisposing factor a common sports injury, and offers a simple countermeasure in the form of specific exercises, that may be included in the routines of athletes at risk for ACL injuries.
Support: Scientific Excellence Program 2019, Ministry of Innovation and Technology, Hungary

**PROSPECTIVE ASSOCIATIONS BETWEEN SPATIOTEMPORAL AND GROUND REACTION FORCE CHARACTERISTICS AND INJURY RISK IN 800+ LEISURE-TIME RUNNERS**

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INTRODUCTION: Running biomechanics may be involved in the mechanisms underlying the development of some types of running-related injury. However, contrary to widespread beliefs, only few potential biomechanical risk factors have been prospectively associated with injury risk so far. Therefore, the main objective of this study was to identify injury risk factors among spatiotemporal and ground reaction force characteristics in leisure-time runners. The secondary objective was to investigate whether shoe cushioning modifies the association between these biomechanical factors and injury risk.
METHODS: This study is a secondary analysis of a participant and assessor blinded randomized trial in which 848 recreational runners were tested on an instrumented treadmill at baseline at their preferred running speed in randomly allocated, standardized running shoes (Hard or Soft cushioning, respectively). The most common kinetic and spatiotemporal metrics were derived from a 2-minute ground reaction force signal recording. Participants were subsequently followed-up for 6 months regarding running activity and injury. Cox proportional hazard regression models for competing risk were used to investigate the association between biomechanical risk factors and injury risk, including stratified analyses by shoe version.

RESULTS: The mean (±SD) participants' preferred running speed at baseline was 9.9 (±1.5) km/h. On average, 326 (±19) steps were analyzed per participant. During the follow-up, the participants reported 22 521 hours of running, and 128 participants (15.1%) sustained a running-related injury. In the crude analysis, greater injury risk was found for greater step length (sub-hazard rate ratio – SHR [95% Confidence Interval] = 1.01 [1.00; 1.02], p = 0.038), longer flight time (SHR = 1.00 [1.00; 1.01], p = 0.028), shorter contact time (SHR = 0.99 [0.99; 1.00], p = 0.030), and lower duty factor (defined as the ratio between contact time and stride time; SHR = 0.95 [0.91; 0.98], p = 0.005). In the stratified analyses by shoe version, adjusted for previous injury and running speed, lower duty factor was associated with greater injury risk in those using the Soft shoes (SHR = 0.92 [0.85; 0.99], p = 0.042), but not in those using the Hard shoes (SHR = 0.97 [0.91; 1.04], p = 0.348). No other significant association with injury risk was found.
CONCLUSION: Lower duty factor is an injury risk factor, especially when using softer shoes. Contrary to widespread beliefs, vertical impact peak, vertical loading rate and step rate were not injury risk factors in recreational runners. Duty factor is an interesting target for preventive measures in runners, as it can be easily monitored with wearable devices. Increasing duty factor may help reducing the risk of running-related injury, but this needs to be confirmed by intervention studies. Conversely, vertical impact peak, loading rate and step rate may not be the most relevant biomechanical factors for overall injury prediction.

## Oral presentations

### OP-PN10 Bone

#### THE ASSOCIATION BETWEEN MEASUREMENTS OF EXTERNAL LOAD AND BONE STRUCTURAL CHARACTERISTICS IN ELITE CRICKETERS AND FOOTBALL PLAYERS.

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INTRODUCTION: Despite exercise being prescribed to benefit bone health [1], little is known about the specific external loading characteristics of exercise required to promote bone accrual. It Is not known how limb specific loading variables are associated with bone characteristics. We aimed to assess if quantified external loading is associated with tibial bone characteristics in elite cricketers and football players.
METHODS: Eleven professional cricketers (right-arm fast bowlers) and eighteen professional footballers (outfield) were monitored with Inertial Measurement Units placed on the anteromedial tibia at 14% of the distal length during a standardised training session. Six competitive overs for cricketers and a warm-up for footballers (hopping, sprinting, cutting) were performed. Peak tibial acceleration, peak positive acceleration (PPA), cumulative load and relative load were calculated as loading variables. Whole-body dual-energy x-ray absorptiometry (DEXA) and tibial peripheral computed tomography (pQCT; 4%, 14%, 38% and 44% of the tibial length) scans were performed on each leg to retrieve bone characteristics. Paired sample t-tests were performed on all variables between legs in each group. Correlations were performed between loading variables and bone characteristics for both groups.
RESULTS: Cricketers showed greater left leg external load variables (peak acceleration (+91 g, +53%) and PPA (+59 g, +38%)) than the right leg ($p<0.001$). The left leg of cricketers showed greater bone characteristics derived from DEXA (leg bone mass (+0.86 kg, +12%), relative leg mass (+0.78, +5%), total BMD (+0.08 g/cm2), leg BMC (+82 g; $p<0.028$)) and pQCT (bone mass (+0.22 kg, +4%), periosteal circumference (38% site; +2.07 mm, +2%) torsional strength (14% site; +214 mm3, +7%; $p<0.035$), and axial strength (14% site; +39 mm3, +3%: 38% site; (+111 mm3, +7%)) than the right leg. There were no differences between legs in football players or correlations between loading variables and bone characteristics in either group.
CONCLUSION: The greater bone characteristics in the left leg during a fast-bowling action may be reflective of the higher left leg loads experienced. No correlations were shown between loading and bone in either group, this likely to be due to factors, such as load frequency, which is known to influence bone accrual [2]. The unilateral aspect of cricket fast bowling causes the planting leg to experience consistently higher loads than the other leg, likely explaining the differences in bone between limbs. The bilateral movement patterns of football likely explain the lack of differences in this group.
REFERENCES:
1. Harding, A.T. and Beck, B.R., 2017. Exercise, osteoporosis, and bone geometry. Sports, 5(2), p.29.
2. Turner, C.H. and Robling, A.G., 2003. Designing exercise regimens to increase bone strength. Exercise and sport sciences reviews, 31(1), pp.45-50.

#### BONE MINERAL DENSITY IN ELITE MALE AND FEMALE CYCLISTS AT DIFFERENT STAGES OF A PROFESSIONAL CYCLING CAREER

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INTRODUCTION: Bone health appears to be compromised in many elite male cyclists, while bone health in female, adolescent and retired, elite cyclists remaining largely unexplored. The lack of osteogenic stimuli and low energy availability may predispose elite cyclists to impaired bone health, although clear evidence for this presumption is lacking. In the present study we assessed the prevalence of low bone mineral density (BMD) in male and female elite cyclists at different stages of a professional cycling career, and evaluated potential predictors of low BMD in elite cyclists.
METHODS: In this cross-sectional study, 93 male and female early (n=31), advanced (n=42) and post (n=20) career elite cyclists underwent dual-energy X-ray absorptiometry for the assessment of total and regional bone mineral density and body composition. Proposed markers of low energy availability (IGF-1, T3) and bone metabolism (CTX-I, P1NP, 25-hydroxy vitamin D) were assessed in fasted blood samples. Training history and injury prevalence were assessed by a questionnaire, complemented with the bone-specific physical activity questionnaire (BPAQ). Backward stepwise multiple regression analysis was conducted to explore associations between BMD and its potential predictors in early and advanced career (i.e. active career) cyclists. Data are presented as mean±SD.
RESULTS: With a Z-score of -0.3±0.8, -1.5±1.0, and -1.0±0.9, low BMD (Z-score <1) of the lumbar spine was prevalent in 27, 68, and 50% of the early, advanced and post-career elite male cyclists, respectively. The lumbar spine Z-scores of -0.9±1.0, -1.0±1.0, and 0.2±1.4 in early,

advanced, and post-career elite female cyclists, respectively, indicated low BMD in 55, 45 and 20% of these female subpopulations. Remarkably, 59% of the active career elite cyclists, exceeded the P1NP reference range, while the CTX-I reference range was exceeded by 10% of these cyclists. Furthermore, 25-hydroxy vitamin D levels were inadequate (<50 nmol/L) in 13% of the active career elite cyclists. Statistical analysis revealed that BMI, past fracture incidence, past bone-specific physical activity, 25-hydroxy vitamin D and T3 were associated with lumbar spine BMD Z-score in the final model, $F(5, 49) = 8.314$, $P < 0.001$, adjusted $R2 = .40$. All retained variables significantly contributed ($P < 0.05$) to the final regression model.
CONCLUSION: Low bone mineral density is highly prevalent in elite cyclists, especially in early career females and advanced career males and females. These low BMD values may not fully recover after the professional cycling career, given the high prevalence of low BMD in post-career male cyclists. Exploratory analyses suggest that low BMD is associated with fracture incidence, lack of bone-specific physical activity and low energy availability in active career elite cyclists. Collectively, these findings provide direction for exercise and nutritional strategies to prevent or treat low BMD in elite cyclists.

**TRAINING AND DETRAINING EFFECT AFTER HOME-BASED EXERCISE PROGRAM ADMINISTERED AS MONITORED INDIVIDUAL HOME TRAINING OR SUPERVISED ONLINE GROUP TRAINING**

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INTRODUCTION: Osteoporosis is a disease characterized by low bone mass and is accompanied by increased risk of fracture resulting in pain, decreased physical and social functional capacity and quality of life. Many studies have shown that resistance training can safely increase both muscle strength and bone mass, and improve functional performance. On the contrary, cessation of training has been found to be associated with a loss of muscle mass and strength. The aim of the present study was to determine training and detraining effects on functional status induced by a specific combinate exercise program for 18 months and after a 6-month detraining period in osteoporosis women. The exercise program administered as monitored individual home training (MIHT) or supervised online group training (SOGT).
METHODS: 20 women with postmenopausal osteoporosis (age: 66 ± 5.7 years) were randomly assigned to an MIHT group (n = 10) or an SOGT group (n = 10). All participants completed 18 months of training consisting of two 1-hour sessions per week using small equipment and bodyweights. The SOGT performed the training sessions under the direct supervision of a trainer via a digital platform. The MIHT participants were instructed by the trainer on how to perform each exercise individually at home in one or two preliminary sessions and were also given printed educational material. In addition, the trainer contacted the MIHT participants at preset time intervals to encourage them to exercise regularly and to obtain information on their health status. Every 6-8 weeks, the exercise workload was reviewed and updated. Physical performance measures were administered at baseline, after 12-month and 18-month training, and after the 6-month detraining period. The function was evaluated with the 6-minute walking test (6MWT), sit-and-reach test (SRT), Wand test (WT), while the 30-second chair stand test (30CST) was used to measure muscle strength.
RESULTS: At the18 month follow-up assessment at the end of the exercise program, both MIHT and SOGT groups showed statistically significant improvements in 6MWT ($p \leq 0.05$); in the other tests an improvement was found in both groups but not statistically significant. In both groups, the 6MWT training-induced improvements remained significantly above baseline after the detraining period ($p \leq 0.05$), while WT indicated a statistically significant decrease in shoulder mobility ($p \leq 0.05$). The comparisons between MIHT and SOGT showed no significant differences after during and after the training or detraining periods for all variables ($p > 0.05$).
CONCLUSION: The exercise program administered as MIHT or SOGT improves gait function in women with postmenopausal osteoporosis in both groups. These gains were largely preserved after the cessation of the exercise program with the exception of shoulder mobility. Supervised or monitored online individual training at home can both be practical alternatives to home-based physical activity.

**RELATIVE MUSCLE POWER AS A PREDICTOR OF AREAL AND VOLUMETRIC BONE HEALTH IN OLDER ADULTS WITH LIMITED FUNCTIONAL CAPACITY.**

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INTRODUCTION: Muscle power (MP) declines with age faster than muscle mass and strength (1). It is an important determinant of functional ability, mortality and quality of life. It is known that muscle and bone metabolism are related both mechanical and metabolically. Thus, the objective of this study was to analyse if relative MP, as mechanical proxy, could predict bone volumetric and areal parameters considering it as an important predictor of other age-related physiopathologies such as osteoporosis.
METHODS: 110 older adults (mean age 80.7±5.7 y, 34 males) were evaluated in the framework of the EXERNET-Elder 3.0 study. To be included, all of them needed to score <10 points in the Short Physical Performance Battery which means they have a limited functional capacity. The sit-to stand test of 5 repetitions was used to assess the MP using the equation developed by Alcázar et al. (2). Height and weight data was also measure. Peripheral computed tomography was used to evaluate areal and volumetric cortical and trabecular parameters at 4% and 38% of the tibia length, respectively. Polar stress strain index (SSIp) and bending (Fracture Load) were also recorded. Linear regression analyses were performed to evaluate association between relative MP and bone variables, adjusted by sex and age.
RESULTS: Relative MP was associated to total bone mineral content at 4% (standardized $\beta=0.202$) and 38% of the tibia length (standardized $\beta=0.205$), cortical thickness (standardized $\beta=0.222$), Fracture Load X (standardized $\beta=0.200$) and SSIp (standardized $\beta=0.117$) (all $p<0.05$). No significant associations were found for bone area or bone mineral density variables.
CONCLUSION: Relative MP shows association with volumetric and fracture indexes of bone tissue in older adults with limited functional capacity, which may indicate that exercise-induce MP enhancement strategies could be associated with reduced fracture risk. However, further studies should be needed to determine if it could be a feasible measurement to determine risk of fractures in older adults.

### P1NP AND B-CTX-1 RESPONSES TO A PROLONGED, CONTINUOUS RUNNING BOUT IN HEALTHY ADULT MALES: A SYSTEMATIC REVIEW AND INDIVIDUAL PARTICIPANT DATA META-ANALYSIS

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INTRODUCTION: Circulating biomarkers of bone formation and resorption are widely used in exercise metabolism research, but their responses to exercise are not clear. PURPOSE: To quantify group responses and inter-individual variability of P1NP and β-CTX-1 after prolonged, continuous treadmill running (60-120 min at 65-75% VO2max) in healthy adult males.
METHODS: The study's protocol was designed following PRISMA-IPD guidelines and pre-registered (1). Studies were identified from the list of articles included in a recent systematic review and meta-analysis on this topic (2) in accordance with pre-defined eligibility criteria. Changes in P1NP and β-CTX-1 relative to baseline were measured during, immediately after, and following exercise on an absolute scale (ng·ml-1). Typical hourly and daily variations were estimated from P1NP and β-CTX-1 changes relative to baseline during the hours/days in non-exercise (control) conditions. Responses were quantified based upon estimates of the mean and standard deviation (SD) of the difference, and the proportion of participants exhibiting an increased response. All models were conducted using a Bayesian framework with random intercepts to account for systematic variation across individual studies.
RESULTS: Levels of P1NP increased during and immediately after running, where the proportion of response was estimated to be close to 100 (75% CrI: 99 to 100%). P1NP levels returned to baseline levels within 1 hour and over the next 4 days, showing similar mean differences and SDs to the typical hourly (0.1 ± 7.6 ng·ml-1) and daily (-0.4 ± 5.7 ng·ml-1) variations. Levels of β-CTX-1 decreased during and for 4 hours after running, but these changes were similar to the typical hourly variation (-0.13 ± 0.11 ng·ml-1); there were trivial changes in β-CTX-1 over the next 4 days after running, which were also similar to the typical daily variation (-0.03 ± 0.10 ng·ml-1).
CONCLUSION: Transient increases in P1NP were likely caused by biological aspects (e.g., leakage from connective tissues) rather than being reflective of bone formation. Small decreases in β-CTX-1 were shown in control and running data, suggesting that these changes were due to the marker's circadian rhythm and not the running intervention. Hence, prolonged continuous treadmill running did not elicit bone responses, as determined by P1NP and β-CTX-1, in healthy adult males.
References:
1. Civil R., Dolan E., Swinton P., Santos L., Varley I., Atherton P. J., Elliott-Sale K. & Sale C. (2021, May 10). β-CTX-1 and P1NP responses to a prolonged and continuous running bout in young adult males: protocol for an individual data meta-analysis. https://doi.org/10.17605/OSF.IO/Y69ND
2. Dolan E., Dumas A., Keane K. M., Bestetti G., Freitas L. H. M., Gualano B., Khort W., Kelley G. A., Pereira R. M. R., Sale C. & Swinton P. The Bone Biomarker Response to an Acute Bout of Exercise: A Systematic Review with Meta-Analysis (2022, February). https://doi.org/10.51224/SRXIV.115

## Oral presentations

## OP-PN02 High intensity training

### THE UMEÅ HIT STUDY: A RANDOMIZED CONTROLLED TRIAL EVALUATING THE EFFECTS OF SUPRAMAXIMAL HIGH-INTENSITY INTERVAL TRAINING ON AEROBIC CAPACITY AND COGNITIVE FUNCTION IN OLDER ADULTS

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INTRODUCTION: Supramaximal High-Intensity Interval Training (HIT) is a time-efficient training method with health benefits potentially superior to traditional aerobic Moderate-Intensity Training (MIT). However, with all-out sprint efforts not being a feasible training method for everyone, this study aimed to examine the effects of controlled and regulated supramaximal HIT intervals adapted for older adults, as compared to MIT, on aerobic capacity, cognitive function, blood pressure, lower-limb muscle strength and subjective quality-of-life.
METHODS: Sixty-eight non-exercising older adults (65-78 years old, 44% males) were randomized to 12 weeks of controlled and regulated supramaximal HIT or MIT. HIT consisted of ten 6-second intervals with a total session time of 20 minutes, and MIT consisted of three 8-minute intervals with a total session time of 40 minutes. The participants exercised twice weekly in groups of 8-10, on stationary bicycles in an ordinary gym setting. Individualized target intensity was watt-controlled, with standardized pedalling cadence and individual adjustment of resistance load (1). Standardized escalation criteria regulated the gradual progression of resistance loading between the sessions. Primary outcomes were aerobic capacity (VO2peak) and global cognitive function (unit weighted composite score of 11 cognitive tests).
RESULTS: Overall attendance at exercise sessions was 88.1% with no difference between the groups. After 12 weeks of exercise regardless of intensity, a significant increase in VO2peak was observed (1.36 ml/kg/min, [0.52, 2.20]), with no difference in change between groups (0.05, [-1.17, 1.25]). No improvement was observed for global cognition (-0.03, [-0.13, 0.06]), nor any difference in change between groups (0.11, [-0.04, 0.24]). Significant between-group differences in change were observed for maximal isometric knee extensor muscle strength (0.07 Nm/kg, [0.003, 0.137]), and for working memory (0.32, [0.01, 0.64]), indicating an advantage for the HIT-group. Overall, regardless of group, there was a significant decrease in systolic blood pressure (-2.21 mmHg, [4.25, 0.18]), and a negative change in episodic memory (0.26, [0.45, 0.08]). No other significant effects were observed.
CONCLUSION: In previously non-exercising older adults, 12 weeks of supramaximal HIT with controlled target intensity appears to have a positive effect on muscle strength in comparison to aerobic moderate-intensity training. Further, our findings suggest that the HIT intervals improve aerobic capacity and blood pressure to a similar extent as MIT, but with only half the amount of training time. The effects of supramaximal HIT on cognitive function appears to be limited, mainly influencing working memory performance.
Clinical Trial Registration: NCT03765385
1. Hedlund M, et al. Development and Feasibility of a Regulated, Supramaximal High-Intensity Training Program Adapted for Older Individuals. Front Physiol. 2019;10:1–12. doi: 10.3389/fphys.2019.00590

**CARDIORESPIRATORY ADAPTATIONS AND PERFORMANCE IMPROVEMENT IN RESPONSE TO HIGH-INTENSITY INTERVAL TRAINING IN DISTANCE RUNNERS: PHYSIOLOGICAL VS RACE PACE APPROACH**

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INTRODUCTION: High-intensity interval training (HIIT) represents an important constituent of athletes' training programs [1]. HIIT prescriptions, characterized by repeated short to long bouts, may be based on individual physiological responses to exercise to keep intensity close to the maximal oxygen uptake (VO2max). Although this approach leads to improvement in functional indexes of endurance performance, some studies failed to report evidence of performance benefits in this population [2]. Data from world-class runners suggest that individualizing training prescriptions according to a given percentage of the target race pace may maximize running performance due to the specific nature of the stimulus [3]. Thus, we compared the effects of the application of the 'physiological-based approach' (PHY) and 'race pace-based approach' (RACE) to HIIT prescriptions on cardiorespiratory adaptations and performance in distance runners.
METHODS: Thirty-one distance runners (20 men and 11 women, age: 38±9 yr, 10-km speed: 14.0±1.4 km/h) were tested before and after 8 weeks of training. The intervention consisted of performing 2 HIIT sessions per week (~25% of the training volume) prescribed using either RACE (n=16) or PHY (n=15). HIIT prescriptions for PHY were the same as those described in [2]. HIIT sessions in RACE consisted of bouts of one km at 110% of the 10-km race pace, interspersed by 300-m recovery distances to be covered in 2 min. The average intensity and distance of the intervals and recovery phases were comparable between PHY and RACE. VO2max and peak treadmill running speed (Vpeak) were determined through an incremental treadmill test, followed by a verification test, whereas 10-km performance was tested on a 400-m track.
RESULTS: VO2max improved significantly in PHY (+2.9 mL/kg/min, p≤.001, 95% confidence interval [CI]: +1.6 to +4.2) and decreased in RACE (–1.9 mL/kg/min, p=.009, 95%CI: –3.3 to –0.6), with a statistical difference of 4.8 mL/kg/min (p≤.001, 95%CI: 3.3 to ∞) between the groups. Vpeak improved significantly in PHY (+0.4 km/h, p≤.001, 95%CI: +0.2 to +0.6) with a statistical difference of 0.5 km/h (p=.002, 95%CI: 0.2 to ∞) between the groups. 10-km speed improved significantly in RACE (+0.5 km/h, p≤.001, 95%CI: +0.3 to +0.8) with a statistical difference of 0.4 km/h (p=.05, 95%CI: 0.0 to ∞) between the groups.
CONCLUSION: The approach adopted to individualize HIIT prescriptions impacts the type of training response in distance runners, leading to improved cardiorespiratory adaptations when based on physiological parameters and performance when prescribed according to race pace. Coaches should select a specific approach depending on the different goals of the training phase.
1. Campos et al. (2021) 2. Helgerud et al. (2007) 3. Kenneally et al. (2018)

**TWO REPEATED INTERVENTIONS OF HIGH-INTENSITY INTERVAL TRAINING INDUCE DIFFERENT FUNCTIONAL AND MOLECULAR ADAPTATIONS OF SKELETAL MUSCLE IN MICE**

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INTRODUCTION: In murine model a first exposure to hypertrophic stimuli, such as testosterone, mechanical loading or resistance exercise, has been shown to lead to faster and larger growth of skeletal muscle when subsequently repeated [1,2,3]. This mechanism, called muscle memory, has been related to the retention of acquired myonuclei or epigenetic modifications [4,5]. Interestingly, greater changes in mitochondrial content and biogenesis were also observed after repeated resistance training interventions [3]. Thereby, even mitochondrial adaptations might be influenced by muscle memory, and it remains to be explored whether repeated endurance training interventions can rely on the same mechanism. The aim of the study was to investigate functional and molecular adaptations of skeletal muscle to two repeated interventions of high-intensity interval training (HIIT) in mice.
METHODS: Twenty-four C57BL/6 adult mice were divided into 4 groups: untrained controls; trained; detrained for 12 wks after training; retrained after detraining. Each HIIT (10 bouts of 2 min separated by 2 min of recovery) intervention lasted 8 wks. Physiological adaptations were compared between initial training (TR) and retraining (RETR) by calculating the difference between controls and trained mice and detrained and retrained mice, respectively. Maximal running velocity (Vmax) was assessed 48 h prior to sacrifice by graded exercise test (GXT). Markers of mitochondrial biogenesis and content, and fusion-fission mitochondrial key factors were analyzed on gastrocnemius muscle by western blot and qPCR.
RESULTS: Vmax increased more in RETR than TR (+10.7 ± 3.3 vs +6.5 ± 1.9 m*min-1, respectively, p<0.001). Mitochondrial biogenesis increased in TR (PGC1α: +19%) but changes were larger in RETR (PGC1α: +72%, p<0.001), being also associated to pAMPK increase (+39%, p<0.05). Mitochondrial content resulted higher in RETR than TR (CS: +49% vs +10%, respectively, p<0.001). Mitochondrial dynamics during TR were characterized by no significant changes in fusion (+9% and +3% for OPA1 and Mfn1, respectively, p>0.05) and an increase in fission (Fis1: +51%, p<0.001) . RETR induced a significant reduction in fusion (-13% and -17% for OPA1 and Mfn1, respectively, p<0.05) and a larger increase in fission compared to TR (Fis1: +96% vs +51%, p<0.001).
CONCLUSION: Endurance performance improved to a greater extent after retraining than training. This functional adaptation was supported by a larger mitochondrial content resulting from a more pronounced mitochondrial biogenesis response after retraining. Interestingly, a shift toward fission rather than fusion was observed after retraining, highlighting a crucial role of detraining for these molecular adaptations. In conclusion, the present study corroborates the existence of muscle memory in response to HIIT endurance training affecting both mitochondrial biogenesis and dynamics.
References
[1] Egner et al, 2013
[2] Brusgaard et al, 2010
[3] Lee et al, 2018
[4] Gundersen, 2016
[5] Wen et al, 2021

**BASAL AUTOPHAGY SIGNALLING IS UPREGULATED BY SPRINT INTERVAL TRAINING (SIT) IN HUMAN SKELETAL MUSCLE, AN EFFECT POTENTIATED BY APPLICATION OF IMMEDIATE POST-EXERCISE ISCHAEMIA.**

MARTINEZ-CANTON, M., GALVAN-ALVAREZ, V., GALLEGO-SELLES, A., GARCIA-GONZALEZ, E., GELABERT, M., SANTANA, A., MORALES, D., FERNANDEZ-GARCÍA, B., BOUSHEL, R., HALLEN, J., MARTIN, M., CALBET, J.A.L.

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INTRODUCTION: Autophagy is a cellular mechanism of self-renewal based on the degradation and recycling of damaged or dysfunctional cellular components, which is necessary for a normal skeletal muscle adaptation to training. Autophagy activation has been associated with high-intensity exercise, hypoxia, and exhaustion. However, little is unknown regarding the molecular signals regulating exercise-induced autophagy in human skeletal muscle. Therefore, this study aimed to determine the role of metabolic stress on the exercise-induced stimulation of autophagy. For this purpose, we used a novel experimental model in which ischaemia is applied to one leg for a few seconds after each repetition of an all-out exercise during a sprint interval training (SIT) program based on Wingate tests. We hypothesized that the application of post-sprint ischaemia during SIT would result in greater stimulation of basal autophagy than SIT alone.
METHODS: Ten physically active subjects were tested before and after a SIT program (4-6 30-s isokinetic sprints with 4 min recovery periods, 6 sessions in total, in 2 weeks). Immediately after each 30-s sprint, the circulation of one leg was instantaneously occluded (300mmHg) for 30-50s, followed by unloaded pedalling for the rest of the recovery interval. The main pre and post-training tests consisted of incremental exercise (IE) to exhaustion followed by 90min rest and 6 bouts of supramaximal exercise to exhaustion at 120%VO2max (SPE) interspaced with 20-s recovery periods, during which the circulation of both legs was completely occluded. Vastus Lateralis m. biopsies were obtained at rest (basal), 90 min after the IE, and immediately after SPE unilaterally at Pre and bilaterally from the leg training with free circulation (FCL) and the leg training with ischaemia (IS) at Post for Western Blotting analysis. Statistical analysis: repeated-measures ANOVA.
RESULTS: SIT induced upregulation of autophagy activating kinases in basal conditions, which was more marked for the leg training with post-exercise ischaemia, particularly pSer253-FOXO3, pSer2448-mTOR, pSer555-ULK1, LAMP2A, and the ratio pSer15/total Beclin1 (IS effect $p<0.01$). These changes did not occur in the FCL. Moreover, the stress kinases response to SPE was attenuated or blunted after SIT, more markedly in the IS trained leg. No significant changes were observed in basal pThr172/total AMPKa, p62 and LC3BII/I ratio.
CONCLUSION: This research shows that the application of post-exercise ischaemia immediately after each bout of sprint training further amplifies the stimulation of autophagy signalling observed in response to SIT by a mechanism involving the chaperone-mediated autophagy and independent of mTOR and FOXOs. Our experimental model indicates that the increased metabolite accumulation and RONS production caused by post-exercise ischaemia may enhance the basal autophagy response. The latter may accelerate the adaptive response to SIT.
Grant: DEP2017-86409-C2-1-P

**THE EFFECTS OF 6-WEEKS SPRINT INTERVAL TRAINING AND POST-EXERCISE BLOOD-FLOW RESTRICTION ON MITOCHONDRIAL RESPIRATION AND DETERMINANTS OF ENDURANCE PERFORMANCE.**

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INTRODUCTION: The addition of post-exercise blood-flow restriction (BFR) to sprint-interval training (SIT) induces greater homeostatic perturbations that acutely augment gene expression of key signaling transcripts compared with SIT alone [1]. Furthermore, 4-week SIT with BFR in trained individuals has been demonstrated to increase peak oxygen uptake (VO2peak) [1][2]. Despite these findings, the addition of BFR to SIT did not result in skeletal muscle phenotypic changes [2]. High-intensity training interventions are postulated to be a potent stimulus for improving mitochondrial respiration [3], however, this is yet to be investigated following combined SIT and BFR. The aim of this study was to examine the effects of 6-week SIT and BFR on mitochondrial respiration and markers of endurance performance.
METHODS: Trained males (n = 20; age, 25 ± 6 yrs) completed 6-weeks of SIT (2 x per week), performing repeated 30-s maximal sprints interspersed with 4.5-min rest (CON; n = 8) with 2-min BFR applied immediately post-sprint in the experimental group (BFR; n = 12). Prior to and following training, VO2peak and lactate thresholds (LT1 and LT2) were determined, and muscle biopsies were obtained for the determination citrate synthase (CS) activity, as a marker of mitochondrial content, and mitochondrial respiration parameters. ADP-stimulated phosphorylation (P) and uncoupled maximal electron transfer (E) states through mitochondrial complexes I – IV (CI – IV) were measured and corrected to CS activity.
RESULTS: Training increased VO2peak (CON, 52.1 ± 5.2 to 53.1 ± 5.1; BFR, 52.8 ± 4.3 to 54.5 ± 4.9 ml·min-1·kg-1; $p = 0.04$), LT1 (CON, 181 ± 44 to 192 ± 37; BFR, 201 ± 32 to 219 ± 31 watts; $p = 0.03$) and LT2 (CON, 198 ± 27 to 208 ± 20; BFR, 215 ± 39 to 227 ± 34 watts $p = 0.04$). However, BFR did not augment increases compared with CON ($p \geq 0.101$). A group x time interaction effect was observed for CS activity (mol·h-1·kg-1; CON = -4.6 ± 6.3 %, BFR = 12.1 ± 17.5 %, $p = 0.01$) , however, there were no differences between groups ($p \geq 0.27$). CS activity corrected mitochondrial P and E (pmol·s-1·CS-1; $p \leq 0.04$) were increased after training in both conditions. BFR enhanced improvements in CIIE (interaction, $p = 0.05$) and CIVE ($p = 0.01$) compared to CON with improvements in CIIE (2.6 ± 0.8 to 4.2 ± 1.3 pmol·s-1·CS-1; $p = 0.02$) and CIVE (11.9 ± 1.6 to 19.5 ± 2.8 pmol·s-1·CS-1; $p = < 0.001$) following training in BFR, but not in SIT (2.5 ± 0.7 to 2.7 ± 7.3 and 15.3 ± to 14.2 ± 5.7 pmol·s-1·CS-1, respectively; $p \geq 0.54$).
CONCLUSION: BFR augmented improvements in maximal mitochondrial oxidative capacity following 6-weeks of SIT. BFR did not, however, augment improvements in parameters of endurance performance.
1. Taylor et al. (2016)
2. Mitchell et al. (2019)
3. Granata et al. (2016)

# Oral presentations

## OP-MH01 Ageing

### SUCCESSFUL AGING: THE ASSOCIATION OF BODY COMPOSITION, MUSCULAR FITNESS AND PHYSICAL EXERCISE WITH COGNITION, BRAIN VOLUME, NEURODEGENERATION AND NEUROINFLAMMATION

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INTRODUCTION: The proportion of physically inactive, old, obese and sarcopenic adults in our society is gradually increasing, and all of these are associated with a risk of cognitive decline. Cognitive disorders like dementias are the fastest increasing cause of disability and death in older adults. Notably, there is a wide variability between persons with respect to the speed of age-related cognitive decline. Therefore, a better understanding of the biological mechanisms that predict successful cognitive aging is of major interest. It was recently proposed that blood biomarkers may be mediating the link between body and brain. Specifically, inflammatory factors released from senescent cells and adipose tissue have detrimental effects, while neurotrophic and anti-inflammatory factors released from healthy muscle -especially during exercise- facilitate neuroplastic processes in the brain, promoting cognitive function.
METHODS: 74 older adults (60-85y) were enrolled in a 12 week leg resistance exercise program directed to improve understanding of blood-brain interactions that may mediate the association of body composition, muscular fitness and physical exercise with cognition, brain volume, and markers of neurodegeneration and neuroinflammation. Analysis was done with bio-impedance analysis, handgrip strength, knee flexion/extension peak torque, 8-Foot Up-and-Go test (8UG), the Montreal Cognitive Assessment (MoCA), brain magnetic resonance imaging (MRI) and brain proton magnetic resonance spectroscopy (1H-MRS). Peripheral inflammation was assessed with serum interleukin-6 and kynurenine, measured with ELISA.
RESULTS: Decreased handgrip strength was associated with elevated peripheral inflammation, markers of neurodegeneration and lower hippocampal gray matter volume. Also, higher body fat percentage was associated with signs of neurodegeneration and decrease of total, hippocampal and medial temporal gray matter volume. Contrary to what we expected, higher skeletal muscle mass index and better performance on the 8UG were also associated with elevated markers of neurodegeneration. No associations were found with MoCA results. Of interest, serum kynurenine was positively associated with signs of neurodegeneration and neuroinflammation. 12 weeks resistance training did not result in significant changes in peripheral inflammatory markers, brain volume or markers of neurodegeneration or neuroinflammation. However, a positive association between knee flexion and extension peak torque gain and neural density increase in the sensorimotor cortex was found.
CONCLUSION: Muscle strength corresponds to neurochemical correlates of brain health in older adults. Of importance, brain health seems to respond to resistance exercise in those showing muscle strength gain. Finally, it is critical to older adults' brain health to maintain a healthy body fat percentage.

### HEALTH-RELATED PHYSICAL PARAMETERS IN ACTIVE AND COMPETITIVE OLDER ADULTS OF DIFFERENT AGE

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INTRODUCTION: Previous literature has shown that older adults who exercise regularly have improved physical abilities compared to their sedentary counterparts and reduced age-related decline across ageing. In this study we aimed at investigating the effect of exercising for well-being or competitive purposes on physical and socio-emotional functioning across late adulthood, in healthy older adults.
METHODS: 17 male competitive cross-country skiers (COMP) and 17 active subjects (ACT) matched for age (8 subjects under 70 years old and 9 over, for both the groups) and amount of weekly physical activity (GPAQ questionnaire) were tested for body composition, health-related physical parameters (arm and leg maximal strength, flexibility, balance, reaction time to auditory stimulus, leg and armcycling efficiency) and socio-emotional functioning (perceived quality of life (SF-36 v.2 questionnaire) and sleep (PQSI questionnaire)). A two Way ANOVA test verified the effect of group (COMP vs ACT), age (under vs over 70) and their interaction.
RESULTS: COMP spent more time than ACT performing in vigorous exercise but less time in moderate daily work and active travelling (all $P<0.05$). Weight, BMI, skinfolds and % fat mass were lower in COMP compared to ACT (all $P<0.05$), arm and leg maximal strength higher (all $P<0.05$) while flexibility, reaction times, balance and metabolic efficiency were comparable. Physical and socio-emotional parameters of both groups were better when compared to normative data for sedentary older adults and did not show a worsening trend across age ($p>0.05$). Only balance was better maintained in COMP than in ACT (interaction: $P=0.05$).
CONCLUSION: Systematically exercising for both well-being and competitive purposes at comparable volumes (around 6000 MET/week) seems to improve health-related physical performances and life quality perception, attenuating the age-related natural decline and guaranteeing a successful aging. Exercising to compete provides further advantages as far as concerned body composition, arm and leg muscle strength, maybe due to more vigorous and targeted stimuli (around 1700 MET/week) but its suitability in relation to cardio-vascular heath must be verified by a specialized medical doctor.

### EFFECTIVENESS OF SUPERVISED CENTER-BASED VS. UNSUPERVISED HOME-BASED TRAINING ON MUSCLE POWER AND QUALITY OF LIFE IN OLDER ADULTS: A SYSTEMATIC REVIEW AND META-ANALYSIS OF RANDOMISED CONTROLLED TRIALS

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INTRODUCTION: Physical exercise is an effective tool for reducing the detrimental effects of aging. However, some older adults do not have access to a gym nor a center to perform exercise under the supervision of a specialist; thus, unsupervised home-based programs (UHB) might be a suitable option for this population. Although it has previously been shown that UHB can provide health benefits (1), we still do not know how effective an UHB exercise programme can be compared to one that is supervised.

METHODS: Two researchers systematically searched five databases (PubMed, CINAHL, PsycInfo, SPORTDiscus and Web of Science) up to 12/01/2022. The electronic search was supplemented by a thorough manual review. Randomized controlled trials that compare supervised center-based (SCB) versus UHB in older adults (≥60yrs) were included. The outcomes analysed were health-related quality of life (HRQOL) through different self-reported questionnaires (e.g. EuroQoL 5-D, SF-36, etc.) and lower limb muscle power using the sit-to-stand test.
RESULTS: A total of 8,068 articles were found. Finally, 16 studies were included in the final synthesis (N= 1,812; mean age 71). SCB training significantly improved muscle power measured through the sit-to-stand test (SMD=0.35, 95%CI=0.09-0.60, p=0.007) compared to UHB, with moderate heterogeneity (64.8%) and signs of publication bias (Begg's test p=0.012). Sensitivity analyses confirmed significance when removing each study at a time. No greater effectiveness was found in the HRQOL variable for SCB training compared to training without the supervision of a professional (SMD=0.06, 95%CI=-0.18-0.31, p=0.606), with no heterogeneity (19.5%) nor signs of publication bias (Begg's test p=0.484).
CONCLUSION: Our analyses suggest that SCB training improved measures of muscle power to a greater extent than UHB programs. Nevertheless, no additional benefits for training under the supervision of a professional in a center compared to training performed at home without direct supervision on the HRQOL variable were found. Although more quality evidence is lacking, whenever possible, SCB exercise sessions are recommended, whenever possible, to improve muscle power in older adults.
(1) Mañas, A., et al. (2021). Ageing Research Reviews, 69, 101368.

**COMPARISON OF WALKING EXERCISE ALONE OR TOGETHER WITH RESISTANCE EXERCISE AS HEALTHY AGING PROMOTING INTERVENTION: A PILOT STUDY**

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INTRODUCTION: The advancements in life expectancy in Korea have been raised the necessity for proper programs to improve the well-being and longevity of the elderly [1]. There is some evidence that maintaining the recommended physical activity could promote healthy aging [2]. However, there is a controversy over which type of exercise confers a greater functional benefit in the elderly. This study aimed to overcome aging-related disease by comparing two different types of exercise for improvement of muscle function and cognition in the elderly population.
METHODS: A total of 62 healthy elderly aged ≥65 years were randomly assigned to one of the following groups: aerobic(AG), resistance+aerobic(RAG), and control(CG) for a 12-week intervention. AG subjects were instructed to follow the walking exercise program and maintain their weekly goal of total walking steps. RAG subjects participated in strength exercise together with the walking program. And CG subjects performed stretching. Participants' body composition, Mini-Mental State Exam and Stroop test (ST), Physical Performance Battery (SPPB), timed up and go (TUG), maximal aerobic capacity (VO2max), handgrip strength (HGS) and knee strength isokinetic test were measured at baseline and at the end of 12 weeks.
RESULTS: As a result of our 12-week intervention, there was a significant difference between RAG and AG in the total score of SPPB (0.42±0.2, p=0.049). Within-group results showed a decrease in fat mass (p=0.038) and enhancement in congruent stimuli of ST score (p=0.043) which was observed in RAG. The walking program alone also improved both scores of neutral (p=0.033) and congruent (p=0.016) stimulus of ST in AG; however, a decline in HGS (p=0.034) and VO2max (p=0.034) was recorded. Moreover, the performance of CG in both the 5-time sit-to-stand test (p=0.020) and TUG (p=0.001) got worse.
CONCLUSION: Our 12-week walking exercise alone or combined with resistance exercise was effective in improving cognitive function and maintaining physical function of the elderly. However, the longer duration of intervention and larger sample size are required to compare which type of exercise is more beneficial for the elderly to maintain and enhance their physical and mental health.

## Oral presentations

### OP-AP17 Recovery strategies

**COLD AND HOT WATER IMMERSION IN ELITE YOUTH FOOTBALL PLAYERS: EFFECT ON RECOVERY OF PHYSICAL PERFORMANCE AFTER A SIMULATED GAME**

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INTRODUCTION: Recovery in competitive team sport such as football is important. Cold Water Immersion (CWI) and Hot Water Immersion (HWI) have become a common practice based on the assumption that they can restore physical performance. While the use of CWI in football is well studied, there are fewer studies on HWI, or studies comparing HWI and CWI. Furthermore, it is important to account for the potential placebo effect in the design of studies assessing recovery. In this study, we investigated the effect of CWI and HWI after a simulated football match (SFM) on the recovery of physical performance in male elite youth football players.
METHODS: Forty male elite youth football players (15-19 years) were included in this study. They were randomized to either CWI (10°C, 10 min), HWI (42°C, 20 min) (immersion up to iliac crest), or placebo (PLA, 6 min, sham laser). The recovery modality was applied 1 h after a 90-min SFM (modified Copenhagen Soccer Test). Physical performance was assessed using the following tests: 20m sprint, submaximal Yoyo Intermittent Recovery Test 1 (until 4 min, i.e. stage 14.1), counter movement jump (CMJ), knee extension maximum isometric voluntary contraction (MIVC), time to exhaustion at 60% of MIVC and MIVC following time to exhaustion. All tests were performed at baseline, immediately after, as well as 21 and 45 h after the SFM.
RESULTS: During the SFM, no significant differences for distance covered, heart rate (HR), rating of perceived exertion (RPE) and blood lactate concentration [lactate] were observed between the three groups. Sprint performance, HR, RPE and [lactate] during the submaximal Yoyo test, as well as CMJ height were affected by time ($p<0.05$), but not by recovery modality. MIVC force was reduced by ~8% after the SFM vs baseline in the three groups ($p<0.05$). At 21 and 45 h after the SFM, MIVC was no longer significantly reduced in CWI (91.7 ± 11.9 and 94.1 ± 9.8% of baseline, respectively) and HWI (96.8 ± 8.9 and 93.8 ± 9.2% of baseline, respectively), while it remained decreased in

PLA (88.2 ± 6.5 and 90.8 ± 9.4% of baseline, respectively, p<0.05). However, no recovery modality effect was observed for MIVC. Time to exhaustion was reduced by ~30% immediately and 21 h after the SFM in all three groups vs baseline (p<0.01). At 45 h after the SFM, time to exhaustion remained reduced in PLA (73.0 ± 19.6% of baseline, p<0.01) and HWI (85.7 ± 19.4% of baseline, p<0.05) but not in CWI (96.3 ± 28.4% of baseline, p=0.95). For time to exhaustion, a main effect of recovery modality was detected (p<0.05), but no specific differences between groups were detected. MIVC following time to exhaustion was neither affected by time nor by recovery modality.
CONCLUSION: CWI and HWI did not improve recovery of sprint, submaximal running as well as jumping performance during a 2-day recovery period following a SFM, while these modalities may positively affect recovery of strength during this period. CWI may also have a beneficial effect on fatigue resistance after 45 h.

**THE EFFECT OF TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION ON THE RECOVERY OF QUADRICEPS FEMORIS FATIGUE IN RECREATIONAL ROWERS**

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INTRODUCTION: Quadriceps muscle contributes significantly to the performance during rowing and is prone to fatigue easily. Transcutaneous electrical nerve stimulation (TENS) can effectively delay the onset of fatigue, and thus might play a role in fatigue recovery after exercises. Therefore, the objective of the study was to investigate the effect of TENS on quadriceps muscle post a rowing ergometer induced fatigue.
METHODS: Twenty-eight recreational rowers were evenly and randomly assigned to experiment (TENS intervention) and control group (placebo TENS intervention). Variables of ratings of perceived exertion (RPE), blood lactate, and peak torque of quadriceps were collected following a brief warm-up and the rowing ergometer induced fatigue program respectively. The rowing ergometer induced fatigue program included 2000m race on the Concept II rowing ergometer(Model D, Concept II Inc., USA). Then the experiment group received a 20-min TENS, and the control group received a 20-minute placebo TENS. One-way repeated measures ANOVA was used for data analysis. Significance was set at $P < 0.05$.
RESULTS: Participants in experiment (RPE: 17.79 ± 1.05, blood lactate: 18.56 ± 3.40 mmol/L) and control group (RPE: 18.50 ± 1.45, blood lactate: 17.82 ± 2.72 mmol/L) were fatigue after the rowing. When compared to control group, peak torque of the right (mean difference = 4.25 ± 0.45, $F = 3.535$, $P = 0.041$, $\eta 2p = 0.153$) and left quadriceps (mean difference = 3.91 ± 0.45 , $F = 4.305$, $P = 0.048$, $\eta 2p = 0.142$) increased, blood lactate decreased (mean difference = 8.73±0.73 , $F = 6.768$, $P = 0.015$, $\eta 2p = 0.207$) significantly in experiment group following TENS intervention. REP decreased from 17.79 ± 1.05 to 9.71±2.19.
CONCLUSION: TENS might be effective in fatigue recovery in quadriceps of recreational rowers. It could be utilized as an assistive strategy for fatigue recovery in recreational rowers.

**AETIOLOGY AND RECOVERY OF NEUROMUSCULAR FUNCTION FROM A PROFESSIONAL SOCCER ACADEMY TRAINING WEEK**

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INTRODUCTION: We profiled the aetiology and recovery time-course of neuromuscular function in response to a mixed-content, standard training week in professional academy soccer players. We concurrently examined physical performance, cognitive function, and perceptual measures of mood and wellness states to identify a range of simple tests applied practitioners could use in the field as surrogate measures of neuromuscular function.
METHODS: Sixteen professional academy soccer players completed a strenuous training day (pitch and strength sessions), followed by a moderate training day two days later. Pre-, post-, and at 24, 48, and 72 h post-strenuous day, participants completed a range of neuromuscular, physical, perceptual, mood, and cognitive function tests. Maximal voluntary contraction force (MVC) and twitch responses to electrical stimulation (femoral nerve) during isometric knee-extensor contractions and at rest were measured to assess central nervous system (voluntary activation, VA) and muscle contractile (potentiated twitch force, Qtw,pot) function. Fatigue and perceptions of wellness and mood states were assessed via visual analogue and likert scales. Cognitive function was assessed via the Stroop task. Countermovement jump, reactive strength index, and bilateral isometric adductor contraction (adductor squeeze) were assessed to profile the recovery of physical function.
RESULTS: Strenuous training elicited decrements in MVC force post-session (−11%, $P = 0.001$) that remained unresolved at 72 h (−6%, $P = 0.03$). Voluntary activation (motor point stimulation) was reduced immediately post-training only (−4%, $P = 0.03$). No change in muscle contractile function (Qtw,pot) was observed post-training, though was reduced at 24 h (−13%, $P = 0.01$), and had not fully recovered 72 h after (−9%, $P = 0.03$). Perceptions of fatigue, muscle soreness, training difficulty and sleepiness increased post-training, and had recovered by 24 h (sleepiness) and 48 h (fatigue, muscle soreness, training difficulty). Perceived levels of energy and readiness to train were decreased at post-training, before recovering at 24 h (energy levels) and 48 h (readiness to train). Countermovement jump performance, though unchanged immediately post-training, declined at 24 h and took 48 h to recover. RSI decrements persisted at 48 h, before recovering by 72 h. No changes were evident in adductor squeeze measures, mood scores or cognitive function.
CONCLUSION: Elite youth soccer training elicits substantial decrements in neuromuscular function, which are still present 72 h post-strenuous exercise. Though central processes contribute to post-exercise neuromuscular alterations, the magnitude and prolonged presence of impairments in contractile function indicates it is the restitution of muscular function (peripheral mechanisms) that explains recovery from strenuous training in academy soccer players. Collectively the findings could inform training, preparation and recovery activities to maximise longer-term player development and athletic progression at this critical point in their maturation.

**EFFECT OF NAP OPPORTUNITY ON PHYSIOLOGICAL RESPONSES AND SPECIFIC ABILITIES IN ELITE BASKETBALL PLAYERS**

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INTRODUCTION: Sleep disturbances are common among elite athletes on training days, night(s) before and following competitions in elite athletes. It was showed that sleep deprivation deteriorates athletes' physical and cognitive performance, increases muscle damage, im-

pairs the recovery from high-intensity exercise, and is associated with higher injury risk. According Souabni et al. [1], napping is a safe and non-invasive intervention in athletes' schedules. However, studies investigating the effect of napping on physical performance showed inconclusive and contradictory results. This study investigates the effect of 40-min nap opportunity on physiological responses and specific abilities in elite basketball players
METHODS: Each participant of twelve professional male basketball players accomplished randomly two conditions: 40-min nap opportunity (NAP) and control condition (CON). Wellness Hooper index was measured before and after both conditions. At 15:00 h, participants completed the shooting skills test (SST) (10 shots from the free throw line) followed by a 15 min standardized warm-up. Then, defensive (MAT) and offensive (CDT) agility, and upper body strength (MBCP) were tested. Next, participants played a 10min small sided game (SSG) followed by the shooting skills retest. RPE at the end of SST-test, SSG and SST-retest and heart rate (HR) during both nap and control conditions, SST-test, SSG and SST-retest were measured.
RESULTS: Better performance for MAT and CDT was obtained in NAP compared to CON condition ($p \leq 0.02$, $d \geq 0.74$, $\Delta \geq 2.7\%$). MBCP performance was higher in NAP ($p < 0.0005$, $d = 1.67$, $= 5.6\%$). Although no significant difference was reported in test session, SST performance was significantly higher in NAP compared to CON condition in retest session (74.2±12.4% vs. 59.2±11.6%, respectively) ($p = 0.003$, $\Delta = 20.2\%$). HRmean was significantly lower in NAP compared to CON condition during SSG ($p = 0.02$, $\Delta = 6.09\%$). HRpeak was significantly lower in NAP compared to CON condition during SSG ($p = 0.02$, $\Delta = 4.9\%$) and SST-retest ($p = 0.01$, $\Delta = 5.25\%$), however no significant difference was reported during SST-test. RPE score was significantly lower in NAP compared to CON condition for SSG ($p = 0.001$) and SST-retest ($p = 0.003$). Hooper's stress and fatigue score were significantly lower after nap compared to values before nap ($p = 0.009$ and $p = 0.01$, respectively), however no significant difference was reported in CON condition.
CONCLUSION: NAP had a positive effect on physiological response operationalized through lower HR values compared to CON condition. This resulted in lower RPE scores and could explain the improvement of shooting performance in retest session. In conclusion, NAP reduces sleepiness, stress and fatigue and enhances physical outcomes of specific skills in elite basketball players. It is also an effective strategy to overcome the deterioration in shooting performance caused by the fatigue induced during exhaustive gameplay situations.

**EFFECTS OF COMBINED INTERVENTIONS TO OPTIMISE RECOVERY DURING HIGH-INTENSITY EXERCISES IN TRAINED INDIVIDUALS**

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INTRODUCTION: Team sports such as ice hockey offer the opportunity of recovery breaks between high-intensity work intervals. Strategies aiming to mitigate fatigue during intermittent physical activity are seldom investigated in combination, although several different mechanisms of action exist, which might be cumulative and therefore beneficial for athletes. This study examined the effects of seven combined recovery interventions (enhanced recovery package, ERP) on exercise capacity during intermittent high-intensity cycling.
METHODS: 16 trained men (age: 24.8 ± 3.4 y; maximal power output: 5.0 ± 0.5 W·kg-1) completed a repeated sprint exercise (RSE) protocol consisting of six 30-s cycling sprints with 3-min breaks between each sprint. The first sprint was always performed at a similar load, while sprints 2-6 were performed with the ergometer in cadence dependent mode (0.075 kg·kg-1). During the breaks, the ERP, Placebo, or Control protocols were applied, all on different days. The ERP condition combined 1) 3-min ice gel packs to the neck; 2,3) 5-s mouth rinsing of a 10% carbohydrate and caffeine (6 mg·kg-1), 4) ingestion of 50 mL of a 6% carbohydrate solution, 5,6) 30 s of all-out hyperventilation while breathing 100% O2 (hyperoxia); and finally, 7) potentiation manoeuvres via performance of 3 half-squats at 75% of one maximal repetition. The placebo intervention masked the interventions except for the ice packs and potentiation manoeuvres. Participants were told they were performing a simplified version with only the known beneficial interventions. Power output, heart rate, blood lactate concentration, rate of perceived exertion and gas exchange were compared between the ERP and Placebo conditions.
RESULTS: Mean power output (W) was significantly higher for the ERP condition compared to Placebo (570 ± 74 W vs. 560 ± 71 W, $t(15) = 4.603$, $P < 0.001$, 95% CI diff = 5 – 14 W, $dz = 1.15$). The rate of power decrement over sprints 2-6 was very similar between trials (ERP -14.2 W per sprint, 95% CI = -21.6 – -6.8 W; Placebo -17.4 W per sprint, 95% CI = -24.7 – -10.2 W per sprint, $P = 0.407$). Mean heart rate was higher (3 ± 4 bpm, $P = 0.012$) for the ERP compared to the Placebo condition, as was breathing frequency (2.4 ± 4.0 breaths·min-1, $P = 0.028$) and respiratory exchange ratio (0.12 ± 0.06, $P < 0.001$). Oxygen uptake was 80 ± 109 mL·min-1 ($P = 0.013$) lower for ERP. No differences were found with regards to the rate of perceived exertion or blood lactate concentration.
CONCLUSION: ERP optimised recovery when applied during the breaks of a high-intensity repeated sprint exercise and shows a small but consistent increase in mean power output. It is possible that the ERP prevented a loss of aerobic efficiency. A top-down approach when tailoring packages for individual athletes might overcome the issue of small improvements that are difficult to detect when strategies are tested in isolation.

## Oral presentations

### OP-AP29 Training and testing: Fatigue

**PERFORMANCE AND FATIGABILITY ACROSS DIFFERENT TRIATHLON RACE DISTANCES: FROM SPRINT TO IRONMAN**

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INTRODUCTION: Triathlon is a unique endurance sport including swimming (S), cycling (C), and running (R) [1]. Classically, triathlon races are classified in Sprint (SP), Olympic (O), Half (H) and Full (F) distances [2]. Previous studies have demonstrated alterations in neuromuscular function after prolonged exercise [3] and a greater muscle contractile properties impairment with increasing exercise duration both in cycling and running [4,5]. Only one previous study investigated fatigue after a long-distance triathlon [6] but, how each discipline can impact neuromuscular function throughout different triathlon distances remains unclear. This study aimed to evaluate and compare the magnitude of neuromuscular function impairments in SP, O, H and F.

METHODS: Forty-two male triathletes (Age:39±9 yrs; VO2peak:54.4±5.6ml·min-1·kg-1) were enrolled in the study. Four triathlon races were selected: SP (n=12, 0.75Km S; 20Km C; 5Km R), O (n=16, 1.5Km S; 40Km C; 10Km R), H (n=11, 1.9Km S; 90Km C; 21.1Km R), and F (n=4, 3.8Km S; 180Km C; 42.2Km R). Performance fatigability was quantified by maximal voluntary isometric contraction (MVIC) force of the knee extensors performed: i) before the race (PRE); ii) during the transition phases after S (T1), iii) after C (T2) and iv) immediately after the end of the race (POST). Race speed was monitored by a GPS system.
RESULTS: Triathletes completed SP, O, H, and F in 77±7min, 158±14min, 400±48min, and 883±96min, respectively. Race speed did not change in S among the races, whereas it was higher in SP and O compared to H and F for both C (33±3 and 34±3Km/h vs 24±3 and 23±3Km/h, respectively; P<.05) and R (13±2 and 12±1Km/h vs 10±1 and 8±1Km/h, respectively; P<.05). MVIC force did not decrease significantly in T1 in any race, whereas it decreased significantly in T2 and POST, resulting at the end -19±9%, -23±9%, -29±15%, and -32±8% from PRE in SP, O, H, and F, respectively (all P<.05). In C, MVIC force loss was greater in SP compared with H (-17±11% and -6±10%, respectively, P<.05). Conversely, in R MVIC force loss was lower in SP than H (3±12% and -17±26%, respectively, P<.05).
CONCLUSION: Triathletes experienced a reversible decline in the ability to produce force which was progressively larger with increasing race distance. Neuromuscular function impairment was primarily affected by cycling in SP and running in H, suggesting an important interplay between exercise intensity and race distance on fatigability in triathlon. The present results will help coaches to select the most appropriate training program in accordance with the target race distance of their athletes.
1. Garcia et al. (2016) 2. Bentley et al. (2002) 3. Millet et al. (2004) 4. Temesi et al. (2021) 5. Lepers et al. (2001) 6. Margaritis et al. (1999)

## A COMPARISON OF THE NEUROMUSCULAR CONSEQUENCES OF EXERCISE WITHIN THE MODERATE AND HEAVY INTENSITY DOMAINS

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INTRODUCTION: Performance fatigability is substantially greater when exercising in the severe versus heavy intensity domain (1). However, the relevance of the boundary between moderate and heavy intensity exercise, the gas exchange threshold (GET), to performance fatigability is unclear. This study compared alterations in neuromuscular function during work-matched exercise above and below the GET.
METHODS: Sixteen male participants completed work-matched cycling for 90, 110 and 140 min at 110, 90 and 70% of the GET, respectively. Knee extensor isometric maximal voluntary contraction (MVC), high-frequency doublets (Db100), low- to high-frequency doublet ratio (Db10:100), potentiated twitch force (Qtw,pot), voluntary activation (VA), motor evoked potential (MEP) and thoracic motor evoked potential (TMEP) were measured at baseline, 25, 50, 75 and 100% of task-completion. During the initial, baseline visit, and following each constant load bout, ramp-incremental exercise was performed, and peak power output and oxygen uptake ($\dot{V}O_2peak$) were determined.
RESULTS: While impairments in neuromuscular function occurred for all exercise intensities, the reductions in MVC (p=0.008) and Db100 (p=0.029) were up to 1.7-fold greater in response to the 110% GET trial relative to the 90% GET trial, with no difference between the 90% and 70% GET trials (p≥0.175). Voluntary activation and MEP were similarly reduced for all trials, while a reduction in TMEP was only observed for the 110% and 90% GET trials (p≤0.044). Peak power output and $\dot{V}O_2peak$ during ramp-incremental exercise were reduced by 7.0±11.3% and 6.5±9.3%, respectively following the 110% GET trial relative to the baseline ramp (p≤0.015), with no changes following the moderate intensity trials (p≥0.078).
CONCLUSION: When exercising at 70% or 90% GET, no differences were observed in fatigability for a given level of work. However, when the power output was elevated by the same magnitude between 90% and 110% GET, thus transcending the moderate-heavy domain boundary, fatigability was substantially exacerbated. These results indicate that even marginally exceeding the moderate-heavy domain boundary has negative implications for neuromuscular function, with evoked twitch responses to relaxed muscle indicating that the greater fatigability is due to intramuscular mechanisms. Moreover, the lower peak power output found only following the 110% GET trial suggests that prolonged heavy intensity exercise has negative implications for subsequent exercise tolerance.
1) Burnley et al. (2012)

## CHANGES OF AGONIST AND SYNERGIST MUSCLES ACTIVITY DURING A SUSTAINED SUBMAXIMAL BRAKE-PULLING GESTURE

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INTRODUCTION: There is a need to consider functional grip tasks in research, ensuring that the setup and ergonomics of instruments are optimal for interpreting fatigue-induced changes on surface electromyography (sEMG) signals accurately. The braking gesture on a motorcycle can be considered as a “power grip” task that require the involvement of both flexor and extensor muscles of the forearm and arm to control finger flexion forces while handling the handlebar in a firm grip while stabilizing the wrist (1)
We aimed to analyze the course of changes in muscle activity of the prime mover and synergist muscles during a sustained a braking action on a motorcycle setup and to investigate the relationship between muscle activity and braking force fluctuation (FF).
METHODS: Thirty-two young adults performed a continuous fatiguing protocol (CFP) at 30% of maximal voluntary contraction (MVC) until failure, on a motorcycle setup that simulated a typical body position when riding a road motorcycle. Moreover, surface electromyography (EMG) was used to analyze root mean square (EMGRMS) values in the flexor digitorum superficialis (FD), flexor carpi radials (FC), extensor digitorum comunis (ED), extensor carpi radials (EC), brachioradialis (BR), biceps brachii (BB), and triceps brachii (TB). Ratios between agonist and antagonist muscles were also calculated for the fingers gesture (RatioFingers: FD/FC), the wrist (RatioWrist: FC/EC) and the elbow [RatioElbow: ((BB+BR)/2)/TB)]. The FF was normalized with the averaged signal of the same periods as a measure of steadiness (2).
All signals were synchronized online by an external analog-to-digital converter (Power 1401; Cambridge Electronics Design -CED-). The offline analysis was done with the Spike2 Software. A multivariate analysis of variance was performed to study the EMGRMS and FF changes across the CFP. The degrees of association and the relations between braking forces, sEMG and time variables were examined by regression analysis. The level of significance was set at 0.05.
RESULTS: The FF and EMGRMS both increased progressively during the CFP, with sharp increments occurring before failure (P<0.001). This was confirmed by a significant correlation between these variables (r = 0.995; P<0.001). At the time limit, the EMGRMS of the FD and FC muscles were comparable to the baseline MVC values (P<0.003). The three flexor/extensor ratios used to measure coactivation levels decreased significantly (P<0.001). The MVC force was still depressed (14±8%) after 10 min of recovery (P<0.001), in spite of the similar EMGRMS values (P>0.516) of the forearm flexors in comparison to pre-fatigue condition.

CONCLUSION: Overall, our results indicate that performance was mainly constrained by fatigue-related mechanisms located at muscle level in the prime movers when exerting a CFP in a natural and ecological setup aimed to reproduce the brake-pulling action on a motorcycle.

### THE SMILE REVOLUTION – A FACIAL ELECTROMYOGRAPHY APPROACH FOR FATIGUE EVALUATION DURING CYCLING AEROBIC EXERCISE TEST

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INTRODUCTION: Recently, a novel, multiarray electrodes sticker was introduced, allowing continuous measurements of facial surface electromyography (sEMG) for long term recordings in freely behaving humans [1]. This sensor has been used for mapping spontaneous and "masked" smiles [2], and to detect facial expressions for emotional affect recordings [3]. Development of a, non-invasive, real-time capability to identify athletes' fatigue during exercise is important for performance enhancement and to avoid over-training and exercise-related injuries. Despite the increasing interest in facial expressions and facial sEMG for fatigue evaluation [4,5], this topic has not been widely studied. The aim of the current study was, therefore, to analyze the facial muscles activity patterns, while focusing on smiles, in response to graded exercise stress test, to exhaustion.
METHODS: 5 young, healthy, and recreationally active participants (3 males), performed an incremental cycling exercise test consisting of 3-minutes stages, below the lactic-acid based threshold, and increasing intensity every 1-min until exhaustion. Facial sEMG sensor, which was applied on the participant's left side of the face, covering the forehead, zygomatic, buccal, nasal, and labial regions by 16 embedded electrodes, was recorded continuously throughout the exercise stress test. Blood lactate and heart rate were documented at each stage. To evaluate the exercise intensity effect on facial expressions, participants were asked, during each stage, to smile spontaneously. The facial sEMG signal's envelope root mean square (eRMS) of the smile-event, recorded from each electrode, was calculated, and then averaged for each stage. The calculated eRMSs were translated into heatmaps and correlated with exercise intensities. Paired T-tests were used to analyze the differences of eRMS values between muscles (spatial variations) and during the exercise (temporal variations).
RESULTS: Average eRMS (obtained from 5 subjects X 16 electrodes each) showed a different stepwise increase with exercise intensity in the frowning muscles (FMs) reaching a maximal value of 2.40±1.14 [μV], versus 1.31±0.42 [μV] for light intensity ($p<0.05$). No significant differences were found between the Zygomatic and Buccal muscles (ZBMs) to exercise. Differences between the FM muscles and the ZBM muscles were only found during high intensity exercise ($p<0.005$).
CONCLUSION: Our data demonstrate that there is a smile signature for different exercise intensities during an incremental aerobic exercise test, in particularly an increased activity of the frowning muscles while smiling close to exhaustion. The data allow us to better understand the spatial and temporal relationships of the facial muscles during aerobic exercise.
RERERNCES:
1. Inzelberg, Rand et al. (2018) 2. Inzelberg et al. (2020) 3. Inzelberg et al. (2018) 4. de Morree & Marcora (2010) 5. Chen & Chung (2004)

### SEX DIFFERENCES IN FATIGABILITY DURING LONG-DISTANCE TRIATHLON RACE

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INTRODUCTION: Human performance during athletic events is in part determined by an acute reduction of force or power in both men (M) and women (W) [1]. Physiological mechanisms responsible for this phenomenon, defined as performance fatigability, can involve inadequate central nervous system activation and/or altered skeletal muscle function, being potentially different between sexes [2]. Several studies demonstrated that W can be less fatigable than M after long-duration cycling [3] and running exercise [4] suggesting a primary role in muscle contractile impairments. Less is known about sex differences in performance fatigability and its determinants when different dynamic tasks are combined. Thus, this study aimed to characterize sex differences in central and peripheral determinants of performance fatigability during a long-distance triathlon.
METHODS: Twenty-two trained triathletes were recruited: 10W (age:41±12ys) and 12M (age:47±6ys). Subjects completed 1.9km of swimming, 90Km of cycling, and 21.1km of running (RACE). Neuromuscular function evaluations were performed before (PRE) and after (POST) the RACE by: i) maximal voluntary isometric contractions (MVIC) of knee extensors; ii) electrically evoked contractions by single (Pt) and doublets stimuli (Db100 and Db10) on a femoral nerve; and iii) countermovement jump (CMJ). The interpolation Twitch Technique was used to quantify the Voluntary activation (VA). The rate of perceived exertion (RPE) was monitored by Borg scale (1-10), speed and pace were obtained from GPS system.
RESULTS: RACE time was longer in W compared to M (7h16±41min; 6h38±43min; P=0.02). RPE was 8±2 for both participants at the end of RACE, with no differences between sexes. At PRE, MVIC torque and CMJ power were lower in W (123.9±38.7N*m and 1902±299W, respectively) compared to M (186.0±28.5N*m and 2674±484W, respectively; all P<0,001). At POST, W showed a smaller MVIC torque loss and CMJ power reduction (-14.4±9.9% and -0.8±7.2%, respectively) compared to M (-29.1±16.1% and -11.6±14.5%; all P<0.05). VA decreased less in W than M (-14.4±10.0% vs -24.9±11.6%; P=0.047) whereas Db100, Db10 and Pt decreased similarly for both sexes.
CONCLUSION: After a long triathlon race, W exhibited a smaller decrease in MVIC torque and CMJ power, suggesting a difference between W and M in performance fatigability. In addition to impaired contractile properties, the loss in torque and power was attributable to changes in central nervous system activation voluntary which differed between sexes. The present results will help coaches in identifying the optimal training patterns for men and women, promoting athletic excellence.
References
1 Hunter SK., Med Sci Sports Exerc. 2016.
2 Ansdell et al., Exp Physiol. 2020
3 Glace BW. & Kremenic IJ., Eur J Appl Physiol. 2013.
4 Temesi et al., Med Sci Sports Exerc. 2015.

# Oral presentations

## OP-BM16 Youth and injury risk

### AGING AND RUNNING IMPACT LOADING IN DIFFERENT FOOTWEAR (PRESCHOOLERS VS. YOUNG ADULTS)

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INTRODUCTION: Effects of various footwear on running impact loading was immensely studied adult population. However, there is lack of scientific knowledge about possible differences between different age groups (children, adolescent, adults). Running skill (technique) substantially develops in preschool children and most children achieved mastery level of running before sixth year of their life (1,2). Nevertheless, there is only one recent study which compared biomechanics during shod running between 10 preschoolers (3-6 year) and 10 adults (3). In abovementioned study, there were no differences in running impact loading, although study had several significant limitations, including small sample resulting in very heterogeneous group of preschoolers (from developmental perspective), non-standardized footwear etc. Therefore, this study aimed to compare impact loading among four groups of preschool children (crucial period of running skill development) and one group of young adult people (A) in three footwear conditions (B-barefoot, M-minimalist, SRS-standard running shoes).
METHODS: Sixty healthy participants (32 males/28 females) performed simple running game in three standardized footwear conditions (B-M-SRS). Participant were divided into 5 age groups (3-4-5-6-yr-old children and 20-24-yr-old adults). There were 12 participants in each group. Six recorded running trials for each participant were included into the 3-D biomechanical analysis. A two-way mixed ANOVA (5x3) was performed on vertical instantaneous loading rate (VILR). Consequently, a one-way ANOVA was used for each footwear separately to compare mean values of VILR among age groups followed by post hoc pairwise comparisons.
RESULTS: An interaction was found between age and footwear condition in VILR (P=0.010). Further analysis showed differences among age groups in both type of shoes; in M (3yr= 233, 4yr= 231, 5yr= 196, 6yr= 170 and A= 136 BW/s; P=0.008) and SRS (3yr= 225, 4yr= 220, 5yr= 164, 6yr= 149 and A= 74 BW/s; P=0.001). There were clear descending trends of VILR with increasing age in both shod conditions. No differences were found when B (3yr= 175, 4yr= 184, 5yr= 165, 6yr= 143 and A= 134 BW/s; P=0.254). Pairwise comparisons showed significant differences in M between 3yr-A (P=0.019), 4yr-A (P=0.023); and in SRS between 3yr-6yr (P=0.012), 3yr-A (P=0.001), 4yr-6yr (P=0.023), 4yr-A (P=0.001), 5yr-A (P=0.002) and 6yr-A (P=0.014).
CONCLUSION: Three and four-year-old children should use minimalist and running shoes gradually with cautious, at least during introduction to running on hard surfaces. It is in accordance with previous study (4) which showed that 3 and 4 had lower VILR in barefoot than in shod condition, on the contrary running shoes in the current study significantly reduced VILR in adults. It seems that barefoot running could be safely used in preschool age with relative less loading than during minimalist and standard shod running. 1)Plesek et al., 2021
2)Hardy et al., 2010
3)Wei et al., 2021
4)Plesek et al, 2022

### HIGH-LEVEL PATELLAR TENDON STRAIN AS RISK FACTOR FOR TENDINOPATHY IN ADOLESCENT ATHLETES – A PROSPECTIVE LONGITUDINAL APPROACH

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INTRODUCTION: The magnitude of strain applied to a tendon determines both sub-rupture fatigue damage progression and the balance of anabolic-catabolic signaling upon repetitive loading (1). High-levels of patellar tendon strain during maximum isometric muscle contractions have been observed in vivo in adolescent risk groups for tendinopathy (2), yet the direct association with tendon overuse has not been established. Therefore, in the present longitudinal study, we regularly measured in vivo patellar tendon strain in adolescent athletes from sports with a high prevalence of tendinopathy (i. e. handball, basketball and volleyball) and examined the hypothesis that athletes which develop tendon pain show higher levels of tendon strain than healthy athletes prior to becoming symptomatic.
METHODS: In 44 adolescent athletes (12-17 years), patellar tendon mechanical properties were measured by combining ultrasonography and inverse dynamics at four time-points during a competitive season. Fourteen athletes developed clinically relevant tendon pain (≥ 13 points reduction of VISA-P score; SYM), while 23 remained completely asymptomatic (ASYM). Tendon mechanical properties of SYM in the session prior to the development of symptoms were compared to a randomly selected ASYM time-point using Bayesian modelling. Cohens d was calculated to estimate effect sizes.
RESULTS: There was a large effect of group on tendon strain (d = 0.85) with a high probability of increased tendon strain in SYM compared to ASYM (mean difference [MD]: 1.17 %; 95 % credibility interval [CI]: 0.08 %, 2.26 %). While tendon force appeared to be similar in both groups (d = 0.18; MD: 0.30 kN; CI -0.95, 1.54 kN) a small effect on stiffness (d = -0.23) pointed towards slightly lower values in SYM, yet with considerable uncertainty (MD: -0.13 kN; CI: -0.57 kN, 0.32 kN). A subgroup analysis however indicated that tendon force likely increased prior to the development of symptoms in SYM (MD: 0.39 kN, CI: -0.08 kN, 0.87 kN), while remaining constant in ASYM (MD: -0.01 kN; CI -0.24 kN, 0.23 kN).
CONCLUSION: The present prospective study provides novel longitudinal evidence that high levels of tendon strain could be an important risk factor for the development of patellar tendinopathy in adolescent athletes. We suggest that inadequate adaptation of tendon stiffness to increases in muscle strength may occur if adolescent athletes with certain preconditions – e.g. a distorted tissue turnover (3) or reduced mechanosensitivity (4) – are subject to mechanical loading which does not offer effective tendon stimulation.
REFERENCES:
1. Wang et al. 2013, Biotechnol Bioeng, 110, 1495–1507
2. Mersmann et al. 2016, J Appl Physiol 121, 893–899
3. Heinemeier et al. 2018, FASEB J 32, 4763–4775
4. Passini et al. 2021, Nat Biomed Eng 12, 457-1471

### EFFECT OF SEX ON MUSCLE-TENDON IMBALANCES AND MICROMORPHOLOGY IN ADOLESCENT ATHLETES – A LONGITUDINAL CONSIDERATION

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INTRODUCTION: In male adolescent athletes, there is a high prevalence of imbalances between muscle strength and tendon stiffness (1) which may lead to tendon structural impairments and an increased risk of tendinopathy (2). As sex-specific hormone concentrations and hormone fluctuations related to the menstrual cycle may affect the adaptation of the muscle-tendon unit (3), it remains unclear if muscle-tendon imbalances are influenced by sex. The purpose of this study was to investigate the sex-specific development of quadriceps femoris muscle strength and patellar tendon stiffness during a competitive season with regard to potential imbalances and tendon micromorphological impairments in adolescent athletes.
METHODS: In 15 female (14.3 ± 0.7 yrs., 168.8 ± 7.7 cm, 63.1 ± 9.8 kg) and 13 male (16.0 ± 0.6 yrs., 186.3 ± 6.9 cm, 80.4 ± 10.3 kg) elite handball players, knee extensor muscle strength, patellar tendon stiffness and peak spatial frequency (PSF) of the proximal part of the tendon (as a measure of micromorphology) were determined at four time points during a competitive season using dynamometry and ultrasonography. A linear mixed model was used to analyze time- and group-dependent developments. The residuals to the model were used as a measure for fluctuations of the investigated parameters.
RESULTS: Males demonstrated significantly greater muscle strength ($p < 0.001$) and patellar tendon stiffness ($p = 0.018$) compared to females with no significant changes of both parameters during the season ($p = 0.346$ and 0.182). Tendon strain during maximum isometric contractions (iMVC) and PSF neither differed between groups ($p = 0.215$ and 0.583) nor changed over time ($p = 0.258$ and 0.558). We found greater fluctuations of muscle strength ($p < 0.001$) in males during the season but no sex-specific differences in the fluctuations of maximum tendon strain, stiffness and PSF ($p = 0.560$, 0.201 and 0.118 respectively). Descriptively, there was a similar frequency of athletes with high-level tendon strain (i.e. > 9%) in both groups (on average 42% in males and 38% in females).
CONCLUSION: Our findings show a similar development in the adaptation of tendon stiffness in relation to muscle strength in the two groups, as the greater muscle strength in boys is accompanied by greater tendon stiffness. Furthermore, sex did not seem to have any specific influence on musculotendinous imbalances in adolescent athletes, but the high frequencies of high-level tendon strain during iMVCs in both groups request the need for specific individual tendon training. The lack of an association between maximum tendon strain and PSF, however, indicates marginal effects on tendon micromorphological impairments in the investigated groups.
REFERENCES:
1) Mersmann et al., JApplPhysiol, 2016
2) Mersmann et al., FrontPhysiol, 2019
3) Magnusson et al., Int JExpPath, 2007

### INJURIES AND SPECIFIC MEDICAL SUPPORT IN AUSTRIAN YOUTH ATHLETES – A MIXED-METHODS STUDY

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INTRODUCTION: Already in youth competitive sport, high physical and mental demands in children and adolescence have been observed (Baur et al., 2008). Due to a large number of health-related issues adequate physical treatment and medical support is required. The aim of this study was to evaluate sports medical and performance assessment and especially of in young athletes.
METHODS: In this mixed-methods research, qualitative and quantitative methods have been combined. First, qualitative, semi-structured interviews were conducted with young athletes, coaches, medical employees and further supportive staff-members (N = 22). The transcripts of the interviews were then processed using the analysis method of Mayring (2015). Based on these results, an online questionnaire was created and answered by young competitive athletes of different sport disciplines (N = 300; 16.8±1.4 yrs; 47.7% female). The statistical evaluation using unpaired T-Tests was conducted using IBM SPSS (Vers. 27). Significance was accepted at $p<0.05$.
RESULTS: The average of total training time of the subjects was 13.1 (±6.7) hours per week. Athletes desired to have more medical support (61.2%) and sports scientific support (51.3%). Surprisingly, more than 40% of athletes had no resting and stress ECG examination for at least one year. It was shown that significantly more athletes have already suffered from an injury (85.3%) compared to uninjured (14.7%) ($P < 0.001$). The group of uninjured athletes was significantly younger than the group of those who had already suffered from an injury ($P = 0.009$). Most frequently injured body parts were lower extremities (ankle/foot/toes 59.0%; knees 45.3%) and upper extremities (forearm/hand/fingers 51.7%). The most common types of injuries are bruises (69.0%), muscle or ligament strains (58.0%), and inflammations (42.0%).
CONCLUSION: The results show that a large number of young athletes has already been injured and an association between the age and the appearance of injuries has been found. According to young athletes sports medical examinations are required more regularly and have to be standardised for different sports disciplines, in particular for internal and orthopedic examinations. Injury prevention programs which are fitted for the requirements of each sport should be implemented in the training to support young athletes and enable a successful career.

### HOW TO COMMUNICATE SLEEP AS A RISK FACTOR FOR SPORT INJURY AMONG YOUTH ATHLETES: A WAKE-A-THON TO CREATE AWARENESS AND INCREASE UPTAKE OF INJURY PREVENTION PRACTICES.

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INTRODUCTION: Sport injury is the leading cause of emergency room visits among youth ages 10 – 14 in Canada and among developed countries around the world. Known risk factors such as decreased muscular strength and neuromuscular control are often addressed to reduce the risk of injury in sport; however, less is known about the importance of sleep and sleep deprivation on sport performance and injury risk among young athletes. Literature demonstrates that athletes with less than the recommended sleep per night have an increased risk of a sport-related injury; however, mechanisms to effectively communicate lack of sleep as a risk factor to athletes are lacking. There is a need to not only provide this information to both athletes and practitioners in sport injury prevention, but to have athletes acknowledge for themselves signs of sleep deprivation on performance.

METHODS: An innovative, participatory action initiative (Wake-a-Thon) that used the concept of vigilance and vigilance performance testing as a communication strategy on sleep deprivation and sport injury was co-developed with student athletes and sleep and injury prevention researchers. The Wake-a-Thon included games and activities that athletes used to assess their own vigilance and experience how sleep deprivation impacts performance. Measures included basic cognition such as hand eye coordination, motor skills, logical/critical thinking and memory in various game formats.
RESULTS: Interim results suggest the Wake-a-Thon was successful at increasing student athlete's ability to recognize and communicate signs of sleep deprivation and its effect on their performance, attentiveness and emotional state.
CONCLUSION: Increasing an athlete's ability to recognize signs of sleep deprivation and acknowledge its impact on performance can reduce the risk of sport-related injury. The Wake-a-Thon is an innovative initiative that allows athletes to both quantitatively and qualitatively monitor their vigilance over time and communicate strategies to address their lack of vigilance and its effect on performance.

## OP-AP24 Training and learning

### SKILL-TIME-RELATED TEST FOR BASKETBALL PLAYERS. EVALUATING RELIABILITY, USEFULNESS, VALIDITY AND CORRELATION OF TIME-RELATED TESTING PROTOCOLS

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INTRODUCTION: Change-of-direction speed while bound dribbling appears to be of interest for on-court physical performance in basketball players. Several studies have assessed basketball change-of-direction tests. However, these tests do not consider other basketball-specific skills which are mainly involved in changes of direction during the game. Also, the effect of somatic maturity in change-of-direction speed while dribbling has not been studied yet. The main objectives were (1) to assess the test-retest reliability, usefulness and validity of VcutBk test in basketball players; (2) to analyse correlation of the VcutBk test with other time-related testing protocols and skill-time-related deficit in basketball players, (3) to describe skills-time-related deficits involved in VcutBk in basketball players considering somatic maturity.
METHODS: VcutBk test design was based on the Vcut test protocol (Gonzalo-Skok et al., 2015). Bounce dribbling was added to the execution of the test to assess a specific basketball skill. To examine test-retest reliability. Test reliability was assessed through absolute (typical error of measurement = TEM) and relative (intra-class correlation coefficient = ICC) reliability. In order to analyse correlations between the VcutBk test with other skills-time-related testing protocols, participants also completed 25m linear sprint (Sp) and 25m sprint while bound dribbling (SpBk). Test-derivated scores - dribbling deficit (Dd) = SprintBK – Sprint (Scanlan et al., 2018); change-of-direction deficit (CODd) = Vcut –Sprint (Nimphius, Callaghan, Spiteri, &Lockie, 2016); dribbling deficit with change of direction (DdCOD) = VcutBk – Vcut; change-of-direction deficit with dribbling (CODdD) = VcutBk – SprintBk, were used for the analysis.
RESULTS: Test-retest reliability and usefulness analysis does not show substantial between-trial differences in VcutBk (i. e., ES < 0.2). Related to convergent validity, the relationship between the VcutBk and the Vcut was very large [r (90% CL) = 0.85]. The usefulness is adequate TEM (0.35)0.51) to very large (r> 0.71). The effect size between pre-PHV and post-PHV groups of basketball players shows significant and large effect in the VcutBk (d = 2.04, MD = 2.59 95% CI [1.86, 3.32]). Also, significant main effect when comparing PHV groups was reported in all skill-time-related deficits (p< 0.001) with large effect sizes ($\eta$2p = 0.13 to 0.28).
CONCLUSION: The VcutBk is a reliable, useful and valid test to assess specific skill-time-related mastery in the change of direction during dribbling performance in basketball players. Additionally, VcutBk correlated larger when skills-time-related deficits were shown in a specific and simultaneous skills situation with change-of-direction deficit while bound dribbling. Performance in specific-skills-time-related deficits seems to be sensitive to somatic maturity.

### FORECASTING SOCCER INJURIES BY COMBINING SCREENING, MONITORING AND MACHINE LEARNING

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INTRODUCTION: INTODUCTION:Acute, exercise related injuries and their negative consequences for player health and team performance are an important issue in football. Identifying players or circumstances associated with an increased risk of injury is fundamental for successful risk management. So far, a considerable number of risk factors have been identified. However, univariable predictive accuracy is low and from the few multivariable prediction models none has been scientifically verified outside the original setting. Of note, time-constant (screening) and volatile (monitoring) risk factors are so far generally considered separately resulting in a restricted set of explanatory variables. Consequently, improvements in predictive accuracy may be expected when screening- and monitoring-data are combined, especially when analysed with current machine learning (ML) techniques able to account for interactions
within a "web of determinants". Expectably, screening parameters will set a personal level for injury risk while monitoring parameters account for short term variations around it.
METHODS: This trial was designed as a prospective observational cohort study aiming to predict non- contact time-loss injuries in male professional soccer on a daily basis. Considering the expectable number of injuries, a panel of 12 explanatory variables (covering basic player characteristics, screening, monitoring and exposure characteristics) had been specified a priori. Injuries were registered according to the Fuller consensus. Gradient boosting was used for data analysis. Respecting the nesting of timepoints within players, cross-validation was performed on the level of players (not datapoints). Upsampling was implemented with the training set to account for the imbalance between days with and without injury occurrence, respectively. Different splits of the original dataset were used to probe the robustness of results.
RESULTS: Data of 88 players from 4 teams (German 3rd and 4th league) could be analysed. 51 non-contact, time-loss injuries could be included in the final analysis. The cross-validated (ROC area under the curve 0.66) and test set performance (ROC area under the curve 0.64) of the
gradient boosted model in forecasting injury occurrence was promising and superior to comparator models without integration of screening features. However, the variation of predictive accuracy and feature importance with different splits of the original dataset reflects the relatively low number of events.

CONCLUSION: It is concluded that injury prediction based on the integration of screening and monitoring data in combination with ML is promising. However, external prospective verification and continued model development with accumulating numbers of injuries are required before application in sports practice may be envisaged.

### METHODS: RESULTS: CONCLUSION: THE DURATION OF THE PREPARATION PHASE IS A PRE-DETERMINANT FACTOR OF BALL PERFORMANCE FOR SUCCESSFUL AND UNSUCCESSFUL FOREHAND STROKES IN TENNIS

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INTRODUCTION: Understanding how a player perceives ball trajectory while the ball is approaching from the opponent and adjusting appropriate joint angles based on both visual and auditory information during forehand directly influence the stroke accuracy. The player consequently needs to create appropriate body positions based on the information also coming from muscle and joint receptors in an attempt to make a prediction on the ball's first bounce location. Detailed investigation of different phases and the total time of forehand could assist player skill development and possibly reduce the number of unforced errors within a real match. The purpose of this study was to identify time-based perception-action coupling differences in the phases of accurate and inaccurate forehand drive.
METHODS: 12 male tennis players who play tennis at the club level volunteered for the study. They were equipped with a total of 52 reflective markers and then performed 10 strokes to the balls sent by the ball throwing machine placed on the opposite side of the court. Motion Capture (MoCap) data were recorded with a semi-infrared MoCap System [Qualisys, Sweden] with 500 Hz. Perception-action times of the 4 stroke phases (preparation, backswing, forward swing, follow-through, and total stroke time) based on 5 events (ball release, racket swing star, racket backswing maximum, impact, and end of the stroke) of successful and unsuccessful forehand strokes to the balls coming with a constant speed (72-75 km/h) were evaluated for 4 stroke types (out, net, low, high).
RESULTS: The duration of the preparation phase was 298±44, 311±15, 227±105, 269±4; the duration of the backswing phase was 765±33, 802±8, 941±78, 840±46; the duration of the forward swing phase was 272±20, 279±1, 259±13, 264±13; duration of the follow-through phase were 459±91, 406±40, 363±5, 427±74 and duration of total time were 1794±13, 1798±18, 1790±8, 1801±74 for out, net, low and high strokes, respectively. Normality of the data set was tested via D'Agostino-Pearson and homogeneity of variances was tested via the Levene test. Two-way repeated-measures ANOVA (factors: ball performance vs. phase duration) revealed that despite total stroke times are not statistically different, unsuccessful strokes exhibited significantly ($p < 0.05$) longer delay during the preparation phase than successful shots, indicating this parameter was a determining factor for the stroke accuracy.
CONCLUSION: These findings demonstrate how the perception of the ball and just after action coupling during forehand stroke can influence the accuracy of strokes. The duration of the preparation phase highlights the need for an early start (but not too early) of backswing for a high-performance stroke. Our data shows that experienced trainers' consistent warning ''do not be late to open your racket'' is clearly true but there is an optimum time block.

### AUTONOMY-SUPPORTIVE TEACHING ON LEARN-TO-SWIM IN (SCHOOL)CHILDREN: AN EXPLORATIVE EMPIRICAL STUDY

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INTRODUCTION: It is demanding to design swimming lessons in which all children are motivated to participate and, thus, sustainably learn to swim regardless of their prerequisites (e.g. inclusion). The concept of "Autonomy-Supportive Aquatic Education" (ASAE) [1] is based on the Self-Determination Theory [2], linking autonomy support in teaching to a strengthening of intrinsic motivation. This explorative empirical study investigates hypothesised benefits of ASAE on autonomy support and intrinsic motivation.
METHODS: A quasi-experimental approach was used to conduct a study with non-swimmers (n=60; female 43.3%, age 8.6 ± 0.82) in five primary schools' regular swimming lessons. An intervention for five weeks (one lesson per week) compared autonomy-supportive teaching (AST) with instructor-centered teaching (ICT). AST learning objective contents including respective games and tasks were offered to participating children by choice with the teacher taking on an accompanying and moderating role. Whereas in ICT the identical learning objective contents, games, and tasks were instructed by a teacher taking on a guide-instructive role without any choices given to the participating children. Autonomy support [BPNSF scale; 3] and intrinsic motivation [SRQ-A scale; 4] were assessed using standardised questionnaires in each lesson.
RESULTS: Autonomy support and intrinsic motivation positively correlate (r=.345). AST led to an improved perception of autonomy support ($p<.05$; d=.351), while a strongly self-regulated intrinsic motivation revealed no statistical significance (p=.453; d=.104) despite a visible negative trend in ICT.
CONCLUSION: All children were highly and rather intrinsically motivated. AST implemented by the concept of ASAE supports autonomy in learn-to-swim as a promising approach.
With respect to this explorative design, further research will be necessary.
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References:
1. Ohlendorf, L. and I. Staub, Handlungsoptionen und Potenziale eines geöffneten Schwimmunterrichts – wirkungsvoll und motivierend Schwimmen lehren [Opportunities and potentials of an autonomy-supportive aquatic education - teaching swimming in an effective and motivating way], in Vermittlungskompetenz in Sport, Spiel und Bewegung - Sportartspezifische Perspektiven, T. Vogt, Editor. 2020, Meyer & Meyer: Aachen.
2. Deci, E.L. and R.M. Ryan, Self-determination theory: A macrotheory of human motivation, development, and health. Canadian Psychology/Psychologie canadienne, 2008. 49(3): p. 182–185.
3. Chen, B., et al., Basic psychological need satisfaction, need frustration, and need strength across four cultures. Motivation and Emotion, 2015. 39(2): p. 216–236.
4. Kröner, J., et al., The Construct Validity of the German Academic Self-regulation Questionnaire (SRQ-A) within Primary and Secondary School Children. Frontiers in Psychology, 2017. 8.

**CAPOEIRA TEACHING-LEARNING PROCESSES IN A SCHOOL IN SOUTHERN BRAZIL**

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Introduction
Capoeira is a complex cultural manifestation, which involves elements of music, fight, and game. Coming from Afro-Brazilian origins, capoeira was born through black Africans who were brought to be enslaved in Brazil, from the 16th century onwards, as a form of resistance to the oppression and violence suffered. Currently, in Brazil, capoeira is part of the school environment as a subject, a content, or a method, and can be approached in partnership with playfulness. This last one, in its turn, is understood as a spontaneous and creative manifestation, which can be further elaborated for the construction of an alternative educational practice to traditional teaching methods, valuing the child and the culture. Thus, this research aimed to investigate the relationship between capoeira and playfulness in the teaching-learning processes at school.
Methods
The study included 18 students, aged between 6 and 9 years old, from a capoeira project that takes place after school in a public school in a city in Southern Brazil, as well as the teacher of that project. This is a descriptive-exploratory field research with a qualitative approach to the data. The instruments used were participant observations of the classes, semi-structured interviews with the teacher, and focus groups with the children. Data were organized using the N-VIVO 11 software and analyzed using the content analysis technique proposed by Bardin (2016).
Results and Discussion
Two categories of analysis were found: Playfulness experience in capoeira classes and Pedagogical strategies for capoeira classes. The playfulness is manifested in capoeira classes, through feelings of joy and tension, being enhanced by pedagogical strategies that value the character of the game present in capoeira. The feelings of joy and pleasure experienced in the context of capoeira classes and reported by the children were more emphatically observed in the moments of the class when they had more freedom of expression, indicating that these moments favored the playfulness experience. Although the project teacher uses more traditional teaching strategies, such as line formation and technicist repetition, it was also possible to perceive the use of pedagogical strategies that value the free expression of children, as well as the playful aspects that permeate the issue of playing and game.
Conclusion
The results indicate that capoeira has an intrinsic playfulness potential in its game aspect, which can be favored by the pedagogical strategies adopted by the teachers. This fact contributes to significant teaching-learning processes for children, and favors their development, leading them to better understand their own abilities and limits, as well as the cultural and historical aspects that surround them.
Reference
Bardin, L. (2016). Content analysis.

## OP-SH07 Mental Health

**MECHANISMS LINKING PHYSICAL ACTIVITY WITH PSYCHIATRIC SYMPTOMS IN YOUTHS: A LONGITUDINAL POPULATION-BASED STUDY**

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INTRODUCTION: Participation in physical activity protects against psychiatric symptoms in youths. However, the underlying mechanisms remain underexplored. Lubans et al. suggested a conceptual model which postulates three groups of potential mechanisms (i.e. neurobiological, psychosocial, and behavioral). Few studies have explored whether any of these three mechanisms in isolation mediate the relationship between physical activity and psychiatric symptoms. Nevertheless, an integrated model examining the joint and independent contributions of the proposed mechanisms is lacking, making it difficult to obtain the overall picture.
Aim: To test an integrative model of the mechanisms linking physical activity with psychiatric symptoms in youths.
METHODS: We analyzed data from 4,216 children (6.0±0.4 years at baseline; 50.2% girls) at three-time points (TP) from the Generation R Study (around ages 6, 9, and 13 years). Physical activity included weekly frequency and duration of walking or cycling to/from school, outdoor play, and sports (TP1). Psychiatric symptoms (internalizing and externalizing symptoms) were assessed by the Child Behavior Checklist (TP3). The neurobiological mechanisms included total brain volume, white matter microstructure, and resting-state connectivity assessed using a 3T MRI scanner (TP2). The psychosocial mechanisms included self-esteem assessed by the Self-perception Profile, body image by the Development of the Children's Body Image Scale, and friendships by the Friendship Quality Questionnaire (TP2). The behavioral mechanisms included sleep assessed by the Children's Sleep Habits, eating behavior by the Eating Behaviour Questionnaire, and screen time in weekly frequency and duration of watching television and playing video games (TP2). First, we explored the correlation between physical activity (predictor) measures and psychiatric symptoms (outcome). Mediation analyses were performed using the Lavaan package in R when a correlation between predictors and outcomes exists ($p<0.05$). Baseline data of the outcome, parents´ education level, children's gender, ethnicity, age, body mass index, and intelligence quotient were modeled as potential confounders.
Results: Sports participation was negatively associated with internalizing problems at the age of 13 ($\beta=-0.025$; $p=0.031$). Only self-esteem (at the age of 9) mediated the relationship between sports participation and internalizing symptoms ($\beta=-0.009$; $p=0.002$). No other correlations were observed for other measures of physical activity and psychiatric symptoms.
Conclusion: This integrative model provides an overall picture of the mechanisms linking physical activity with psychiatric symptoms in youths. Only one psychosocial mechanism (i.e., self-esteem) mediated the association between sports participation in childhood and internalizing problems in adolescence. These findings may guide the design of future physical activity interventions which aim to improve mental health in youths

### ASSOCIATIONS OF PHYSICAL ACTIVITY AND FITNESS WITH STRESS REACTIVITY IN CHILDREN AGED 10-13 YEARS

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*UNIVERSITY OF BASEL*

INTRODUCTION: High stress reactivity can be detrimental for physiological and psychological health. According to the cross-stressor-adaptation hypothesis, physical activity has health-beneficial effects on psychosocial stress reactivity. However, studies investigating such effects in children are scarce. Therefore, our ongoing study (data collection continues until April 2022) aims to investigate the association of physical activity and aerobic fitness with physiological and psychological stress reactivity in children.
METHODS: Sixty healthy, right handed children aged 10-13 years (34 male, 26 female) were recruited from schools and through distribution of flyers in public places (target sample of the study N=108). On two different lab appointments, the Trier Social Stress Test for Children (TSST-C) and a non-stressful control condition were performed. Appointments were scheduled in randomized order. Before and after both conditions, salivary cortisol (samples directly before and 0 min, 15 min and 30 min after the stressor) and state anxiety (8-item questionnaire based on the state scale of the State-Trait Anxiety Inventory) were measured representing physiological and psychological stress, respectively. For cortisol analysis, the area under the response curve was calculated. Psychological stress was analyzed using a pre-post-stressor comparison. Actigraphs worn over the course of 7 days were used to quantify moderate-to-vigorous physical activity (MVPA), and aerobic fitness was measured using a submaximal bicycle ergometer test (PWC170).
RESULTS: A median split was performed on MVPA and fitness, respectively, and separate analyses of variance were performed. For both cortisol ($F(1, 49) = 8.45$, $p = .005$, $\eta p2 = 0.147$) and state anxiety ($F(1, 55) = 46.81$, $p < .001$, $\eta p2 = 0.460$), a significant main effect of condition was found. Significant interactions condition × MVPA indicated lower physiological and psychological stress reactivity in more physically active participants (cortisol: $F(1, 47) = 4.08$, $p = .049$, $\eta p2 = 0.080$) and anxiety: $F(1, 53) = 4.43$, $p = .040$, $\eta p2 = 0.077$)), while interactions condition × fitness were not significant for both cortisol ($F(1, 48) = 3.04$, $p = .088$, $\eta p2 = 0.060$) and anxiety ($F(1, 47) = 0.16$, $p = .695$, $\eta p2 = 0.003$)).
Discussion/CONCLUSION: Preliminary results of our ongoing study indicate health-beneficial associations of higher levels of MVPA with physiological and psychological stress reactivity. For aerobic fitness, neither beneficial nor detrimental effects on stress reactivity were observed. Further longitudinal and intervention studies are necessary to confirm potential causal relationships.

### INDEPENDENT AND COMBINED ASSOCIATIONS OF DOMAIN-BASED PHYSICAL ACTIVITY AND ULTRA-PROCESSED FOOD CONSUMPTION WITH ELEVATED DEPRESSIVE SYMPTOMS: A CROSS-SECTIONAL STUDY OF THE NUTRINET-BRASIL COHORT

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*UNIVERSIDADE DE SÃO PAULO*

INTRODUCTION: Although physical activity (PA) is a recognized protective factor for depression, gaps still exist regarding the association between the different domains of PA and depression. In addition, the consumption of ultra-processed foods (UPF) can also be associated with depression by similar mechanisms to those of PA. However, how the consumption of UPF could affect the association between PA practice in different domains and depression is unknown.
METHODS: We used data from the NutriNet-Brasil cohort study, a web-based prospective cohort study, for a cross-sectional analysis including 25,501 adults (19,969 women), with a mean age of 43.3 (SD:12.9) years, who provided information on both outcome and exposure at the baseline. Depressive symptoms were assessed using the Patient Health Questionnaire-2. Domain-based PA (i.e., leisure-time, transportation, and occupational) was assessed through the Global Physical Activity Questionnaire. We used the highest tertile of each PA domain (gender-specific) as the cutoff point. Consumption of UPF was assessed using a validated short questionnaire containing 23 UPF subgroups, based on the Nova classification, during three non-consecutive days. The Nova-UPF score is a simple sum of the subgroups consumed in the previous day. We divided the score into quintiles. Gender, age, education, ethnicity, living status, month of the questionnaire completion, and consumption of fruits, vegetables, legumes, whole grains, and nuts were used as covariates. Poisson regression models were used for the association analyzes, reporting prevalence ratio (PR) and 95% confidence interval (CI). Multiplicative interaction was tested including interaction terms in the models, while additive interaction was tested through the estimation of relative excess risk due to interaction and attributable proportion.
RESULTS: In the independent models, leisure-time PA (PR: 0.74; 95%CI: 0.71-0.78) and transportation PA (0.94; 0.90-0.98), but not occupational PA (0.97; 0.92-1.03), were associated with a lower prevalence of elevated depressive symptoms. UPF consumption (reference: Q1 = Q2: 1.17; 1.09-1.26, Q3: 1.24; 1.16-1.33, Q4: 1.25; 1.16-1.34, Q5: 1.37; 1.28; 1.47) was associated with higher prevalence of elevated depressive symptoms. There were no multiplicative or additive interactions between domain-based PA and UPF consumption in the association with elevated depressive symptoms.
CONCLUSION: The association between PA and elevated depressive symptoms is domain-dependent, with leisure-time and transportation domains acting as protective factors, while a higher UPF consumption was associated with higher elevated depressive symptoms. However, the associations of domain-based PA and UPF consumption with elevated depressive symptoms were independent. Our findings highlight the need for interventions targeting increasing leisure-time and transportation PA as well as reducing UPF consumption.

### A PSYCHOLOGICAL STRESS ASSESSMENT MODEL BASED ON PHYSIOLOGICAL SIGNALS IN A VIRTUAL REALITY ENVIRONMENT

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A psychological stress assessment model based on physiological signals in a virtual reality environment
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INTRODUCTION: With the development of virtual reality (VR) technology, virtual reality exposure therapy (VRET) offers a great opportunity to explore stress disorder recognition and treatment [1],[2]. With integrated sensors, VRET could acquire users' physiological data under specified stress. Physiological signals exhibit unique characteristics during stress, hence the extraction of features and classification of stress levels from signals are gaining enormous popularity and importance currently. Therefore, the aim of this study was to create a psychological stress assessment model based on physiological signals using the machine learning algorithm, which is adaptable to different stress conditions provided by VR.

METHODS: 57 adults (20.9±1.9 yrs) volunteered to participate in this study after signing informed consent forms. Participants were asked to first take the Short State Anxiety Inventory（SSAI）to assess benchmark stress states before putting on a heart rate belt, EDA (electro-dermal activity) wrist band and a VR head-mounted display. Then they logged into the self-developed VR stress training system, which comprises of three stressful scenes with two stress modes and sit peacefully in a chair for 3 min, during which benchmark values of EDA, heart rate and eye-blink rate were recorded. Participants then entered the three VR scenes in a random order and complete the SSAI immediately after the experience of each mode.
The physiological dataset was divided into training and validation sets (sample size ratio 8:2) respectively, and stress levels were labeled as "no stress"（1-2）, "low stress"（2-3） and "high stress"（>3） based on the score intervals from SSAI. Moreover, the statistics of EDA, heart rate, and eye-blink rate per participant were calculated as the feature vector to feed into the machine learning models.
RESULTS: Rest-state values were significantly lower than those in stress modes. Average heart rate and EDA were higher in the high-stress mode than the low-stress mode. As for the self-reported stress ratings, results showed that all three VR scenes produced a higher stress level. In addition, mean, median, standard deviation, maxima and minima of EDA, heart rate and maxima of eye-blink rate were used as an eleven-element feature vector to feed into the SVM, LR, RF, kNN, XGBoost and bagging supervised learning algorithms. The performance metrics of bagging algorithm achieved the highest scores on accuracy (0.742), F1-score (0.709) and recall (0.774).
CONCLUSION: This study revealed the relationship between physiological data and self-reported stress ratings and the psychological stress assessment model adopted the bagging ensemble learning algorithm for the best classification results, which motivates the further investigations of stress disorder recognition and treatment.
1. Salkevicius et al. (2019) 2. Taneja et al. (2017)

# Oral presentations

## OP-AP28 Tactical analysis

### ON ROUTE TO THE OLYMPIC PODIUM: A COMPARATIVE NEW ZEALAND YOUTH RUGBY SEVENS MATCH ANALYSIS

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INTRODUCTION: 9.6 million people play rugby in 124 countries and 40 teams will compete in the 2022 Rugby World Cup Sevens. Rugby Sevens (7s) has gained in popularity since its introduction to the 2016 Olympics and the 2018 Youth Olympics saw 11 countries from 6 regional associations compete at 7s. Rugby 7s school youth participation has grown by 185% between 2012 and 2020 in New Zealand. While microsensor technology has been applied to field-based sports, little is known about the physical demands of Youth Rugby 7s.
METHODS: Two New Zealand-based male academy cohorts (U15 n=13, 14.9 ± 0.3 y; U19 n=14, 16.9 ± 1.2 y) were monitored in 7 games during a national Rugby 7s tournament using 10 Hz VX Sport microsensor technology.
RESULTS: Time-motion and heart rate (HR) analysis across squads showed an average work rate (WRavg) of 111.4 ± 11.9 m/min covered at an average speed (Vavg) of 6.7 ± 0.7 km/h and 90.0 ± 0.04% HRmax. Players performed 41.6 ± 7.6 sprints per game with maximal speed (Vmax) averaging 27.6 ± 2.9 km/h, while a peak velocity of 33.7 km/h was measured. The U15 players demonstrated a higher WRavg than U19 (115.7 ± 13.3 vs. 107.8 ± 10.5 m/min [ES= 0.66]) at greater Vavg (6.9 ± 0.8 vs. 6.5 ± 0.6 km/h [ES= 0.66]) ($p<0.01$). Average HR intensity was statistically similar between U15 and U19 (90 ± 3 vs. 89 ± 4% HRmax), yet a small effect was detected for ActivityLoad 3D rate (cumulative X, Y, Z-accelerometry per unit of time: 5.2 ± 1.4 vs. 4.7 ± 0.6 AU, p= 0.06 [ES= 0.42]). No significant differences were found for any high-intensity (HI) running nor HI acceleration/deceleration measures. Both cohorts covered significantly different distances in different relative speed and HR zones (Vzones, HRzones), with most distance covered between 20-50% Vmax and >90% HRmax. Of note, 57.9 ± 24.1% (U15) and 56.8 ± 26.4% (U19) of game time was performed at >90% HRmax. The U15 players covered more distance than U19 in Vzone2 (55.9 ± 11.8 vs. 53.6 ± 9.0 m/min, p= 0.01 [ES= 0.51]) and Vzone3 (25.7 ± 8.8 vs. 22.5 ± 6.9 m/min, p= 0.04 [ES= 0.41]). Pairwise comparisons for distance and time spent in relative HRzones revealed no differences between cohorts.
CONCLUSION: Youth Rugby 7s games are characterised by very high physical demands. Different age cohorts demonstrate overlapping match characteristics with key differences on specific performance markers, relative to the metrics used. Younger players show higher values for speed and distance, which suggests greater loads could be placed on youth as compared to senior players and other cohorts described in the literature. Training approaches, including monitoring and classification of metrics, should be differentiated by target population, individualised, and complemented with age-specific performance targets. Practitioners should be aware that younger 7s players may undergo higher loading relative to older cohorts; thus, there is a need for clear developmental benchmarks.

### RECOGNIZING TEAM TACTICS USING REPRESENTATIVE SEARCH

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INTRODUCTION: Team tactics are coordinated moves of team members as for example in team handball or soccer. In the past, the application of deep learning methods has been proposed to automatically recognize team tactics based on positional data of players and the ball. The spatiotemporal data of players and the ball can be collected for example using systems from Kinexon or Catapult. However, deep learning approaches need pre-classified data of team tactical moves as so-called training and test data. I.e., a class label must be manually assigned that identifies the class of the tactical move that is contained in the spatiotemporal data. Since deep learning approaches need a lot of training data to derive appropriate models, thousands of video clips need to be classified before the training might be able to produce a model with an acceptable recognition accuracy.
METHODS: Rather than directly training a deep learning network with pre-classified data, the approach presented follows the idea to identify segments of similar tactical moves first. Then, one move of each segment can be used as a representative of the segment it belongs to. Only the representatives are then evaluated by the experts to assign the class label. All moves belonging to the same segment also belong to the same class of tactical moves, thus getting the same label. Hence, the number of video clips that need to be evaluated corresponds to the number of classes of tactical moves rather than to the number of cases needed to train a deep learning network.

RESULTS: A mechanism to extract sets of spatiotemporal data that represent timeframes of interest, i.e., that contain at least potentially a tactical move of a team, will be presented. It will be shown how match information can be used to extract the interesting timeframes. A canonical representation will be introduced to avoid problems with changing origins of the coordinates, changing sides of the field, changing sequences of player coordinates and such. The canonical data is a prerequisite to be able to compare the data of the moves. Based on the spatiotemporal data of 275 attacks, three different clustering approaches have been compared. It has turned out that Hierarchical Clustering is the optimal method in case of offense tactics and Self-Organizing Maps are best to group defense tactics. Using these clustering techniques 22 clusters of offense tactics and 15 clusters of defense tactics have been identified and a representative of each cluster has been extracted to be classified by a professional handball coach.
CONCLUSION: Examples of representatives in terms of tactic videos are presented to visualize the results of the representative search. These "visual" representatives are used to identify the “tactical class” of a segment and thus of all members of the same segment. The key prerequisites for the approach are to define an appropriate distance function for tactical moves as well as a problem specific quality indicator for the extracted clustering models.

### AMPLIFYING SPACE EXPLORATION AS RESULT OF PITCH OBSTACLES DURING ASSOCIATION FOOTBALL LARGE-SIDED GAMES IN SEMI-PROFESSIONAL PLAYERS

COUTINHO, D.1,2,3, FOLGADO, H.4,5, GONÇALVES, B.4,5,6, SANTOS, S.1,2,3, TRAVASSOS, B.6,7, ABADE, E.2,3, SAMPAIO, J.1,2

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INTRODUCTION: Football coaches design training tasks to optimize the team performance while amplifying the players’ ability to support their actions on the relevant information from the environment. To assist them, a wide body of research has explored how different rules affect players’ performance. However, there is scarce information on how adding specific location pitch obstacles may impact players’ behaviour. Thus, this study aimed to explore the effects of adding wall barriers on ball possession behaviours during Gk+9vs9+Gk football large-sided games.
METHODS: Twenty semi-professional players performed 3 LSG consisting of: 1) Control condition (CTR) - without any obstacle; 2) central wall barrier (MID), in which a 6m length wall barrier was placed 20m in front of each target; and 3) side-line wall barrier (SIDE), in which four 3m wall barriers were placed at each half, 4m from each side-line. The LSG was performed on a 70x50m natural turf pitch and consisted of 6-min interspersed with 2-min of passive recovery. Positional data were collected with GPS units while video analysis, allowed to compute multidimensional parameters.
RESULTS: Results revealed lower width in MID than in CTR (Cohen’s d with 95% of confidence intervals: -0.67 [-1.03; -0.3], p = .017), while in turn higher length in MID (-0.85 [-1.12; -0.47], p = .017). Also, there were higher values of length in the MID than the SIDE (-0.49 [-8.56; -0.1], p = .006). In addition, players covered more distance while walking and jogging in the MID than in both the SIDE and CTR (p<.001; and p< .001, respectively). From the technical analysis, players were further from the closest defender when performing a pass in the MID compared to the CTR (018 [0.12; 0.35], p = .041).
CONCLUSION: Overall, coaches may use centre pitch obstacles to emphasize the use of pitch length, while increasing the physical demands. Accordingly, having the obstacles in the middle zone may afford the offensive team to explore diagonal movements towards the opponents’ goal, while limiting the position of the defenders contributing to the highest distance compared to the CTR. Thus, this condition may be helpful to prepare matches against deep defending teams, whereas players usually have higher distances to the closest defenders and may have to explore movements in the longitudinal direction. In contrast, removing it emphasizes the use of the pitch width under lower physical demands. It may be expected that the defensive team close the space in the front of the target, which in turn may guide the offensive team to explore the wide channels. Thus, playing without obstacles can be used in the latter days of the microcycle due to the lower physical demands, while strategically enhancing the team ability to use the pitch width to develop offensive actions. Overall, coaches may vary the location and inclusion of obstacles to induce movement adaptability during ball possessions and enhance the players’ ability to sustain their actions on surrounding information.

### PHYSICAL AND PHYSIOLOGICAL RESPONSES OF SOCCER PLAYERS PERFORMING REPEATED MAXIMAL EFFORTS: THERMO-NEUTRAL CONDITIONS VS SIMULATED CONDITIONS OF THE FIFA WORLD CUP QATAR 2022

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INTRODUCTION: This year, for the first time in history, the FIFA World Cup in Qatar 2022 will be moved to November and December in order to make the climatic conditions more bearable and less thermally troublesome for players (Konefał et al., 2021). According to the calculations of climatologists, despite the fact that during the tournament there will not be extremely high temperatures as in June and July, it can still reach close to, or even exceed 30 C degrees (Chodor et al., 2021). This study aimed to assess the capacity for repeated maximal effort (RME) of soccer players in the thermo-natural conditions (NC) and in simulated conditions for the 2022 FIFA World Cup in Qatar (QSC).
METHODS: Twenty-four semi-professional soccer players participated in the study. The exercise test consisted of ten 6-second maximal efforts on a cycloergometer. A 90-second passive rest interval was used. The test was performed in a Weiss Technik WK-26 climate chamber under two different conditions: 1) thermo-neutral (NC - 20.5°C; 58.7% humidity); 2) simulated for the 2022 World Cup in Qatar (QSC - 28.5 ± 1.92°C; 58.7 ± 8.64% humidity). Power-related, physiological, psychomotor, blood, and electrolytes variables were recorded.
RESULTS: Results showed that, (1) players achieved higher peak power, needed less time to peak power, had higher values of fatigue slope in QSC than in NC (in each repetition of research protocol); (2) comparing to the 1st repetition, subsequent repetitions were observed many significant changes among physiological, blood-related, and electrolyte variables, but their direction was similar in both simulated conditions; (3) an 8°C of temperature difference between the climatic conditions did not significantly affect the physical and physiological responses of the soccer players in RME.
CONCLUSION: The current study provides a better understanding of the effects of different climatic conditions, with particular emphasis wide group of parameters to determine the different reactions of players on RME. Results can be used in the design of training programs to increase players physiological adaptations by simulating soccer-specific conditions of play in terms of anaerobic capacity, in particular

repetitive maximal effort. These findings will be useful during the upcoming FIFA World Cup in Qatar 2022 and in locations where high ambient temperatures are customary.
References:
1. Konefał, M., et al. (2021). The influence of thermal stress on the physical and technical activities of soccer players: lessons from the 2018 FIFA World Cup in Russia. Int. J. Biometeorol, 65, 1291–1298.
2. Chodor, W., et al. (2021). Impact of climatic conditions projected at the World Cup in Qatar 2022 on repeated maximal efforts in soccer players. PeerJ, 9, e12658.

### "ONE SIZE DOES NOT FIT ALL!" HIGH-SPEED AND SPRINT RUNNING EXPOSURE DURING SIDED-GAMES TRAINING IN SOCCER PLAYERS: A STATE-OF-THE-ART SYSTEMATIC REVIEW AND META-ANALYSIS

DELLO IACONO, A.1, MCLAREN, S.J.2,3, MACPHERSON, T.W.1, BEATO, M.4, WESTON, M.5, UNNITHAN, V.B.1, SHUSHAN, T.6
*1. UNIVERSITY OF THE WEST OF SCOTLAND; 2. NEWCASTLE FALCONSRUGBY CLUB; 3. DURHAM UNIVERSITY; 4. UNIVERSITY OF SUFFOLK; 5. UNIVERSITY OF EDINBURGH; 6. WESTERN SYDNEY UNIVERSITY*

INTRODUCTION: Sided-games (i.e., small- [SSG], medium- [MSG], large-sided [LSG]) involve tactical, technical, and physical elements and are therefore widely assumed as time efficient means for physical development and match preparation in soccer. The objective of this systematic review and meta-analysis was to: 1) synthesise the existing evidence on high-speed and sprint running exposure induced by sided-games in senior soccer players, 2) establish pooled estimates and intra-individual reliability for high-speed and sprint running exposure, and 3) explore the moderating effects of game format and playing constraints.
METHODS: A literature search was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines. Four databases (PubMed/MEDLINE, Scopus, SPORTDiscus, Web of Science) were systematically searched up to 25 January 2022. Eligibility criteria were senior soccer players (population); an acute or chronic training programme incorporating sided-games (intervention); game manipulations including number of players, pitch dimension, game orientation (comparator); and high-, very high-speed and sprint relative (m·min-1) running distances and their associated intra-individual reliability (outcome). Pooled estimates for high-speed and sprint running exposure, and their intra-individual reliability, along with the moderating effect of running velocity thresholds, pitch dimension (i.e., area per player), and game orientation (i.e., score or possession), were determined via multilevel mixed effects meta-analysis. Estimate uncertainty is presented as 95% compatibility intervals (CI) with the likely range of relative distances in similar future studies determined via 95% prediction intervals (PI).
RESULTS: A total of 104 and 7 studies met our eligibility criteria for the main and reliability analyses, respectively. The range of relative distances covered across SSG, MSG and LSG was 14.8 m·min-1 (95% CI 12.3 to 17.3) to 17.3 m·min-1 (13.6 to 21) for high-speed running, 2.6 m·min-1 (1.8 to 3.5) to 3.6 m·min-1 (2.3 to 4.9) for very high-speed running, and 0.2 m·min-1 (0.1 to 0.4) to 0.7 m·min-1 (0.5 to 0.9) for sprinting. Across different game formats, 95% PI's showed future exposure for high-speed, very high-speed running, and sprinting to be from 0 m·min-1 to 48 m·min-1, 0 m·min-1 to 14.3 m·min-1, and 0 m·min-1 to 2.6 m·min-1, respectively. High-speed, very high-speed running, and sprinting showed poor reliability with a pooled coefficient of variation of 22.6% with distances being moderated by velocity thresholds, pitch dimension and game orientation.
CONCLUSION: Irrespective of format, sided-games do not replicate the physical demands of soccer match play; therefore, their application as a panacea for physical preparation is discouraged. Large intra-individual variability and the moderating influence of velocity thresholds, area per player and game orientation should be considered for the effective programming of SSG, MSG and LSG training games.

## 17:00 - 18:15

## Invited symposia

### IS-MH04 High-intensity interval exercise training for the promotion of health in children and adolescents

### HIGH-INTENSITY INTERVAL EXERCISE AS A MODEL FOR IMPROVING HEALTH IN CHILDREN AND ADOLESCENTS: INSIGHTS FROM LABORATORY-BASED STUDIES

BARKER, A.
*UNIVERSITY OF EXETER*

This talk will draw on recent observational data showing that as little as 10 minutes of vigorous intensity physical activity per day may drive improvements in health outcomes in youth. As a vehicle for promoting vigorous intensity physical activity, the talk will provide an overview of controlled laboratory-based studies using both acute and chronic exercise models to examine the efficacy of high-intensity interval exercise (HIIE) to improve health outcomes in children and adolescents. Specifically, a range of health outcomes will be explored, including blood markers (e.g. glucose, insulin, and triglyceride), blood pressure, lipid oxidation and vascular function both in the fasted and post-prandial states. Recent work examining exercise enjoyment and feelings of pleasure/displeasure in youth in response to HIIE will be evaluated, given their importance for future participation in exercise. Where possible, the talk will examine the effects of HIIE in relation to a comparative bout of continuous moderate intensity exercise, and recommendations for the prescription of HIIE will be provided.

### THE ROLE OF SCHOOL-BASED HIGH-INTENSITY INTERVAL EXERCISE FOR IMPROVING HEALTH IN CHILDREN AND ADOLESCENTS

WESTON, K.
*EDINBURGH NAPIER UNIVERSITY*

Over the last decade the application and evaluation of high-intensity interval exercise (HIIE) training within school settings has substantially increased, such that its use as a potential health promotion tool for children and adolescents is now being explored across different continents, climates and school systems. While it appears that school-based HIIE training can improve outcomes such as cardiorespiratory

fitness, its impact on other cardiometabolic risk factors and outcomes such as mental health and habitual physical activity is less clear. Accordingly, this talk will discuss contemporary evidence on the use of school-based HIIE training as a means of improving various health and fitness markers in children and adolescents, and offer perspectives and critical insight on the variety of school-based HIIE training models utilised to date. Important methodological issues associated with conducting HIIE interventions within schools will also be appraised. Specifically, challenges regarding study design, activity modes, exercise intensity monitoring, participant recruitment and scalability will be discussed; thus, bringing together the considerations of paediatric exercise scientists and practitioners. The overarching aim is to provide clear, evidence-based directions for future school-based HIIE training research, and create a platform for international and interdisciplinary collaborations on the topic.

**EFFICACY OF HIGH-INTENSITY INTERVAL EXERCISE TRAINING FOR MANAGEMENT OF PAEDIATRIC OBESITY**

INGUL, C.

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Obesity in childhood predisposes individuals to cardiovascular disease and increased risk of premature all-cause mortality. Management of paediatric obesity mostly focus on the importance to prevent further weight gain, but should we focus on the improvement of the cardiometabolic profile through increased cardiorespiratory fitness rather than on weight loss alone? Very few children and adolescents meet current physical activity guidelines and children with obesity are less physically active compared with healthy-weight children. This talk will summarise the current knowledge about the effect of exercise intensity in the form of high-intensity interval exercise (HIIE) training in comparison to traditional moderate-intensity continuous exercise training on cardiometabolic health in paediatric obesity. Specifically, the effect of HIIE training on cardiac structure and function, body composition and cardiorespiratory fitness, their relationships and importance will be discussed. This session will be of relevance to researchers and practitioners interested in exercise training interventions as a lifestyle modification for obese children to prevent increased risk of morbidity and premature mortality as adults.

## Oral presentations

### OP-AP02 Fatigue

**MENTAL FATIGUE REDUCES TIME TO EXHAUSTION IRRESPECTIVELY FROM EXERCISE INTENSITY**

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INTRODUCTION: It has been demonstrated that mental fatigue (MF) impairs exercise tolerance [1,2]. Although some authors have hypothesized that the higher the exercise intensity the lower the impact of MF [3], it is unclear whether physiological determinants of endurance performance at different intensity domains are modulated by ergolytic effects of MF. Thus, we evaluated the effect of MF on time to exhaustion (TTE) during cycling at heavy- and severe-intensity exercise.
METHODS: Twenty-three highly trained triathletes (26±5 yr; 71±6 kg) performed an incremental cycling test to exhaustion immediately followed by a 2-minute all-out test, enabling the detection of the Critical Power (CP) [4]. Each subject underwent four testing sessions on different days, involving either 45-min of intervention followed by TTE tests at heavy (90%CP) or severe (110%CP) intensity. Interventions consisted of a documentary watching (CTRL), used as control task, or a continuous Simon Task (SIM), used to induce MF. The time-course of reaction time (RT) and error-rate (ER) during SIM was monitored. Subjective rating of MF, assessed by VAS scale, and mental workload (MW), evaluated by NASA TLX questionnaire, were collected before exercise. Cardio-respiratory and metabolic responses to exercise were monitored.
RESULTS: Maximal oxygen uptake (V'O2max) and maximal work-rate were 53.5±8.0ml*min-1*kg-1 and 368±65w, respectively. CP was 279±58w. VAS score and MW were significantly higher after SIM than CTRL (VAS: CTRL 8.26±4.4 vs SIM13.2±4.3, $p<0.01$; WL: CTRL 23.3±22.9 vs SIM 74.5±15.4 $p<0,01$). During SIM, RT did not change over time ($p>0.05$) but ER increased significantly ($p<0.01$). TTE at heavy was significantly lower after SIM compared to CTRL (CTRL: 2004±903s; SIM: 1766±907s, $p<0.05$), whereas physiological responses to exercise were not different between conditions. TTE at severe was also significantly lower after SIM (CTRL: 438±270s; SIM: 393±248s, $p<0.05$) but led to a reduced V'O2 and heart rate values. No significant differences in performance loss due to MF between intensity domains were observed (H -9,2±25,7%, S -7,5±24,8%, $p>0,05$).
CONCLUSION: Completion of 45-min cognitive task significantly impaired cognitive function, induced significantly higher ratings of mental fatigue and mental workload, decreasing exercise tolerance to a similar extent in both heavy and severe domains. Thus, performance impairments induced by mental fatigue do not seem to be exercise-intensity dependent. Our results suggest avoiding tasks that may induce MF before activities and competitions irrespectively of their intensity above anaerobic threshold.
1. Boksem & Tops (2008) 2. Marcora et al. (2009) 3. Van Cutsem et al. (2017) 4. Murgatroyd et al. (2014)

**THE INDIVIDUAL RESPONSE TO MENTAL FATIGUE: A SYSTEMATIC REVIEW AND META REGRESSION**

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INTRODUCTION: Mental fatigue, a psychobiological state that is induced when engaging in prolonged cognitive activity, affects both cognitive as well as physical performance. However, the significance and magnitude of these effects has recently been questioned. One of the underlying reasons could be the interindividual differences that are present in mental fatigue-effects. However, it's not known yet whether these interindividual differences are trait or state-related, or which internal and/or external factors mediate these interindividual differences. The aim of this systematic review and meta-regression was to give an overview of interindividual differences in the effects of mental fatigue on physical performance, and possible internal factors influencing this effect.
METHODS: Pubmed, Web of Science, SPORTDiscus and PsycINFO were searched for studies detailing the effect of mental fatigue on dynamic maximal whole body endurance performance. Studies needed to feature healthy participants with the inclusion of at least one

internal factor in participants' characteristics, and were required to include at least one manipulation check. The Cochrane crossover risk of bias tool was used to assess risk of bias. The meta-analysis and regression itself were conducted in R.
RESULTS: 29 studies were selected for inclusion, with 24 studies eventually added to the overall random-effects meta-analysis (with 34 distinct effects) based on the successful induction of mental fatigue. This meta-analysis showed a small but significant effect of mental fatigue on endurance performance (g = - 0.31, 95% CI [-0.44; -0.17], t = -4.83, p < 0.001). The multiple meta-regression analysis (incorporating 11 effects) showed a significant influence of physical fitness level on mental fatigue-effects (estimate = 0.18, SE = 0.06, t = 2.84, p = 0.0296). However, this effect was only present when incorporated within the model together with sex ratio, mean age and body mass index.
CONCLUSION: The present review confirms findings of the overall literature regarding the mediating influence of physical fitness level on the negative effects of mental fatigue on endurance performance. However, this influence is only apparent when different individual factors, such as sex, are taken into account. Moreover, multiple limitations still undermine these conclusions, from the overall underreporting of different participant characteristics to significant publication bias. An overall experimental study incorporating multiple different internal factors is therefore necessary to draw a definitive conclusion on this subject.

### SUBJECTIVE FEELINGS OF MENTAL FATIGUE DIFFERS BETWEEN COMPETITIVE PHASES IN SEMI-PROFESSIONAL SOCCER

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Soccer game scenarios imply vigilance, decisions making, emotions or constantly processing information causing mental fatigue in soccer players (Coutts, 2016). Mental fatigue may impair soccer physical and technical-tactical performance (Badin et al., 2016; Coutinho et al., 2017). Therefore, controlling and limiting the presence of mental fatigue may be important for enhancing soccer performance. The present study aimed to check the influence of play a play-offs phase on the mental fatigue reported by semi-professional soccer. 53 players (Mage=24.59 years) for two semi-professional teams participated during the 2020/21 season. Mental fatigue was quantified with a Visual Analogue Scale during four trainings per week (Monday=MD+1, Wednesdey=MD-4, Thursday=MD-3 and Saturday=MD-1), with a competitive match on Sunday. The total duration of the study was 10-weeks (five dates of regular season – five dates of play-offs). A Linear Mixel Model was performed with R-studio, using the competitive phase as independent variable. The results showed that the mental fatigue reported by players was significantly higher during the play-offs phase that during the regular season. The play-offs phase is played by the best teams of a competition whereplayers usually have monetary recompenses by achieve the objectives or possibilities to sign better contracts the next season. Despite we have not the specific data to confirm this, the results suggest that the play-offs phase implies emotional demands that may increase the mental fatigue reported by players. Then, in agreement with Van Cutsem and Marcora (2021) we recommended coaches the possibility to use recovery strategies for mental fatigue during the play-offs phase (specially nearly the match day) and to avoid the presence of mentally fatiguing tasks nearly competitions.
References
Badin, O. O., Smith, M. R., Conte, D., & Coutts, A. J. (2016). Mental fatigue: Impairment of technical performance in Small-Sided soccer games. International Journal of Sports Physiology and Performance, 11(8), 1100–1105. https://doi.org/10.1123/ijspp.2015-0710
Coutinho, D., Gonçalves, B., Travassos, B., Wong, D. P., Coutts, A. J., & Sampaio, J. E. (2017). Mental fatigue and spatial references impair soccer players physical and tactical performances. Frontiers in Psychology, 8, 1645. https://doi.org/10.3389/fpsyg.2017.01645
Coutts A. J. (2016). Fatigue in football: its not a brainless task!. Journal of sports sciences, 34(14), 1296. https://doi.org/10.1080/02640414.2016.1170475
Van Cutsem, J., & Marcora, S. (2021). The effects of mental fatigue on sport performance. In Motivation and self-regulation in sport and exercise (pp. 134–148). Routledge.

### NO BRAIN, NO GAIN: ATHLETE MENTAL FATIGUE AND RECOVERY IN PRACTICE, WHAT DO WE KNOW AND HOW DO WE MANAGE IT?

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INTRODUCTION: INTRODUCTION: Mental fatigue and recovery have recently gained scientific attention in relation to sporting performance. The potential negative effects on physical, technical, tactical, and psychological performance determinants are demonstrated, however research has traditionally been critiqued for a lack of ecological validity. Whilst large scope exists for practitioners to manage mental fatigue and recovery to aid in maximisation of performance, little is understood about current practices used by performance staff in the daily training and competition environment.
METHODS : A mixed methods approach through a cross-sectional survey obtained perceptions from 156 high-performance practitioners working in a performance support, sports science, or sports medicine capacity. The public survey questioned practitioner knowledge and confidence, sources of evidence, perceived impact, assessment and management, role responsibility, and challenges. Descriptive outputs were analysed using RStudio with the R statistical programming language, and Braun & Clark's thematic analysis approach identified patterns in context of theoretical understanding.
RESULTS : More than 97% of respondents believed mental fatigue and recovery impacts training and competition performance. Deliberate inducement of mental fatigue was reported by 44.2%, and 54.5% reported deliberate enhancement of mental recovery. In training and/or competition practices, 38.5% and 23.7% reported assessment of mental fatigue and mental recovery respectively. A low number of respondents reported to be very knowledgeable on mental fatigue (11.5%) or mental recovery (5.1%). The minority reported being largely confident in applying their knowledge of mental fatigue (10.9%) and mental recovery (8.3%) to maximise performance. A multitude of staff were perceived as being responsible for the inducement and management of mental fatigue and recovery. Staff knowledge was the most common barrier to implementing mental fatigue or recovery protocols, followed by athlete buy-in and time-availability. In terms of accessing information, colleagues and published research, were the most common sources, interestingly, asking researchers was the fourth least frequently used source.
CONCLUSION : High-performance practitioners perceive mental fatigue and recovery to impact on training and competition, yet their knowledge, confidence in application and current assessment and management is limited. Researchers should endeavour to undertake research which builds a progressive evidence-base for the practitioner to assess and manage mental fatigue and recovery in athletes. Greater focus on education, and use of translational and behavioural change models to influence applied practice,

whilst targeting frequently used sources of evidence, and responsible practitioner roles, may aid in maximising performance through improved assessment and management of athlete mental fatigue and
recovery.

**METHODS: RESULTS: CONCLUSION: IS THE ACUTE MENTAL FATIGUE CAUSED BY DIFFERENT SPORT TRAININGS SIMILAR?**

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Is the acute mental fatigue caused by different sport trainings similar?
Know the mental fatigue caused by trainings may help staffs to adequate the state of mental fatigue of their players correctly. This study aimed to compare how mentally fatiguing are two different trainings. Twenty-three physically active (Seventeen males: Mage = 24yr; 7 females: Mage = 22,57yr) performed two experimental sessions: (1)Physically fatiguing (PF): 30-minutes of cycleergometer work (at 65-75% of maximum heart rate), (2)Mentally fatiguing (MF): 30-minutes of an incongruent Stroop task. Pre- and post- fatiguing protocol were measured: Electroencephalogram (EEG) signals, subjective mental fatigue using a Visual Analogue Scale, ocular-manual reaction time using a Psychomotor Vigilance Task and cognitive performance with 45-seg of Incongruent Stroop. Furthermore, EEG was measured during the experimental protocols. Results indicated significant increments in the subjective perceptions of mental fatigue after the two tasks, although this increment was significantly different between protocols. Due to the increases in the perceptions of mental fatigue was significantly higher by MF, only MF caused significant impairments in reaction time. With regard EEG signals, the activity of the cerebral cortex – specifically at the pre-frontal area - was significantly higher during MF than PF. These results suggest that the use of PF and MF, should be avoided nearly competitions by the negative consequences that mental fatigue may cause on performance. Findings also showed more light about the brain areas that are more related with mental fatigue in sports.
Keywords: mental fatigue, cognitive fatigue, physical fatigue, sport practitioners, EEG.

## Oral presentations

### OP-PN09 Thermoregulation

**SEX-MEDIATED DIFFERENCES IN CORE TEMPERATURE AND THERMOREGULATORY SWEATING ARE NOT EVIDENT IN CHILDREN EXERCISING IN THE HEAT**

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INTRODUCTION: Historically, both females and children have been perceived to be thermoregulatory disadvantaged, which may increase their vulnerability to hyperthermia during exercise in the heat. However, previous research comparing thermoregulatory responses to exercise between independent groups (e.g., males/females, adults/children) may have been limited due to a failure to account for differences in body size, which can confound the interpretation of findings. When isolating the effect of an independent variable (i.e., sex, age) on the change in core temperature and thermoregulatory sweating during exercise, work rate should be prescribed to elicit a matched rate of metabolic heat production (Hprod) per unit body mass and body surface area, respectively (1). To our knowledge, no prior studies have investigated whether a sex difference in exercise thermoregulation occurs within children using this methodology. Thus, we aimed to evaluate sex-mediated differences in the change in core temperature and sweating between boys and girls during exercise at a matched Hprod per unit body mass and per body surface area respectively.
METHODS: In two separate trials, 11 boys (mean ± SD: age 14 ± 1 yr; body mass 60.0 ± 9.1 kg; body surface area 1.69 ± 0.15 m2) and 11 girls (age 13 ± 2 yr; body mass 52.6 ± 8.5 kg; body surface area 1.53 ± 0.15 m2) walked for 45 min at a fixed Hprod per unit body mass (8 W·kg-1) and per body surface area (300 W·m-2) in 40°C and 30% relative humidity. Changes in gastro-intestinal temperature and local sweat rate (back and forearm) were measured continuously. Whole-body sweat loss was estimated from pre and post body mass and reported in grams per body surface area (g·m-2).
RESULTS: In the W·kg-1 trial, the change in gastro-intestinal temperature did not differ between boys (1.08 ± 0.40°C) and girls (1.23 ± 0.32°C; P = 0.358). In the W·m-2 trial, end-exercise local sweat rate on the back was not significantly different between the boys (1.24 ± 0.10 mg·cm-2·min-1; n = 9) and girls (1.10 ± 0.24 mg·cm-2·min-1, P = 0.096; n = 11). Similarly, local sweat rate on the forearm did not differ between the boys (0.85 ± 0.25 mg·cm-2·min-1; n = 7) and girls (0.75 ± 0.17 mg·cm-2·min-1, P = 0.340; n = 11). Whole-body sweat loss in the W·m-2 trial was not significantly different between boys (355 ± 47 g·m-2) and girls (334 ± 45 g·m-2; P = 0.315).
CONCLUSION: Our data indicate no significant difference in the core temperature change and time-dependent thermoregulatory sweating responses between boys and girls during exercise at a matched Hprod per unit body mass and per body surface area, respectively. These findings suggest that girls are not thermoregulatory disadvantaged when compared to boys during exercise matched to body size in a hot environment.
REFERENCES:
1. Cramer & Jay, J Appl Physiol (2014)

**MEASUREMENT OF THERMAL SWEATING AT REST AND STEADY-STATE EXERCISE IN HEALTHY ADULTS: INTER-DAY RELIABILITY AND RELATIONSHIPS WITH COMPONENTS OF PARTITIONAL CALORIMETRY**

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INTRODUCTION: Valid and reliable measurements of the thermal sweating response to exercise are important for accurate estimations of evaporative cooling and detection of heat acclimation. Indeed, changes in measures of thermal sweating, such as local sweat rate (LSR; ~30%) and sweat gland activation (SGA; ~27.9%) have been reported following heat acclimation [1]. Therefore, these measures, and their determining factors (metabolic heat production [Hprod] and evaporative requirement for heat balance [Ereq]), are fundamental to the

investigation of human thermoregulation. The purpose of the current study was to: i) evaluate the inter-day reliability of various sweat measurements, including the absorbent patch and modified iodine-paper techniques, at rest and a range of exercise intensities; ii) evaluate the effect of iodine-paper size and the method of establishing SGA (sweat gland counting or surface area covered) on reliability; iii) determine the relationships between all measurement techniques and Hprod or Ereq.
METHODS: Twelve healthy, non-heat acclimated males and females (29 ± 6 years, 175.0 ± 7.6 cm, 76.5 ± 11.6 kg) participated in an inter-day test-retest reliability trial. Participants were assessed for whole-body sweat loss (WBSL), LSR (absorbent patch technique) and SGA (modified iodine-paper technique) during rest and 30-min periods of sub-maximal cycling at Hprod ~200, ~250 and ~300 W/m2 while exposed to ambient heat (37.6 ± 0.4°C and 27.0 ± 5.9% relative humidity). Heat balance parameters, including Hprod and Ereq, were estimated for each exercise period via partitional calorimetry. Variations in iodine-paper size (1 cm2 to 9 cm2) were used to quantify SGA by counting sweat glands or determining surface area covered. The 'optimal' area of SGA was also determined within the 9 cm2 area, as the highest density of recruited glands.
RESULTS: Hprod and Ereq were positively related with all sweating response measures ($r = 0.53$ to 0.84; $P < 0.05$), with the 9 cm2 and 6 cm2 iodine-paper sizes observed to have the strongest correlation for SGA ($r = 0.66$ to 0.84). Inter-day reliability was greater for all measures during exercise (CV% = 7.8 to 30.0) compared to rest (CV% = 33.5 to 77.9). The modified iodine-paper technique was most reliable at 9 cm2 (CV% = 15.9) or when the 1 cm2 (CV% = 17.6) and 3 cm2 (CV% = 15.5) optimal area of SGA was determined, particularly when measuring the sweat gland number as opposed to surface area covered.
CONCLUSION: WBSL, LSR and SGA measurement techniques are sufficiently reliable during exercise - but not at rest - to detect the changes in thermal sweating typically reported. We recommend using 9 cm2 iodine-paper sizes or establishing the 1 cm2 or 3 cm2 optimal area using either sweat gland counting or surface area covered to determine SGA.
1. Ravanelli et al., 2018, Med. Sci. Sports Exerc.

**CARDIOVASCULAR RESPONSES TO ORTHOSTASIS DURING A SIMULATED 3-DAY HEATWAVE**

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INTRODUCTION: Global warming has caused an increase in the frequency, duration, and intensity of summer heatwaves (HW). Prolonged exposure to hot environments caused by these heatwaves, and orthostasis, may cause conflicting demands of thermoregulation and blood pressure regulation on the vasomotor system, potentially contributing to cardiovascular complications and heat strain. The type of heat strain produced may have severe impacts on athletes in competition, as well as workers in industry. The study assessed cardiovascular and skin blood flow (SkBF) responses to orthostasis before, and during a 3-day simulated HW.
METHODS: Seven male participants were confined to the Planica PlanHab Facility (Rateče-Planica, Slovenia) where they maintained a standard work/rest schedule for nine consecutive days split into 3-day segments; thermoneutral pre-HW (25.4°C), simulated HW (35.4°C), thermoneutral post-HW (25.4°C). Gastrointestinal (Tgi) and skin (Tsk) temperatures, cardiovascular responses, and SkBF were monitored during a 10-minute supine rest period and 10-minute 60° head-up tilt (HUT) period. SkBF, indexed using proximal-distal skin temperature gradient (ΔTskP-D), was also validated using Laser-Doppler Flowmetry (LDF).
RESULTS: During the HW, there was a significant increase in heart rate, cardiac output, and SkBF of the leg, in the supine position; whereas during HUT, there was an increase in SkBF of both the arm and leg, and all cardiovascular variables were significantly affected besides cardiac output. Significant regional differences in SkBF presented between the arm and leg in all conditions; the arm displaying vasodilation throughout, while the leg vasoconstricted in non-HW before shifting to vasodilation in the HW. Additionally, the validation of ΔTskP-D displayed a strong correlation with LDF ($r = -.78$, $p<0.001$).
CONCLUSION: Prolonged HW exposure and orthostasis elicited significant yet expected responses to cardiovascular variables and SkBF variables. In addition, varying regional blood flow responses were observed between the arm and the leg, suggesting the upper and lower vasculature receives differing vasomotor control. Combined cardiovascular alterations and shifts towards vasodilation indicate an increased challenge to athletes and industrial workers during HWs.

**ACCLIMATION PROCESS OF MARATHON ATHLETES FOR THE TOKYO OLYMPIC GAMES 2020**

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INTRODUCTION: Women's marathon of Tokyo Olympic Games 2020 was held on the 7th of August in Sapporo, Japan. This region has recorded, exactly in this day its highest temperature in 21 years, at 6 a.m. at the start of the race, the sky was clear, the temperature was 25 °C and a relative humidity was 82%. The temperature rose during the competition to above 30°C with relative humidity above 80%, which means values of WBGT exceeding 30, already in the dangerous category. With this type of warning, the acclimatization process becomes essential in an athletes sports preparation, not only to improve sport performance but also to preserve physical integrity.
METHODS: In this study, two female athletes underwent a period of 15 days of acclimation. The process was carried out in the climatic chamber (CC) located at the laboratory of Industrial Aerodynamics (LAI) of the University of Coimbra. In all sessions, the duration was 60 min, temperature was 34.2°C±0.4, relative humidity 77.2% ±5.4%, and air speed was lower than 2.1 m s-1 at the chest level. A treadmill (HP Cosmos) was used for all sessions, VO2 max tests were performed on the first day of each acclimatization period using a gas analyser (Metamax cortex), to define the work intensity of the following acclimatization sessions (60% of VO2 max). Oxygen consumption tests were performed at days 1, 7 and 15. Urine temperature and density, body mass, heart rate variability before and after effort were controlled (Polar V800+H10 chest band). In addition, heart rate and lactate concentration (spectrophotometer Dr. Lange) and fluid consumption, loss of plasma volume and percentage of loss of body mass throughout each session were also controlled.
RESULTS: Due to the acclimatization process the following changes were observed: an increase of 3.3% in the athletes running velocity and a decrease in oxygen consumption around 2.1 ml/kg/min, for the same percentage of VO2max; plasma volume loss varied from 9.98% to 3.97%; a decrease of urine density (1013 to 1007.5) and heart rate (151 to 138 bpm), a 1073 ml/h increase in sweat rate; an increase of percentage of loss of body mass (1.12% to 2,72%); as regards Heart Rate Variability, a decrease in LF/HF ratio (3.46 ms2 to 1.38ms2), Mean RR increased (951 - 1203 ms) and LnRMSSD increased (3.69 ms to 4.44 ms). The core temperature after the exercise had not large variations. Its average was 38°C ±0.53°C, which is 2.9°C±0.38°C above the initial temperature, across all training sessions. Mean blood lactate was 1.23 ± 0.27 mmol/l.
CONCLUSION: The acclimatization process showed a clear improvement in performance indicators and the decrease in sympatho-vagal activity prior to exercise may suggest an adaptation to thermal adverse conditions. Additionally, decreases in the plasma volume loss, heart

rate, ventilation and oxygen consumption were verified for the same intensity which is essential to be able to maintain body thermoregulation and hight levels of performance in adverse weather conditions.

**THE INFLUENCE OF L-CITRULLINE SUPPLEMENTATION ON HYPOHYDRATED ENDURANCE RUNNING PERFORMANCE IN THE HEAT.**

CABLE, T.G., HUDSON, E.F., REYNOLDS, K.M., FUNNELL, M.P., JOHNSON, D.A., TAYLOR, L., BAILEY, S.J., MEARS, S.A., JAMES, L.J.

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INTRODUCTION: 7 days L-Citrulline supplementation decreases oxygen uptake during cycling in a temperate environment through increased nitric oxide availability in the blood. During exercise in the heat, and/or where dehydration occurs and total blood volume and blood flow to the muscles are compromised, L-Citrulline supplementation may be ergogenic. Therefore, this study assessed the impact of 7 days L-Citrulline supplementation on 3 km running performance in the heat whilst in a state of hypohydration.
METHODS: 9 endurance runners (8 male, 1 female) (age 32 ± 7 y; V̇O2max 59 ± 6 mL/kg/min) participated in a randomised, double-blind, crossover trial with 7 days of L-Citrulline (CIT) (6 g/day) or placebo (PLA) supplementation. Participants completed a 50 minute running 'preload' at 65% V̇O2max in the heat (32°C, 50% RH) to induce hypohydration (~2% body mass loss) before a 3 km running time trial. Body mass, core and skin temperature, heart rate, perceptual responses, sweat rate and oxygen uptake were recorded during the preload and time trial.
RESULTS: During the preload and time trial, alterations in the physiological variables associated with thermoregulation and hypohydration (i.e. core temperature, skin temperature, heart rate and oxygen uptake) were increased, but were not different between trials (P≥0.150). Local sweat rate was similar between trials (CIT 2.99 ± 1.22 mg/cm2/min, PLA 2.71 ± 1.99 mg/cm2/min, P=0.563). Thirst, RPE, gastrointestinal comfort and thermal sensation increased throughout the preload but were not different between trials (P≥0.360). Thermal sensation was lower at the final stage of the time trial in CIT (CIT 7.0 ± 1.1, PLA 8.0 ± 0.9, P<0.010). Time trial performance was not different between trials (CIT 865 ± 142 s, PLA 892 ± 154 s, P=0.161). Pacing of the time trial was similar between trials for 0 – 1 km (CIT 298 ± 52 s, PLA 305 ± 54 s, P=0.254), 1 – 2 km (CIT 288 ± 49 s, PLA 288 ± 56 s, P=1.000) and 2 – 3 km (CIT 280 ± 42 s, PLA 300 ± 53 s, P=0.08).
CONCLUSION: 7 days L-Citrulline supplementation did not alter physiology or performance responses to running in the heat whilst hypohydrated. The lack of attenuation of core and skin temperature may be attributable to the intense nature of the environmental conditions. However, perception of thermal sensation was lower during the time trial, indicating that L-Citrulline may be used in an endurance context to reduce the perception of heat stress during competition. Further research should assess increased dosage of L-Citrulline in this context.

## Oral presentations

### OP-MH04 Injuries and prevention

**NETWORK FUNCTIONAL CONNECTIVITY RESPONSE TO SUBMAXIMAL EXERCISE AFTER A SPORT-RELATED CONCUSSION**

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INTRODUCTION: Return-to-sport (RTS) after a sport-related concussion (SRC) is guided by clinical symptom presentation and assessments, however there is a need to explore and develop objective biomarkers. Resting state electroencephalography (rsEEG), may be a suitable technique to identify functional deficits in relevant networks that are assumed to be affected by SRC. The aim of this study is to explore rsEEG whole brain and network changes in response to submaximal exercise during RTS.
METHODS: Thirty-six athletes were recruited for this study; 18 patients post SRC (age: 24 ± 5, BMI: 24 ± 2, time since concussion: 2 – 140 days, symptom score: 1 - 87), and 18 matched controls (age: 25 ± 5, BMI: 23 ± 2). 128-channel rsEEG recordings were collected pre- and post- submaximal cycle exercise (70% of the athletes' age calculated maximal heart rate (HR)). Functional connectivity (FC) calculated by mean phase locking value (PLV), within the alpha band (7-13 Hz) was analyzed for whole brain (68 ROI, Desikan Killiany atlas), default mode network (DMN, 14 ROI) and central autonomic network (CAN, 24 ROI). Wilcoxon Signed Rank Tests were used to explore statistical significance between pre and post exercise.
RESULTS: For concussed athletes, there was a significant difference between pre- (Mdn = 0.258, IQR = 0.082), and post- (Mdn = 0.275, IQR = 0.079; Z = -2.635, p = 0.008, r = -.62) exercise for whole brain FC. In addition, concussed athlete's pre- (Mdn = 0.363, IQR = 0.060, and post- (Mdn = 0.370, IQR = 0.080) exercise FC within DMN differed significantly; Z = -2.678, p = 0.007, r = -.63, and within CAN pre- (Mdn = 0.298, IQR = 0.069), and post- (Mdn = 0.320, IQR = 0.081) exercise; Z = -2.809, p = 0.005, r = -.66. For control athletes, there was no significant difference between pre- and post- exercise FC within whole brain and selected networks.
CONCLUSION: Whole brain and network FC significantly increased pre- to post-exercise within the concussed patient group, but not the control group. There appears to be an altered response to submaximal exercise in SRC athletes, possibly driven by altered central network activity.

**THE FOOTBALL ASSOCIATION INJURY AND ILLNESS SURVEILLANCE STUDY: THE INCIDENCE AND SEVERITY OF INJURIES IN ENGLISH MEN'S SENIOR INTERNATIONAL FOOTBALL**

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INTRODUCTION: Injury surveillance is an integral part of elite football given medico-legal responsibilities and the need to mitigate injury occurrence in the interests of player welfare. Long-term, large-scale studies characterising specific injury diagnosis in international football are scarce, with previous studies only examining international tournaments [1,2]. The aggregation of injuries into broad categories, a lack of injury severity analysis and the inability to assess specific match and training injury patterns limit the practical use of current literature. This study aimed to compare injury patterns and specific diagnoses in matches and training, and their associated incidence and severity, in English men's senior international football over 8 seasons.

METHODS: Time-loss injuries and match and training exposure were collected across 8 seasons (2012-20) in English men's international teams (U20/U21/Senior). Incidence (injuries/1000h), and severity (% of total days absent) of injury patterns and specific injury diagnoses were determined. Chi-square test was used to assess differences in the distribution of injuries between matches and training. Significance was set at P<0.05.
RESULTS: 215 injuries were recorded (match: 126, training: 89) over 8 seasons. The most common match injury diagnoses were lower limb haematomas (22%,7.0/1000h), hamstrings muscle/tendon (13%,4.0/1000h) and lateral ankle ligament injuries (10%,3.3/1000h). In training, lower limb haematomas (12%,0.4/1000h), hamstrings muscle/tendon (11%,0.4/1000h) and quadriceps and hip/groin muscle/tendon injuries (both 9%,0.3/1000h) were most common. There were no differences in commonality between matches and training (P>0.05). The most severe match injury diagnoses were ACL (19%), lateral ankle ligament (13%) and quadriceps muscle/tendon injuries (11%). In training, MCL (19%), quadriceps muscle/tendon (16%) and hamstrings muscle/tendon injuries (12%) were most severe. ACL and lateral ankle ligament injuries were more severe in matches than training (both P<0.001). Quadriceps muscle/tendon (P<0.001), MCL (P<0.001) and hamstrings muscle/tendon injuries (P=0.048) were more severe in training than matches.
CONCLUSION: No differences were shown in the patterns and specific diagnoses of injuries in matches compared to training, suggesting that the differing contextual factors between matches and training did not influence injury commonality. Lateral ankle ligament injuries were more severe in matches compared to training, potentially attributed to increased player contact through tackling and fouls in matches. The greater severity for hamstrings and quadriceps muscle/tendon injuries in training compared to matches warrants further investigation.
REFERENCES:
[1]Hägglund M, Waldén M, Ekstrand J. UEFA injury study-an injury audit of European Championships 2006 to 2008. BJSM. 2009 1;43:483-9.
[2]Junge A, Dvorák J. Football injuries during the 2014 FIFA World Cup. BJSM. 2015 1;49:599-602.

**DIFFERENT MOTOR RECOVERY PROGRESS BETWEEN ADOLESCENT AND ADULT RECREATIONAL ATHLETES AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION**

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INTRODUCTION: In recent years the incidence of anterior cruciate ligament (ACL) injuries in the skeletally immature population has grown [1]. Nonetheless, there is still a limited understanding of the recovery processes of these patients after reconstructive surgery, making it difficult to define appropriate criteria for their safe return to sport. The progress in motor recovery in ACL-injured patients is often evaluated using isokinetic tests [2]. Here, we compare for the first time the outcomes of these tests between adolescent and adult patients after ACL reconstruction (ALCR) with bone-patellar tendon-bone (BPTB) technique, providing critical insights into their different processes of motor recovery.
METHODS: Fifty-five adolescents (13-18 years old) and 76 adults (19-39 years old), who underwent BPTP ACLR, performed isokinetic tests 6 months after surgery. The outcomes of these tests were: (1) the maximum torque produced by hamstrings (H) and quadriceps (Q) muscles (i.e. muscle strength) during flexion and extension movements at 30°/s normalized by body weight; (2) the ratio of hamstrings to quadriceps strength (HQ ratio); (3) the ratio of muscles strength in the injured to the uninjured leg (limb-simmetry, LSI). Mixed models with repeated measures were used to compare the outcomes between adolescents and adults, and between legs within patients.
RESULTS: Both adults and adolescents exhibited a decrease of quadriceps strength in the injured compared to the uninjured leg (Δadolescents: -0.5±0.8 Nm/kg; Δadults: -0.8±0.9 Nm/kg; p<0.001), but no change in the hamstring strength (Δadolescents: -0.1±0.6 Nm/kg; Δadults: -0.1±0.6 Nm/kg; p=1). Interestingly, in adolescents this decrease was significantly lower than in adults (injured Q adolescents vs adults, p<0.05). As a result, in both populations the quadriceps LSI was lower than the hamstring LSI (p<0.001). Yet, quadriceps LSI of adolescents was higher than that of adults (p<0.001), with no significant difference between populations in hamstring LSI (p=1). The HQ ratio in the injured leg was significantly higher than in the uninjured leg in both populations (adolescents: 0.66±0.13 vs 0.53±0.07; adults: 0.74±0.15 vs 0.53±0.08; p<0.05). However, in adolescents this measure was lower than in adults for the injured (p<0.001) but not for the uninjured leg (p=1).
CONCLUSION: There were clear differences between the recovery progress in adolescents and adults. Since the hamstring muscles are synergistic and the quadriceps muscles are antagonist to the ACL [3], the lower HQ ratio in adolescents suggests that in these patients the reconstructed ligament may be subject to higher loads than in adults 6 months after surgery. Adolescents may therefore need a longer period of rehabilitation to have a safe return to sport.
REFERENCES:
1. Jayanthi et al., Sports Health, 2013
2. Gokeler et al., Knee Surg Sports Traumatol Arthrosc., 2017
3. Luque-Seron et al., Sports Health, 2007

**NEUROMUSCULAR CONTROL OF THE CONTRALATERAL LEG DURING JUMP LANDINGS FOLLOWING AN ACL INJURY**

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INTRODUCTION: After an anterior cruciate ligament (ACL) injury and subsequent repair, there is a high risk of sustaining a second ACL injury (1). Interestingly, the rates of contralateral ACL injuries exceed the rates of ipsilateral graft rupture (1). One underlying mechanism may be that the loss of afferent input from the ruptured, ipsilateral ACL leads to a reorganization of activity in motor areas of the brain, ultimately affecting neuromuscular function of both legs (2). The current study tested the hypothesis that dynamic postural stability, quantified through the time to stabilization (TTS) during jump landings, would be reduced for the healthy contralateral leg in individuals with a previous, unilateral, fully rehabilitated ACL injury in comparison to healthy controls. Further, effects of leg dominance were investigated.
METHODS: Twenty-three females with a previous ACL injury (8 dominant leg; 15 non-dominant leg) and eighteen healthy females (control group) performed unilateral horizontal jump landings over a 30cm hurdle onto a force plate (1000Hz) (3). They were instructed to stabilize as quickly as possible and remain still for 10 seconds. Medio-lateral TTS (TTS-ML) was calculated as the time required for the medio-lateral force to reach and remain within ± 1 SD of the subject's overall series mean for 1s. Independent t-tests were used to compare the ACL

leg/contralateral leg to the control group irrespective of leg dominance. Two Kruskal-Wallis and Bonferroni-corrected posthoc tests (alpha = 0.05) were used to compare injured, contralateral and control-group legs separately for the dominant and non-dominant side.
RESULTS: Average unilateral TTS-ML was significantly higher in the ACL injured leg (1.59s versus 1.26s; p=0.006; d= 0.90) and borderline significant in the contralateral leg (1.51s; p= 0.050; d= 0.68) compared to the control group. For dominant leg injuries a significant increase was found between injured and control-group legs (1.89s versus 1.30s; p= 0.006; r= 0.49) and contralateral and control-group legs (1.73s versus 1.26s; p= 0.034; r= 0.40). However, this was not found for injuries on the non-dominant leg.
CONCLUSION: Our results suggest an interaction effect: neuromuscular control was less effective in the contralateral leg compared to healthy controls if the injury had happened on the dominant leg. A deficit in contralateral leg control was not detectable if the injury had occurred on the non-dominant leg. Rehabilitation programs following ACL injury should also focus on neuromuscular training of the contralateral leg, and in particular so, when the patient's dominant leg was injured.
REFERENCES:
1) Wiggins et al., Am J Sports Med, 2016.
2) Needle et al., Sports Med, 2016.
3) Heinert et al., Int J Sports Phys Ther, 2018.

**EVALUATION OF POSTURAL STABILITY AND PROPRIOCEPTION IN SUBJECTS BEFORE AND AFTER TOTAL ANKLE REPLACEMENT**

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INTRODUCTION: Ankle osteoarthritis is a debilitating condition, which includes balance impairment, range of movements limitations and a consequence increased risk of falls. Conservative management is the first approach but for severe ankle osteoarthritis, total ankle replacement (TAR) should be taken into account. The aim of this study is to measure postural control and proprioception in subjects with primary TAR, before and nine months after the surgery.
METHODS: Subjects with ankle osteoarthritis admitted in the Istituto Ortopedico Rizzoli of Bologna (Italy) waiting for a TAR were recruited. Delos Postural Proprioceptive System (Delos S.r.l, Turin, Italy) was used to assess postural control and proprioception. All subjects performed the Static Riva test, which consists of maintaining a single leg stance with open and closed eyes. The parameter considered is the Stability Index (SI) which is a percentage score where 100% is a theoretical task performed with maximum stability.
RESULTS: Subjects recruited were 17 (12 male and 5 Female) aged 59.29 ± 10.83 years with a body mass index of 28.20 ± 2.45. The SI, of the operated limb, decreased from 68.22% ± 18.65 to 60.93% ± 18.86 with opened eyes (p = 0.16) and from 37.09% ± 14.14 to 34.24% ± 10.17 with closed eyes (p = 0.37). The SI of the contralateral limb, slightly decreased from 87.51% ± 4.10 to 86.75% ± 6.03 with opened eyes (p = 0.53) and from 53.19% ± 16.58 to 52.16% ± 13.89 with closed eyes (p = 0.67). Considering all tasks, the operated limb has significant lower results than the contralateral (p<0.001). There is a strong correlation between the open and closed eyes results in the operated limb both before (r = 0.79; p<0.001) and after surgery (r = 0.63; p<0.01). Same correlations are found in the contralateral limb. Age and BMI did not influence the SI.
CONCLUSION: The static Riva test with his open and closed eyes tasks is an indicator respectively of postural stability and proprioception. Subjects showed a consistent difference between limbs in all tests; therefore, we suppose that postural stability and proprioception are strongly influenced in a severe ankle osteoarthritis condition. Moreover, even if the current literature shows great results after TAR in terms of function and pain, 9 months seems is not to be enough to restore balance and proprioception.
Reference: Riva D et al. (2013) Single stance stability and proprioceptive control in older adults living at
home: Gender and age differences. J Aging Res 2013: 561695

## Oral presentations

### OP-MH05 COVID-19: Impact on exercise capacity, fitness and quality of life

**ASSOCIATION BETWEEN STRINGENCY OF COVID-19 CONTAINMENT MEASURES AND WALKING MOBILITY. AN ANALYSIS OF MOBILE DATA FROM 60 COUNTRIES.**

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INTRODUCTION: COVID-19 containment measures curb virus transmission, but increase the risk of physical inactivity [1,2]. Movement restrictions, travel bans, and stay-at home recommendations can hamper walking mobility, and reducing daily steps is a risk factor for non-communicable diseases and all-cause mortality [3]. The relation between stringency of containment measures and walking mobility has not been quantified; however, combined global-scale datasets on population mobility, containment policies, weather and solar light may allow to investigate it while controlling for major confounders. Our aim was to assess the dose-response relation between containment stringency and walking mobility across the 60 countries of the Apple Mobility Trends Reports (AMTR) dataset [4], and model the impact of the subsequent physical inactivity on health outcomes.
METHODS: Daily data on 60 countries from the 21st January 2020 to the 21st January 2022 were harmonized from open-access sources: AMTR, Oxford COVID-19 response tracker, and National Oceanic and Atmospheric Administration weather stations. Walking mobility was regressed over containment stringency in a mixed effect model, while controlling for weather factors. A non-linear model estimated how different containment levels impacted on the all-cause mortality hazard (expressed as hazard ratio, HR) due to physical inactivity, having as parametres the regression results, data on pre-pandemic walking mobility, and the association between daily steps count and HR.
RESULTS: A negative log-linear association was found between stringency of containment measures and walking mobility (-1.202·10^-2 [-1.221·10^-2; -1.183·10^-2]; fixed effect [95% CI]). Increasing the stringency of containment measures, thus deceasing walking mobility, incremented the modelled HR, with the greatest effect when starting from lowest stringencies and a maximum predicted HR of 1.42 [1.24; 1.60] (central value [95% CI]).

CONCLUSION: A higher stringency of containment measures was associated with lower walking mobility with a non-linear relation; such results agree with previous evidence from mobile data and self-reported physical activity [1,2]. As containment measures curb active mobility, they can increase the HR due to physical inactivity. The modelled HR reached a maximum with maximal containment measures, and the magnitude of its changes was comparable to that observed in large pre-pandemic cohorts of people who sustainedly reduced their physical activity level [5]. The present findings can help shaping balanced containment policies during pandemics and planning counter-measures against the subsequent physical inactivity. Besides, they serve as a model of how environmental factors jointly impact on active mobility worldwide.

1. Hale, T. et al., Nat Hum Behav (2021)
2. Wilke, J. et al, Int J Environ Res (2021)
3. Jayedi, A. et al, Sports Med (2022)
4. Apple. covid19.apple.com/mobility (2020)
5. Byberg, L. et al. BMJ (2009)

**EPIDEMIOLOGICAL DATA AND PERSISTANCE OF CLINICAL SYMPTOMS OF COVID-19 POSITIVE ELITE ATHLETES**

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INTRODUCTION: The COVID-19 pandemic is posing profound challenges to the athletic community. While there are numerous studies investigating the SARS-CoV-2 infection and its consequences in the general population, there is a lack of data concerning elite athletes. The objective of this study was to evaluate the epidemiological data to identify contact mechanisms of SARS-CoV-2 and the prevalence of persisting symptoms with a focus on sport-restricting complaints 16 weeks after COVID-19 infection in elite athletes.
METHODS: 65 German Olympic Sports Confederation athletes (43 men, 22 women; age 23 ± 4.6), including 16 Olympic athletes, from various sports with laboratory-confirmed COVID-19 (via reverse transcription-polymerase chain reaction (PCR) or serum immune globulin G antibody against SARS-CoV-2) were included. Data were collected longitudinally between June 2020 and October 2021. Standardized questionnaires were used to collect data about contact mechanisms, number, type and duration of symptoms, severity of the disease, training suspension and the current perceived physical performance ability. SARS-CoV-2 antibody status was determined at the Institute of Cardiology and Sports medicine of the German Sports University Cologne.
RESULTS: 39 athletes (60%) were infected in Germany, whereas 22 (33.8%) were infected abroad. In 4 (6.2%) athletes the location of infection could not be determined. 48.8% of the infections occurred in the athletic context, with most (40.6%) being infected during a competition abroad. Combat sport athletes were most frequently affected (53.8%).
96.8% of the athletes experienced a symptomatic course. 93.8% had at least one Covid-specific symptom (e.g. cough), while 71.2% reported of other symptoms, that are not officially declared as COVID-specific. In 44.1 % of the symptomatic cases, symptoms lasted > 4 weeks, while 28.8 % and 20.3 % experienced symptoms lasting longer than 8 and 16 weeks, respectively. After 16 weeks, the majority of athletes (63.8%) reported not being symptom-free during physical exercise. Most frequently a reduction in physical performance ability (19%), fatigue and shortness of breath during physical exertion (15.5% respectively) and musculoskeletal complaints (6.9%) were notified. 78.1% of the athletes reported reduced performance ability at baseline. Of these, 42.2% indicated their performance to be reduced by 30% or more. 16 weeks after baseline, 42.6% had not regained their former performance level, but only 3.8% reported a reduction by 30% or more. In 80% of the cases, a training suspension of at least 4 weeks was recorded. None of the SARS-CoV-2 positive athletes required hospitalization.
CONCLUSION: The main cause of SARS-CoV-2 transmission in elite sports was competitions abroad. Although no hospitalization was required, a broad spectrum of clinical symptoms was evident in the studied cohort 16 weeks after confirmed infection, especially sport restricting complaints and performance limitations.

**PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR CHANGE DURING THE FIRST COVID-19 'LOCKDOWN' IN AN ADULT ENGLISH COHORT WITH A BODY MASS INDEX ≥25 KG/M².**

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INTRODUCTION: The SARS-CoV-2 (Covid-19) pandemic, resulted in enforced 'lockdown' restrictive measures. Negative effects upon health promoting behaviours (physical activity (PA) and sedentary behaviour (SB)) are likely. A body mass index (BMI) ≥25 kg/m² has been associated with severe COVID-19 symptoms, research analysing the lockdown's impact within this population is limited. This study aims to investigate this contemporary area of research.
METHODS: Based on an online survey (n=818) incorporating the International Physical Acitvity Questionnaire Short From (IPAQ-SF), data from 376 participants with BMI≥25 kg/m² were analysed for self-reported daily walking time and weekday and weekend-day sitting time. Descriptive statistics and a contingency table using Pearson's-Chi square/Fishers exact test was carried out.
RESULTS: Daily walking time, X2= 281.6 and p<0.01, 42% increased, 21% decreased. Weekday sitting time, X2= 216.9 and p<0.01, 43% increased, 16% decreased. Weekend-day sitting time, X2=322.1 and p<0.01, 41% increased, 7% decreased. Large increases in sitting >10 hours/day (weekday, 105%; weekend-day, 194%).
CONCLUSION: The first COVID-19 lockdown increased both PA (daily walking time) and SB (weekday and weekend-day sitting time) amongst UK adults with a BMI ≥25 kg/m2 concurring with other studies from different countries.
Further analysis of the BMI categories showed that the obese category showed a 37% increase in daily walking time and the morbidly obese category showed a 33% increase in daily walking time, however 38% of the morbidly obese decreased their walking time.
Regarding self-reported weekday sitting time, 43% of the overall cohort increased and 16% deceased. Specific to weekday sitting time, 105% increased sitting time >10 hours/day and at weekend-days there was a 194% increase.
Distinguishing sitting time between weekdays and weekend-days is not well documented within current literature, however, the overall conclusion within this present study is that the COVID-19 lockdown has negatively influenced daily sitting time. It is widely accepted that sitting is a SB associated with all-cause mortality (impartial to PA), due to its dangerous impact upon metabolic and cardiovascular health. The increase in sitting time >10 hours/day for both weekday and weekend-days within the present study, shows the sobering negative effect the first COVID-19 lockdown has had upon SB amongst UK adults with a BMI ≥25 kg/m2.
With this increase in both PA and SB this change in behaviour concurs with the term 'active couch potato'.

### VERY LOW-VOLUME HIGH-INTENSITY INTERVAL TRAINING MAINTAINS CARDIOMETABOLIC HEALTH AND QUALITY OF LIFE AMONG HOME-OFFICE WORKERS DURING COVID-19 PANDEMIC: A 1-YEAR FOLLOW-UP STUDY

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INTRODUCTION: Initially, this study aimed to investigate the long-term effects of cycle-ergometer-based very low-volume high-intensity interval training (LOW-HIIT) performed over 1 year in a supervised worksite setting on cardiometabolic health and self-reported outcomes in a cohort of sedentary office workers. As the COVID-19 pandemic unexpectedly emerged during the study, training was discontinued and participants were given recommendations on how to continue exercising at home. One year after study onset, participants were invited for a follow-up examination to evaluate their physical actvity (PA) behaviour and outcome changes during lockdown.
METHODS: 114 sedentary office workers (50.2±10.1 yrs, 46% females) from a large company participated. All participants received a comprehensive baseline health examination (T-1) at our Research Center to ensure safe participation in exercise and to collect study outcomes. Examination included blood sampling, assessment of body composition, cardiopulmonary exercise testing including resting and exercise electrocardiography, blood pressure measurements and determination of maximal oxygen uptake (VO2max) and collection of self-reported data including quality of life (QoL, EQ-5D-5L VAS score) using validated questionnaires. LOW-HIIT (5x1 min intervals at 80-95% maximum heart rate, 14 min total session time including warm-up, cool-down) was performed twice weekly within the workplace at the companys sports center in supervised group classes. Outcome reassessment was conducted after 6 months (T-2, termination of supervised LOW-HIIT) and after 12 months (T-3, follow-up). T-1 and T-2 data were compared in a pre-/post intervention manner. T-3 data analyses were performed as subgroup analysis after dividing participants into 3 groups based on their PA behavior during lockdown: A) Continued with LOW-HIIT (HIIT), B) continued regular exercising but not with LOW-HIIT (EX) or C) discontinued exercise in general (NON-EX).
RESULTS: At T-2, data from n=72 were available. We observed significant improvements in VO2max (+1.4 mL/kg/min, p=0.002), mean arterial blood pressure (MAB, -4 mmHg, p<0.001), glycated hemoglobin A1c (-0.2%, p=0.005), high-sensitivity C-reactive protein (-1.5 mg/L, p=0.040) and QoL score (+5 points, p<0.001). N=57 (HIIT: n=19; EX: n=12; NON-EX: n=26) finished the T-3 examination . The HIIT-group maintained VO2max and QoL score and further improved MAB (-3 mmHg, p=0.032). The EX-group (mainly performing walking, moderate running and gymnastic exercises) maintained MAB and QoL but experienced a decrease in VO2max (-3.7 mL/kg/min, p=0.002). In the NON-EX group, VO2max (-5.8 mL/kg/min, p<0.001), MAB (+3 mmHg, p=0.035) and QoL score (+5 points, p=0.015) values deteriorated.
CONCLUSION: Six months of worksite LOW-HIIT improve VO2max, QoL and cardiometabolic health indices in sedentary office workers. Only participants who continued LOW-HIIT during COVID-19 lockdown for 6 months at home maintained VO2max and QoL and further improved blood pressure.

### MECHANISTIC BASES OF EXERCISE INTOLERANCE IN PATIENTS WITH POST-ACUTE SEQUELAE OF COVID-19: A TRANSLATIONAL APPROACH BY IN-VIVO AND EX-VIVO MEASUREMENTS

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INTRODUCTION: Covid-19 has become a global health issue since December 2019. Although the clinical manifestations of COVID-19 may be life threating due to severe respiratory and cardiac failure in acute phase (1), previous studies showed persisting and often debilitating symptoms at long-term even in patients who develop the mild form of the disease (2,3). Patients report exercise intolerance, muscle weakness and fatigue that seem to be related to impairments in O2 supply and utilization by skeletal muscle (4). Aim of the study was to investigate the mechanistic bases of exercise intolerance in patients with post-acute sequelae of Covid-19 (PASC).
METHODS: At least 3 months after infection, non-hospitalized PASC patients (n=10, ys:52±9; PASC) and patients without long-term symptoms (n=8, ys:47±9; CTRL) visited the laboratory on three non-consecutive days. Spirometry, lung diffusion capacity and quality of life (5) were assessed at rest. Peak O2 consumption (VO2peak) was evaluated during cardiopulmonary incremental exercise test (CPX). Oxygen consumption (VO2) kinetics were determined by moderate-intensity exercises. Muscle oxidative capacity recovery rate constant (k) was assessed by repeated arterial occlusion by near-infrared spectroscopy. Mitochondrial respiration was evaluated by high-resolution respirometry in permeabilized muscle fibers from vastus lateralis using saturating substrates for complexes I+II combined (CI+II).
RESULTS: Pulmonary functions were within normal range in all patients. Quality of life was significantly lower in PASC vs CTRL (66±15 vs 91±2, respectively, P<.01). VO2peak was lower in PASC than CTRL (24.9±0.3 vs 33.7±0.5 ml*min-1*kg-1, respectively, P<.005). VO2 kinetics were slower in PASC than CTRL (43±2 vs 31±1 min-1, P<.05). k was lower in PASC than CTRL (1.64±0.57 vs 2.35±0.36 min-1, P<.05). O2 flux for CI+II in activated state of oxidative phosphorylation and maximal uncoupled state condition were lower in PASC (36.7±16.3 and 51.2±20.1 pmol*s-1*mg-1) than CTRL (56.9±11.7 and 79.6±15.6 pmol*s-1*mg-1, all P<.05).
CONCLUSION: Exercise intolerance of PASC patients is primarily due to impaired mitochondrial function as suggested by both functional in-vivo indexes of muscle oxidative metabolism and ex-vivo measurements on permeabilized muscle fibers.
1. Huang C et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 395:497–506,2020.
2. Singh I et al. Persistent Exertional Intolerance After COVID-19: Insights From Invasive Cardiopulmonary Exercise Testing. Chest 161:54–63,2022.
3. Soares MN et al. Skeletal muscle alterations in patients with acute Covid-19 and post-acute sequelae of Covid-19. J Cachexia Sarcopenia Muscle 13:11–22,2022.
4. Serviente C et al. From heart to muscle: Pathophysiological mechanisms underlying long-term physical sequelae from SARS-CoV-2 infection. J Appl Physiol 132:581–592,2022.
5. Devlin NJ et al. Valuing health-related quality of life: An EQ-5D-5L value set for England. Heal Econ 27:7–22,

# Oral presentations

## OP-BM20 Motor control: Ageing

### THE ASSOCIATION OF MUSCULAR STRENGTH AND GRAY MATTER VOLUME IN COGNITIVELY – HEALTHY OLDER ADULTS: THE AGUEDA TRIAL

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INTRODUCTION: The association between higher cardiorespiratory fitness and gray matter volume in the hippocampus and prefrontal cortex led to the prediction that participation in greater amounts of physical activity might be associated with greater gray matter volume as well. Nevertheless, the role of muscle strength in brain structure is still unknown. Thus, this study investigated the associations of muscular strength and gray matter volume in older adults.
METHODS: A total of 86 cognitively normal older adults aged 65-80 years from the AGUEDA trial participated in the present cross-sectional study. Muscular strength was measured with a Handgrip Dynamometer (TKK 5101 Grip D, Takey, Tokyo Japan). The test was performed twice for each hand and the score was recorded in kilograms. The maximum scores of the left and right hands were averaged to calculate an absolute indicator of muscular strength (kg). T1-weighted images were acquired with a 3.0 T Siemens Magnetom Prisma Fit scanner and were pre-processed using Statistical Parametric Mapping software (SPM12, London, UK). Gray matter volume was determined by voxel based morphometric analysis. General linear models assessed the association between muscular strength and gray matter volume, controlling for age, sex and years of education. The statistical threshold for the cluster extent was calculated with AlphaSim, and further Hayasaka adjusted to account for the non-isotropic smoothness of structural images.
RESULTS: The main results showed that higher muscular strength was related to greater gray matter volume ($p<0.001$) in 3 clusters, including two clusters in the culmen (left: k=1286, t=5.42; right: k=261, t=4.02), and one in the left middle frontal gyrus (k=291, t=3.72). Muscular strength was not negatively related to gray matter volume in any brain region.
CONCLUSION: Muscular strength is associated with greater gray matter volume in the frontal lobe and the cerebellum in cognitively normal older adults. Future exercise-based randomized control trial should examine whether increases in muscle strength by an exercise program may positively influence the development of distinctive gray matter regions, and thus counteract the harmful effect of aging in this population.

### COMPARING THE EFFECTS OF TWO PERTURBATION-BASED BALANCE TRAINING PARADIGMS IN FALL-PRONE OLDER ADULTS: A RANDOMIZED CONTROLLED TRIAL

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INTRODUCTION: The declining ability to successfully react to slipping and tripping is a key component of the multifactorial etiology of falls. There is increasing evidence that perturbation-based balance training (PBT) is highly effective for improving the ability to recover balance after an unexpected event such as a slip or a trip. However, it is unclear, which PBT paradigm is most effective. Two different paradigms of PBT seem to be promising: 1. Training of dynamic stability mechanisms in the presence of perturbations induced by unstable surfaces (PBT-unstable); 2. Technology-supported training on a perturbation treadmill (PBT-treadmill). The aim of this study was to compare the effects of both programs.
METHODS: Seventy-one adults aged 65 years and older with a verified fall risk were randomly assigned into three groups: PBT-unstable using unstable conditions such as balance pads, PBT-treadmill on a motorized treadmill and a passive control group. In both intervention groups, participants conducted a 6-weeks intervention with 3 sessions/week. Effects were assessed in balance ability (Brief-Balance-Evaluation-Systems-Test, Stepping-Threshold-Test, Center-of-Pressure, Limits-of-Stability), leg strength capacity, functional performance (Timed-up-and-Go, Chair-rise), gait (speed) and fear of falling (Short-Falls-Efficacy-Scale-International). Analysis of covariance (ANCOVA) was used to compare the effect of the intervention on outcome parameters at follow-up. Statistical analysis was conducted according to the intention-to-treat principle.
RESULTS: Fifty-one participants completed the study (74.8±5.9 years, 65% female). Training adherence was high in both intervention groups (91% for PBT-treadmill and 87% for PBT-unstable). The ANCOVA revealed an effect of group in the Brief-Balance-Evaluation-Systems-Test ($p=.009$) and in the Limits-of-Stability ($p=.020$) in favor of PBT-unstable and a group effect in the Stepping-Threshold-Test ($p<.001$) in favor of PBT-treadmill. The other outcomes demonstrated no effects.
CONCLUSION: Both training paradigms induced distinct task-specific effects. PBT-treadmill showed higher improvements in reactive balance, which might be promoted by the unpredictable nature of the included perturbations. PBT-unstable showed more wide-ranging effects in balance ability, although with a smaller magnitude. Leg strength was only affected significantly in PBT-treadmill. Advantages of both formats should be evaluated in the light of individual needs and preferences before recommending either format. Larger studies are needed to investigate the effects on falls.

### BOTH GAIT SPEED AND IN-GAME PERFORMANCE (IGP) IMPROVE AFTER A MIXED-REALITY TRAINING IN PEOPLE WITH INTELLECTUAL DISABILITY. A PRELIMINARY STUDY.

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INTRODUCTION: People with intellectual disability (ID) often show motor impairments (1) due to their poor cognitive skills or their physical activity level which is frequently low (2). Long term consequences of altered motor skills might be severe. Falls occur more frequently in people with ID than in healthy pairs (3). Better motor skills might also help in everyday tasks and social interactions. In addition, gait speed is a relevant indicator of motor functioning (2). In recent years, new therapeutics such as Virtual, Augmented and Mixed Reality technolo-

gies developed (4). This study aims at investigating if adults with ID might increase their in-game performance and gait speed after a Mixed Reality (MR) training.
METHODS: Participants were 18 adults with ID from a home for disabled adults. They participated in a weekly intervention using the application PopBalloons (Actimage, France) on a Microsoft Hololens2 MR device for 15 to 25 minutes, for 9 weeks. Its purpose is to detect, walk to and pierce virtual balloons with the finger. Both cognitive and motor functions are thus stimulated. In-game performance (IGP) was assessed by the average time to complete a level (piercing 5 balloons) at first and last weeks. Gait speed was measured with a Zeno walkway gait analysis system before and after training.
RESULTS: Both IGP (in s; PRE: 255.4±181.9, POST: 163.7±136.0; P=0.002) and gait speed (in cm/s; PRE: 78.1±22.0, POST: 89.1±29.9; P=0.02) significantly improved.
CONCLUSION: Gait speed naturally tends to decrease with age (5). Thus, increased gait speed is evidence of improved motor functioning. This can explain the better IGP at the end of training. The low training load (15-25 minutes/week) may have been enough to induce motor improvement due to the novelty of the motor demand during the activity and the low initial physical activity level of the participants (2). The MR task also demanded cognitive involvement (attention, detection, space orientation, strategy elaboration etc.). Thus, cognitive-motor abilities might also have been improved thanks to the cognitive-motor MR training (5). This study shows that adults with intellectual disability can improve their motor functioning after a cognitive-motor Mixed-Reality training, despite a low training load. Further research should focus on the impact of such MR training on this populations motor skills and cognitive functions, in comparison with usual activity only, so they could be used as therapeutics. One might also wonder if performance increase in the activity is necessary to get motor improvement, or if practicing only is enough. The present study takes part in a larger project which tries to answer these questions.
REFERENCES:
1) Oppewal et al., Am J Intellect Dev Disabil, 2018
2) Hilgenkamp et al., Res Dev Disabil, 2012
3) Smulders et al. J Intellect Disabil Res, 2012
4) Bioulac et al., Encephale, 2018
5) Verlinden et al., Gait Posture, 2013
6) DeAndrade et al., J Am Geriatr Soc, 2013

### OVERWEIGHT/OBESITY IN CHILDHOOD AND ADOLESCENCE INVOLVES A REDUCTION IN POSTURAL COMPLEXITY

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Using techniques borrowed from dynamical systems theory (i.e., sample entropy, largest Lyapunov exponent, and detrended fluctuation analysis), we have recently reported postural control deficits in young overweight/obese children and adolescents (YO) during quiet bilateral standing (1). Indeed, the YO revealed a stiffening strategy for maintaining balance, which was interpreted as a less complex and, thus, less flexible control of posture. To further challenge this conclusion, the present work aimed to re-investigate our original records (employing a purely complexity-based procedure, that is, refined composite multiscale entropy (rCMSE) analysis (2).
METHODS: Nineteen YO and 19 carefully matched young normal-weight (YN) secondary school students were asked to stand as still as possible for 60 s, first on firm, and after a break of 2 min, on foam ground. Trunk acceleration signals in medio-lateral (ML) and anterior-posterior (AP) directions were captured with an inertial measurement unit and pre-processed to correct for tilt and noise. Resultant time series were then scrutinized with the rCMSE method, while the sum of the associated entropy values from scale 1 to 7 was considered as a complexity index (CI). ANOVAs and ICCs(1,1) were calculated to compare means and to address data reliability (test-retest design).
RESULTS: 2 (group) x 2 (task) x 2 (visit) ANOVAs revealed no significant main or interaction effect except themain effects of task and group ($p < 0.05$). Here, the post-hoc analysis revealed the following: first, standing on firm ground caused higher CI-ML and CI-AP values than standing on foam in each group (all $p < 0.05$), and, second, compared to their YN controls, the YO displayed lower CI values in the ML direction ($p < 0.05$) and tendentially also in the AP direction ($p < 0.10$) in both tasks. The reliability of the measures studied was fair to excellent [$0.44 \leq ICC(1,1) \leq 0.80$], except for the CI-AP variable [$ICC(1,1) = 0.38$] as regards the YN within the firm condition.
Discussion
The currently conducted rCMSE analysis successfully underlined our original notion that the YO would undergo a decline of postural complexity reflected as rigidity. Such less complex patterns are usually linked with diverse pathologies, are detrimental to compensate for internal or external perturbations, and are attributed to lower adaptability and task performance (see 3 for review). Without targeted balance stimuli, the YO likely end in a lifelong vicious circle of mutually dependent poor balance.
CONCLUSION: 1. Wiesinger et al. (2022). Front Hum Neurosci, Ahead of print.
2. Wu et al. (2014). Phys Lett A, 378, 1369-1374.
3. Goldberger et al. (2002). Neurobiol Aging, 23, 23-26.
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### LONG TERM ATHLETIC TRAINING AND MATURATION EFFECTS ON MUSCLE-TENDON PROPERTIES IN PREADOLESCENCE

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INTRODUCTION: Systematic research concerning the effects of long-term athletic training on muscle-hypertrophy and tendon stiffness in preadolescence is scarce. The purposes of this study were (a) to investigate training effects on triceps surae muscle strength, gastrocnemius medialis (GM) morphometrics and Achilles tendon stiffness in preadolescence and (b) to examine the development of these properties over 1-year with regard to potential imbalances between muscle and tendon adaptation in preadolescent athletes.
METHODS: We recruited 21 preadolescent artistic gymnastic athletes (9.2 ±1.7 yr, 14 Tanner stage I and 7 Tanner stage II) and 11 untrained participants (9.0 ±1.7 yr, 5 Tanner stage I and 6 Tanner stage II) as a control group. Muscle strength of the plantar flexors, GM morphometrics and Achilles tendon stiffness were measured over 1-year with 3-month intervals using dynamometry, ultrasonography and electromyography. Furthermore, we documented the training volume in athletes 3 months before the first measurement and for the entire period of

the investigation. A linear mixed-effects model for repeated measures was used to compare the outcomes between the two groups and to investigate their development over time.
RESULTS: The athletes trained on average for 20 h/wk. They demonstrated greater muscle strength ($p<0.001$) but no differences in GM pennation angle, thickness and fascicle length ($p>0.05$) compared to non-athletes. Muscle strength and GM thickness increased similarly in both groups during the 1 yr period ($p<0.001$). Achilles tendon stiffness neither differed between athletes and non-athletes ($p>0.05$) nor changed over time in both groups ($p>0.05$). Athletes showed greater fluctuations in muscle strength ($p=0.033$), pennation angle ($p=0.005$) and maximum tendon strain ($p=0.017$) than non-athletes over time. Further, the frequency of individuals that reached high-level tendon strain values (≥9%) during the 1-yr was higher in athletes (up to 67%).
CONCLUSION: We found higher muscle strength in athletes but no significant differences in Achilles tendon stiffness between the two groups, which indicates imbalances between muscle strength and tendon stiffness in preadolescent athletes. Similar to tendon stiffness, we did not find significant differences between groups in GM morphometrics despite a high sport-specific muscle-tendon loading. We propose that the hormonal status could be the limiting factor for both training-induced alterations in GM morphometrics and Achilles tendon stiffness in preadolescence (1,2). Our findings provide first-time evidence that athletic training in preadolescence is associated with higher fluctuations of Achilles tendon strain and a temporarily increased tendon mechanical demand. Therefore, we recommend the implementation of individual training concepts to preserve a balanced adaptation in preadolescent athletes.
References
1) Veldhuis et al. 2000; J Clin Endocr Metab
2) Doessing et al. 2010; J Physiol

# Oral presentations

## OP-MH02 Cancer

### AGREEMENT BETWEEN TWO OBJECTIVE MEASURES FOR CATEGORIZING INDIVIDUALS AS SUFFICIENTLY ACTIVE BASED ON CONTINUOUS PHYSICAL ACTIVITY MONITORING

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INTRODUCTION: Physical activity (PA) is a multidimensional concept, and PA level (PAL) can be presented in numerous ways. Wearable PA monitors are rapidly improving as technological developments increase their accuracy and ability to capture several PA dimensions. PA profiles, where activity level is conditioned on more than one dimension, may be the future of PA monitoring. Many sophisticated monitors allow for continuous wear and measurement. Continuous PA monitoring is increasingly used for research purposes, but also by the general population through various activity watches. Reaching 150min MVPA/week is a widely used threshold for categorizing individuals as sufficiently active, both in research and in public health promotion. However, this threshold may be inappropriate to use with continuous monitoring as the development of this recommendation was largely based on self-reported PA. PAL-values are also used for categorizing individuals as sufficiently active and represent total energy expenditure (TEE) relative to basal metabolic rate (BMR). A PAL of 1.75 are commonly used as the lower cut-off for being moderately active. The objective of the present study was to compare 150min MVPA/week and PAL 1.75 as thresholds for categorizing individuals as sufficiently active based on continuous PA monitoring.
METHODS: The SenseWear Armband (SWA) was worn ≥22hours/day for six consecutive days in 692 cancer survivors. Mean MVPA/day was used to estimate MVPA/week. The SWA calculates metabolic equivalents (METs) based on a tri-axial accelerometer and temperature sensors, and MVPA was defined as METs ≥3. PAL-values were calculated as TEE measured by the SWA divided on BMR calculated with the formula by Mifflin-St Jeor. Linear regression determined the association between PAL-values and time in MVPA and was used to predict the amount of MVPA corresponding with PAL 1.75. The ROC curve was used to assess the sensitivity and specificity corresponding with this predicted value.
RESULTS: Mean MVPA/week was 556.9±396.9min and mean PAL was 1.63±0.20. MVPA was significantly association with PAL ($R2=0.646$, $B=0.003$, $p<0.001$). With MVPA ≥150min/week, 91% were categorized as sufficiently active, while 25% of the sample had PAL ≥1.75. The likelihood of being categorized as sufficiently active based on PAL-value for a person having ≥150min MVPA/week was 28%. The predicted amount of MVPA corresponding with PAL 1.75 was 735 min/week, achieved by 27.6% of the sample, with a sensitivity of 76.9% and specificity of 85.0%.
CONCLUSION: Time in MVPA was significantly associated with PAL when assessed on a continuous scale, however, their thresholds for categorizing individuals as sufficiently active were not compatible. Time in MVPA corresponding with PAL 1.75 was approximately five times the current recommendations. When PA is monitored continuously, 150min MVPA/week appear inappropriate for categorizing someone as sufficiently active.

### ASSOCIATIONS OF SKELETAL MUSCLE MASS WITH OBJECTIVE AND SUBJECTIVE MEASURES OF PHYSICAL FUNCTION IN MEN TREATED WITH ANDROGEN DEPRIVATION THERAPY FOR PROSTATE CANCER

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INTRODUCTION: Androgen deprivation therapy (ADT) in men with prostate cancer (PC) is associated with a loss of skeletal muscle mass resulting in reduced muscle strength and physical function [1]. The disturbance of normal skeletal muscle function caused by ADT put individuals at a higher risk of falls and physical impairment [2]. However, studies have shown that the majority of men treated with ADT are unaware of these side effects and their potential long-term consequences [3]. In order to examine whether muscle mass determines the actual or perceived level of physical function during ADT, we assessed its associations with objective and subjective measures of physical function in men with advanced PC. Furthermore, we investigated the relationship between objective and subjective measures of physical function.
METHODS: Sixteen men (age: 65 ± 8 years; body mass index (BMI): 26 ± 3 kg·m-2) treated with continuous ADT for metastatic PC participated in this cross-sectional pilot study. Body composition measurements included bioimpedance analysis to assess lean body mass (LBM)

and panoramic ultrasound to assess muscle cross-sectional area (CSA) of the rectus femoris. Objective measures of physical function included muscle strength, which was assessed using a leg extension one-repetition maximum (1RM) test, as well as aerobic capacity (VO2max) and 400 m walking time. The activities-specific balance confidence scale (ABC-scale) was used to determine subjective physical function.
RESULTS: Neither whole-body LBM nor muscle CSA of the rectus femoris were associated with any objective or subjective measures of physical function ($p > .05$). Subjective ratings (ABC-scale: 88% ± 18) indicated a high level of physical function among the participants but were not associated with any of the objective measures of physical function ($p > .05$).
CONCLUSION: Despite the importance of skeletal muscle mass for overall health and physical performance, we did not find an association with any measures of physical function in our study. Interestingly, subjective physical function was also independent of objective measures such as maximal strength or cardiorespiratory fitness, indicating a potential mismatch between perceived and actual physical capabilities. Defining the determinants of physical performance in men with advanced PC treated with ADT may help to improve the design of future exercise intervention studies.
REFERENCES:
1. Gonzalez, BD, et al., Support Care Cancer 2016, 24 (5), 2201-2207. DOI 10.1007/s00520-015-3016-y.
2. Bylow, K, et al., Urology 2008, 72 (2), 422-7. DOI 10.1016/j.urology.2008.03.032.
3. Walker, LM, et al., Urol Oncol 2013, 31 (7), 1098-105. DOI 10.1016/j.urolonc.2011.12.015.

## CHARACTERIZATION OF THE COMBINED EFFECTS OF ACUTE EXERCISE AND IMMUNO CHEMOTHERAPY TREATMENTS ON SKELETAL MUSCLE IN MC38 COLORECTAL CANCER MICE

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INTRODUCTION: Colorectal cancer (CRC) usually leads to skeletal muscle cachexia, characterized by loss of skeletal muscle mass and function (Baracos et al., 2018). Treatment with immunochemotherapy (ICT) improves patient survival but induces muscle toxicity leading to increase in inter-cures time and/or to dose reduction (Feather et al., 2018). Aerobic exercise may increase tumor perfusion (Zhang et al., 2019). In addition, the combination of physical activity and ICT may be the most effective method to fight the adverse effects of cancer and treatment and could limit cachexia. However, so far, no studies have tested the effects of acute exercise-ICT interaction on CRC. Thus, the objective of this study is to investigate the effects of acute aerobic exercise on skeletal muscle pre-injection of ICT in a mouse model of colorectal cancer.
METHODS: Four weeks mice model of colorectal cancer (MC38) were divided in four groups (n=4/group): control (CTRL), immune-chemotherapy (TRT), exercise (EXE) and combined intervention (TRT-EXE). Mice in EXE and TRT+EXE groups performed daily aerobic exercise for one week on a treadmill at 60% of their maximal aerobic running speed. Mice in TRT and TRT+EXE groups received ICT treatment (anti-PDL-1 + capecitabine + oxaliplatine) five times for one week, just before the daily exercise for the TRT+EXE group. After one week, tibialis anterior (TA) and gastrocnemius (GAS) muscles were collected and weighed. Histological staining were performed to assess muscle characteristics. Results were given as mean ± SD with a p-value significance level below 5% ($p<0.05$). Muscle weight is given in mg and is related to the initial weight of the mouse.
RESULTS: All results will be available at the end of April 2022. Preliminary results on muscle mass show that TA mass for TRT group (1.74±0.04 mg) was significantly lower than the EXE group (2.01±0.06 mg, $p=0.003$) and the TRT+EXE group (1.96±0.04 mg, $p=0.01$). The GAS mass in the EXE group (5.32 ± 0.6 mg) was significantly higher than the TRT group (4.55±0.1 mg, $p=0.04$).
CONCLUSION: The pleiotropic effects of PA on muscle could explain the greater muscle mass in the exercise' groups of MC38 mice. Indeed, acute PA stimulates the Akt/mTOR pathway, responsible for protein synthesis, and thus may limit the muscle atrophy observed in cachexia (Aquila et al., 2020). This pre-clinical study may provide insights on the musculoskeletal parameters in response on the combined effect of pre-treatment exercise and immuno-chemotherapy in colorectal cancer.

## EFFECTS OF EXERCISE-CONDITIONED HUMAN SERUM ON THE IN VITRO GROWTH CHARACTERISTICS AND METABOLIC ACTIVITY OF HUMAN LUNG CARCINOMA CELLS

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INTRODUCTION: Cancer is a leading cause of death worldwide with an increasing incidence that could reach 28.4 million new cases by 2040. In spite of advances in diagnosis and treatment, prevention is still the most efficient measure against the progression of incidence and mortality (1). A large proportion of new cancer cases and cancer deaths are preventable by eliminating or reducing exposure to environmental risk factors and/or modifying lifestyles, namely by increasing physical activity (2). Higher levels of physical activity have been linked to a lower risk of many types of cancer. In the case of lung cancer, the leading cause of cancer death (1,796,144 of the 10 million cancer deaths in 2020), evidence is moderate (3). There is now some evidence that exercise-conditioned human serum reduces the viability of cultured cancer cells (4). The present study aimed at extending those findings, namely by evaluating whether serum conditioned by a bout of physical exercise affected the in vitro growth characteristics and metabolic activity of human lung carcinoma cells in ways that might explain the observed reduction of the relative risk of lung cancer.
METHODS: Blood was collected from master athletes prior to and 5 mins after a single bout of incremental exercise until exhaustion on a cycle ergometer. Cultures of human lung carcinoma A549 cells were exposed to pre-exercise human serum and exercise-conditioned serum and the effects of these exposures were evaluated in terms of proliferation (SRB assay), metabolic activity (MTT assay), and ability of single cells to grow into colonies (clonogenic assay). A paired t-test was used to compare the effects of pre-exercise and post-exercise human serum.
RESULTS: Compared with at rest serum, exercise-conditioned serum reduced significantly the cells' ability to form colonies, as evidenced by the significant reduction in mean colony area (48.5% reduction; $P < 0.01$) and total colony occupied area (46.71% reduction; $P < 0.05$). Regarding metabolic activity, the slight increase observed for a 24-h incubation was reversed when exposure was extended to 72-h.
CONCLUSION: These data suggest that acute exercise promoted systemic changes that significantly reduced the ability of A549 cancer cells to form colonies, i.e., that compromised their ability to undergo unlimited division, a hallmark of cancer.
REFERENCES:
1. Sung, H.; et al.; Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. 2021.

2. Wilson, L.F.; et al. How many cancer cases and deaths are potentially preventable? Estimates for Australia in 2013. International Journal of Cancer 2018.
3. McTiernan, A.; et al.; Physical Activity in Cancer Prevention and Survival: A Systematic Review. Medicine and Science in Sports and Exercise 2019, 51, 1252-1261.
4. Soares, C.M.; et al.; Effect of exercise-conditioned human serum on the viability of cancer cell cultures: A systematic review and meta-analysis. Exercise Immunology Review 2021.

**LATE CARDIO-METABOLIC TOXICITY IN TGCT SURVIVORS IS MODULATED BY HABITUAL PHYSICAL ACTIVITY**

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INTRODUCTION: Late chemotherapy-related toxicity could largely affect health and quality of life in cancer survivors [1]. Here we examined cardiometabolic toxicity in testicular germ-cell tumor (TGCT) survivors in relation with cumulative chemotherapy dose, post-treatment time and habitual physical activity. The aim was to evaluate if increased physical activity provides benefits for cardiometabolic health in this population.
METHODS: 195 TGCT survivors were stratified according to their habitual physical activity and examined for the prevalence of cardiometabolic health parameters, i.e. metabolic syndrome components, systemic immune inflammation, atherogenic risk and hepatic function markers. 98 of patients were further stratified into the three age- and BMI-matched groups differing in number of chemotherapy cycles (≤3 vs. >3) and post-treatment time (5-15 vs. 15-30 yrs.) and compared to healthy men (n=38). Subgroup of TGCT survivors who did not receive chemotherapy (n=17) were compared to matched population of patients treated with no more than 3 CHT cycles. The level of habitual physical activity (hPA) was assessed by validated questionnaire >5 years after treatment.
RESULTS: TGCT survivors with high hPA had lower waist circumference and systemic immune inflammation index and their habitual physical activity correlated positively with HDL cholesterol and testosterone and negatively with waist circumference. Irrespective of the chemotherapy dose (≤3 vs. >3 cycles) and post-treatment time (5-15 vs. 15-30 yrs.) TGCT survivors had higher prevalence of metabolic syndrome as compared to controls. However, the highest prevalence of metabolic syndrome was found in patients diagnosed and treated at younger age (23.2±5.6 yrs.) who were examined 15-30 years post-treatment. Interestingly, neither the number of chemotherapy cycles (≤3 and >3) nor its absence seemed to affect metabolic syndrome prevalence in TGCT survivors diagnosed and cured in their thirties and examined 5-15 years post-treatment. This implies the presence of disease-related chemotherapy-independent effects on the cardiometabolic health. Moreover, higher habitual PA correlates with lower waist circumference, and reduced atherogenic risk in the entire population of TGCT survivors and this relationship is specifically strong in TGCT survivors with ≤3 chemotherapy cycles.
CONCLUSION: Conclusions: Metabolic syndrome and cardiovascular risk were more pronounced in TGCT survivors, than in healthy controls. The risk progressed with time and was independent from chemotherapy dose. Cardio metabolic benefits of higher habitual physical activity were found in controls, in the entire population of TGCT survivors, and it was specifically strong in patients who received less than 3 cycles of chemotherapy and examined 5-15 years post-treatment.
References:
1. Amiri A, et al. Chemotherapy-induced toxicity in patients with testicular germ cell tumors: The impact of physical fitness and regular exercise. Andrology. 2021 Nov;9(6):1879-92.

## Oral presentations

### OP-MH11 The metabolic syndrome

**EFFECT OF DIFFERENT LEVELS OF ACUTE HYPOXIA ON ORAL GLUCOSE TOLERANCE, INFLAMMATION, OXIDATIVE STRESS AND APPETITE IN OVERWEIGHT AND OBESE MEN.**

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INTRODUCTION: Obesity is associated with increased inflammatory cytokines and insulin resistance. Hypoxia increases skeletal muscle glucose transport and disposal (Mackenzie & Watt, 2016), reduces appetite and increases metabolic rate (Palmer & Clegg, 2014). However, lower fractions of inspired oxygen (O2) have been shown to increase inflammation and oxidative stress compared to moderate hypoxia (Siervo et al., 2014). The aim of this study was to examine the effect of different levels of hypoxia on glucose tolerance, inflammation, oxidative stress and appetite in overweight and obese men.
METHODS: In a single blind, randomised, balanced, crossover design, 6 overweight/obese men (BMI; 27.8 ± 1.2 kg/m2) completed the study (a priori power calculation = 12). Participants attended 3 separate visits, during which they inspired different fractions of O2 (20.9%; [normoxia] 15.5%; 12.0%) for 1 h prior to a 3 h oral glucose tolerance test (OGTT; 75g). Plasma [glucose], [insulin], [ghrelin], [4-hydroxynonenal], [interleukin-6], systolic blood pressure (SBP), diastolic BP (DBP) and hunger were measured at baseline, after the intervention and at 30 min intervals during the OGTT. Arterial O2 saturation (SPO2) and expired gas analysis were averaged over each hour. Repeated measured ANOVAs (oxygen fraction x time) and post-hoc tests were performed.
RESULTS: SpO2 decreased as the degree of hypoxia increased ($p<0.0001$). Area under the curve (AUC) [glucose] (20.9%: 34.2 ± 6.5; 15.5%: 37.3 ± 6.6; 12.0%: 38.5 ± 7.5 mmol.L-1, $p=0.30$) and peak [glucose] (20.9%: 6.9 ± 1.6; 15.5%: 7.0 ± 1.3; 12.0%: 7.5 ± 1.3 mmol.L-1, $p=0.28$) were not different between conditions. Total energy expenditure was not different between conditions ($p=0.08$). There was a significant reduction in carbohydrate (CHO) oxidation at the highest level of hypoxia (20.9%: 345 ± 55; 15.5%: 283 ± 93; 12.0%: 263 ± 14 kcal.4h-1, $p=0.02$) but no change in fat oxidation ($p=0.12$) between conditions. There was no effect of hypoxia on hunger ($p=0.14$), SBP ($p=0.32$) or DBP ($p=0.40$).
CONCLUSION: Interim analysis suggests that high levels of hypoxia (12.0%) may reduce CHO oxidation in overweight/obese men, whereas peak plasma [glucose] and AUC do not change during an OGTT. Together this suggests that glucose storage may be increased with acute hypoxia.

### AEROBIC CAPACITY AND BODY COMPOSITION CHANGES INDUCED BY A COMBINED TRAINING IN ADULTS WITH TYPE 1 AND TYPE 2 DIABETES COMPARED TO HEALTHY ADULTS

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INTRODUCTION: Exercise is a key factor in the management of diabetes mellitus (1), but it remains unclear whether diabetes affects the response to exercise training as compared to normoglycemic individuals.
METHODS: Ten adults with type 1 diabetes (T1D; 43 ± 13 years), fifteen adults with type 2 diabetes (T2D; 53 ± 8 years) were matched by age and gender to two groups of healthy volunteers (CTL1: n = 10, 43 ± 13 years; CTL2: n = 15, 55 ± 11 years), All participants took part in a 12-week (3x/week) standardized but self-managed exercise training program performed in an easily accessible gym. Cardiopulmonary exercise testing on a cyclo-ergometer and body composition assessment, with dual-energy x-ray absorptiometry, were performed before and after the intervention. The training program consisted of 30 min of high intensity interval training on a stationary bike (8 bouts of 2 min at 90% of maximal heart rate interspaced with 2 min of active recovery) and ~30 min of strength training (3 sets of 10 repetitions of weight-lifting with 4 main muscle groups). Sessions were recorded using an activity tracker.
RESULTS: Statistical analysis revealed that the 4 training groups improved their cardio-respiratory fitness with a VO2max increase ranging from +9 to +18% ($p<0.05$) and an associated major increase of the first ventilatory threshold from +20 to +33% ($p<0.05$). In adults with T2D only, training decreased the ventilatory response and chemo-sensibility, as reflected by a smoothened VE/VCO2 slopes; (Pre: 29.9 ± 3.7; Post: 27.7 ± 3.0; $p<0.01$) but also improved the body composition; -4% of body fat mass, ($p<0.05$), -10% of visceral adipose tissue ($p<0.05$), +2.3% of lean mass ($p<0.05$). However, intergroup comparisons revealed a lower training induced increase of VO2max in T2D as compared to their age-matched controls (T2D +9%; CTL2 +18%, $p<0.05$). No other intergroup differences were observed.
CONCLUSION: The proposed combined aerobic and resistive training program improved VO2max in adults with diabetes regardless of the etiology. T1D patients responded similarly to healthy subjects, while adults with T2D exhibited limited VO2max improvements as compared to age-matched healthy controls. However, subjects with T2D benefit anyway from training, as it improves the ventilatory response to exercise, the lean mass and it decreases the total and visceral fat.
References:
1) Codella et al, Acta Diabetologica, 54(7), 615 630, 2017

### THE EFFECTS OF AEROBIC AND RESISTANCE HEALTH-ENHANCING EXERCISE PROGRAMS ON GUT MICROBIOTA AND METABOLIC PARAMETERS IN WOMEN WITH METABOLIC SYNDROME

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INTRODUCTION: Metabolic syndrome is a cluster of cardiometabolic risk factors, including obesity, atherogenic dyslipidemia, hypertension and hyperinsulinemia. Hypodynamia is considered one of the main risk factors for MS and its complications, so increasing muscular and cardiorespiratory fitness is an effective therapeutic strategy to influence the performance of carbohydrate and lipid metabolism, improve quality of life, prevention of MS. The aim of the study is to investigate the effectiveness of resistance and aerobic exercise and their impact on biochemical parameters of carbohydrate metabolism and gut microbiota composition in women with metabolic syndrome.
METHODS: The functional state (heart rate, blood pressure), the body weight, the BMI, body composition (the content of fat, the lean body mass, percentage of visceral fat) and body circumferences of 50 women with MS involved into health-enhancing exercise programs were evaluated before and after the 3-month exercise training. All women were divided into group I (20) and group II (30), which were engaged in aerobic and resistance programs. The body fat reduction and changes in the main markers of metabolic syndrome (HDL, LDL, TG, total cholesterol, blood glucose, HbA1c, insulin, HOM-IR index, AST and ALT) were assessed. Determination of microbiota composition at the level of major bacterial phyla was performed with quantitative real-time PCR (qRT-PCR) using universal primers targeting bacterial 16S rRNA gene, as well as primers specific for Actinobacteria, Firmicutes and Bacteroidetes.
RESULTS: Group I had significant changes in cholesterol, which decreased by 16.1% and triglycerides by 26.6%, while carbohydrate metabolism, HDL, LDL, BMI, body weight, fat mass and visceral fat remained without statistically significant changes. Group II had a significant decrease in the mean values in the following indicators: HbA1c decreased by 16%, Homa-IR by 16.7% and fasting glucose by 14%. Additionally, there is a decrease in average body weight by 6.6%, BMI by 7%, the percentage of fat mass and visceral fat by 7% and 15.6%, respectively. Indicators of cholesterol and triglyceride fractions in group II have a pronounced tendency to decrease, but not confirmed by statistical analysis. Bacteroidetes increased by 24.5% and the F/B ratio changed by 3.8%. Comparative analysis of the two groups revealed significant differences ($P<0.05$) of HbA1c, Homa-IR, glucose and ALT.
CONCLUSION: Physical intervention of resistance training had a more significant effect on improving carbohydrate metabolism, body weight, BMI, fat mass, visceral fat, increasing Bacteroidetes and changing the F/B ratio in individuals with metabolic syndrome. Thus, resistance exercise will allow to influence the course and treatment of MS more effectively and to prevent the development of concomitant pathological conditions.

### THE ROLE OF ISOMETRIC AND ISOKINETIC LEG STRENGTH IN MAXIMAL FAT OXIDATION IN TYPE 2 DIABETICS

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INTRODUCTION: Type 2 diabetes (T2DM) directly affects muscle health, including muscle mass, strength, quality, and function. In fact, the loss of skeletal muscle mass is associated with a concomitant decline in muscle strength in T2DM. However, little is known if it can also influence fat oxidation, which is considered a biomarker of metabolic flexibility. Moreover, Cardiorespiratory Fitness (CRF) is a major influence on maximal fat oxidation (MFO) capacity, however this capacity also depends on muscle mass. Hence, this study aimed to analyse the influence of muscle strength on maximal fat oxidation capacity in a T2DM group.
METHODS: Fourteen volunteers (8 men) age 53.3 ± 8.7 years with T2DM from the EDUGUTION project were evaluated in an incremental exercise protocol in a cycle ergometer with two consecutive phases performed for MFO and VO2max using indirect calorimetry. The first phase aimed to determine MFO, and it consisted of 3 min steps of 15W increments with a cadence of 60rpm. The test was stopped when RQ ≥1. After 5 min rest, the second phase to detect VO2max began with steps of 1 min and the same incremental load until exhaustion. An

Isometric knee extension test (Isom) for 6 seconds and 15 repetitions of knee flex-ext at 120° per second (Iso120) were performed in an isokinetic dynamometer for peak torque and total work. Bioimpedance analysis was used to assess fat mass and muscle mass. Spearman correlation test and linear stepwise regression analyses were performed to explain MFO with a significance of 95%.
RESULTS: The correlation of MFO with Lean Mass (r=0.51), Isom Peak Torque (r= -0.46) and Iso120 Work in Flexion (r= 0.15) and Extension (r=0.04) was not significative (p>0.05). However, MFO correlates significatively (p<0.05) with VO2max/Kg (r=0.62) and fat mass (r= -0.55). VO2max had significative (p<0.05) correlation with leg lean mass (r=0.543) and Iso120 Work Flexion (r=0.60). When MFO normalized for body weight, the results were similar. The stepwise regression best model of MFO adjusting by Lean Mass and Leg Lean Mass include VO2max/LeanMass and VO2max/Leg Lean Mass, respectively (Beta standard 0.636 and 0.732, p = 0.015 and 0.03).
CONCLUSION: MFO was strongly influenced by CRF, and CRF is related to leg isometric and 120° isokinetic strength. However, the oxidative muscle capacity is more important for fat oxidation than the muscle isometric and 120° isokinetic strength in T2DM patients. More research is needed to understand the role of other strength manifestations and strength training in fat oxidation metabolism. Grants: 1) PID2019-110063RA-I00. 2) PID2020-120034RA-I00. 3) LI19/21IN-CO09

**EFFECTS OF HIGH INTENSITY INTERVAL TRAINING ON METABOLIC SYNDROME IN BREAST CANCER PATIENTS RECEIVING ANTHRACYCLINE CHEMOTHERAPY**

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INTRODUCTION: Anthracycline chemotherapy is a commonly used treatment for breast cancer, however it can increase the risk of harmful physiologic outcomes, such as metabolic syndrome (MetS). High-intensity interval training (HITT) has been shown to improve MetS in other clinical populations such as patients with diabetes or cardiac rehabilitation patients, whereas the impact of HITT on MetS and associated biomarkers in breast cancer patients receiving anthracycline chemotherapy is still unknown. Thus, the aim of this secondary analysis was to evaluate the effects of an 8-week HIIintervention on MetS and associated biomarkers in breast cancer patients undergoing anthracycline chemotherapy.
METHODS: Breast cancer patients (n=30) were recruited prior to initiating treatment and randomized into HIIT (n=15) or control (n=15). The HIIT group attended
supervised cycling exercise sessions three days/week for eight weeks. The control group was asked to maintain their current level of physical activity. Body composition was assessed, and blood samples were obtained before and after the 8-week intervention. MetS z-score was calculated by assessing waist circumference, blood pressure, fasting levels of high-density lipoprotein cholesterol (HDL-C), triglycerides, and glucose. Circulating levels of MetS-related biomarkers were also measured, including total cholesterol, insulin, HbA1c, leptin, adiponectin and c-reactive protein (CRP). Linear regression models were used to estimate mean differences between groups post- intervention adjusted for baseline values.
RESULTS:At baseline, 70% of all patients had MetS, with non-significant differences
between groups. Post-intervention, MetS z-scores significantly improved in the HITT group compared to the control group (between-group difference, -7.60, 95% CI: -9.08 to -6.13, P<0.001). Importantly women in the control group increased MetS by over 13% over the course of treatment. Compared with the control group, HITT showed 27th annual ECSS Congress Sevilla/ Spain, 30 Aug –2 Sep, 2022 significant improvements in MetS variables (increased HDL-C and decreased glucose and triglycerides) and circulating MetS-related biomarkers (cholesterol, insulin, HbA1c, leptin and CRP), as well as an increase in adiponectin (P<0.001) at the end of the study. MetS variables (HDL-C and triglycerides) and all circulating MetS-related biomarkers remained significantly improved compared with baseline in the HITT group (P<0.01). In contrast, there were no significant differences between groups in body composition outcomes at the end of the study.
CONCLUSION: An 8-weeks HIIT intervention is an effective strategy to improve MetS in breast cancer patients undergoing anthracycline chemotherapy. Furthermore, changes in MetS and associated biomarkers were independent of changes in body composition. These findings have important clinical implications and support the incorporation of supervised HITT programs during breast cancer chemotherapy. NCT0245477

## METHODS: RESULTS: CONCLUSION: Oral presentations

### OP-MH17 Frailty and falling in elderly

**SEX DIFFERENCES IN FRAILTY, FALLS RISK, AND INDEPENDENCE IN OLDER ADULTS. ROLE OF ADHERENCE TO EXERCISE PROGRAMMES.**

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INTRODUCTION: Despite having a longer life expectancy, the prevalence of frailty is higher among women (W) than men (M). This fact leads to a decrease in functional capacity, quality of life and independence. Also, with the decline in functional capacity comes an increase in the risk of falls. In a clinical trial (CT) involving 100 individuals (NCT02331459), we previously reported the benefits of a multicomponent, social, personalized, and supervised exercise intervention to revert age-associated frailty and prevent its transition to disability. Results of such trials should be confirmed by Real-Life (RL) experience.
METHODS: In this study, 33 women and 17 men aged 78.9±2 years participated in a RL intervention based on a successful previous CT. The RL intervention lasted six months and was performed outside the hospital setting and independently of the primary care centers. We used the same inclusion criteria as in the CT. For the statistical analysis, the t-student test was used for qualitative variables with normal distribution, and the Wilcoxon test was used for non-parametric ones
RESULTS: With the RL intervention we achieved an adherence of 79% (95%[CI]72%-86%) compared to the 47% (95%[CI]39%-56%) for the CT. W in the RL group reduced Fried`s frailty criteria from 4 to 0.7, p=0.0001, those in the CT from 3.4 to 2.0, p=0.0278 and those in the control group from 3.9 to 5.0. M in the RL group went from having 3.6 frailty criteria to 0.8, p=0.0001, those in the CT went from 3.2 to 1.8,

p=0.0349 and those in the control group from 3.7 to 4.0. W in the RL group improved the Barthel scale from 74.8 to 88.4, p=0.0001, those in the CT from 84.6 to 88 and those in the control group worsened from 86.6 to 78.8, p=0.0012. M in the RL group improved from 81.1 to 92, p=0.0007, those in the CT group went from 92 to 94.7, p=0.0138 and those in the control group worsened from 89.3 to 82.5, p=0.0021. On the Tinetti scale, W in the RL group increased from 18.1 to 23.4, p=0.0001, those in the CT group from 22.3 to 23.8 while those in the control group went from 22.9 points to 20.7. M in the RL group went from a mean score of 21 to 24.3, p=0.0001, those in the intervention group from 25 to 26 and those in the control group from 23.1 to 20.8, p=0.0397. Finally, W in the RL decreased the falls number from 1.6 to 0.5, p<0.0001, those in the intervention group from 0.8 to 0.2, p=0.0329 and those in the control group from 0.5 to 0.8. The number of falls in the RL group in W decreased from 1.4 to 0.1, p=0.0002 while those in the intervention group decreased from 0.6 to 0.3. The control group increased from 0.5 to 0.6.
CONCLUSION: The greater adherence to the RL programme resulted in greater benefits in both M and W, when compared to the CT. It has been found that the higher prevalence of frailty among women leads to a lower capacity to perform basic activities of daily living, as well as a higher number of falls. In the RL intervention we found the biggest improvement in the women group.

### INDIVIDUAL EFFECTS OF A SHORT CONCURRENT TRAINING INTERVENTION IN PRE-FRAIL AND FRAIL OLDER ADULTS AFTER 6 MONTHS OF DETRAINING PERIOD

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INTRODUCTION: In the last decades, physical exercise has played an important role in improving physical function and frailty syndrome in older adults. However, individual effects after 6-month exercise cessation on this population still remains unclear. The aim of this work was to determine the individual response to concurrent exercise training after a 6-month detraining period.
METHODS: Quasi-experimental, non-randomized controlled training on frail and pre-frail older adults (82.5 ± 5.7 years). The intervention group (EX) performed a 6-week concurrent training program (Power-based resistance training + High-Intensity Interval Training) followed by a 6-month detraining period, whilst the control group (CON) conducted usual care. Short Physical Performance Battery (SPPB), absolute and relative sit-to-stand muscle power, frailty trait scale 5 (FTS5) and frailty phenotype were assessed in both groups at baseline, 2 months and 6 months from the beginning of the intervention program. The minimal clinically important difference (MCID) was used to interpret results and participants were classified into Responders (R) change > MCID + 99%CI and Non-responders (NR) change < MCID + 99%CI. Linear mixed models and independent samples t-test were used for contrasting the mean differences at baseline (CON group vs EX group) and after the detraining period (CON group vs NR vs R).
RESULTS: No significant differences were found between CON and EX group in baseline values, however, meaningful differences were found after the training period. The EX group showed 95% of the subjects responded with a minimal clinically important improvement to the intervention after 6 months of training cessation to at least one variable. Finally, the percentage of positive response was heterogeneous, 85% of participants in SPPB, 57% in absolute power, 69% in relative power, 75% in FTS5 and 45% in frailty phenotype.
CONCLUSION: This study showed that a short concurrent exercise training of 12 weeks provoked positive minimal clinically important differences after 6 months of detraining period in pre-frail and frail older adults.

### PHYSICAL ACTIVITY LEVELS AFTER FALLING – ASSESSMENT METHODS FOR OLDER ADULTS WITH AND WITHOUT COGNITIVE IMPAIRMENT

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INTRODUCTION: Falls in older adults, especially in individuals with cognitive impairment (CI), may mark the starting point of a vicious circle affecting long-term health and quality of life. This vicious circle is characterized by functional decline, decreasing physical activity, and a progressive reduction of social participation. Therefore, it is essential to accurately assess physical activity levels of older adults with and without CI after a fall, as a change in PA level may be an early marker for future functional decline.
METHODS: The SeFallED study aims to recruit 450 patients, aged 60 years and older, who are treated in the emergency department at the “Klinikum Oldenburg” or the “Evangelisches Krankenhaus Oldenburg” after a fall without hospital admission. After an initial assessment within four weeks of the incidence, the participants will be observed for 24 months. Fall risk factors such as cognitive function and physical activity will be assessed. The Montreal Cognitive Assessment (MoCA) will be used as a screening tool for CI, which is defined as a score <25. Physical activity will be self-reported using the Physical Activity Scale for the Elderly (PASE) and objectively measured with an activity monitor (activPAL) worn for 7 days. Respective outcomes are a PASE score between 0-400 and average steps per day. We will correlate activity levels measured by questionnaire and by activity monitor and compare their level of agreement using Bland-Altman plot between individuals with and without CI. Further, we will explore the associations between physical activity levels and functional outcomes using the results of the short physical performance battery, which will also be assessed during the initial study visit.
RESULTS: 22 data sets (mean age: 74 ± 8 years, 31.8% females) have been analyzed thus far with 9 of the participants having a score of less than 25 on the MoCA. Pearson’s correlation revealed a strong association (r=.713, p=.002) between PASE scores (mean: 114.8 ± 65.3) and steps per day (mean 6778.5 ± 4003) in the total sample, but also in the two different groups with (r=.923, p=.09) and without CI (r=.706, p=.022). Further analyses will include the level of agreement between the two assessments sorted by group and its association with functional outcomes.
CONCLUSION: Preliminary results indicate a strong association between objectively assessed and self-reported physical activity levels in both; individuals after a fall with and without CI. With recruitment ongoing throughout 2022, sample size will increase significantly allowing for more detailed and further analyses. This will inform about the usability of different assessment methods. If a fast and easy to administer questionnaire can assess physical activity accurately, it may be used to identify individuals with low levels of physical activity in the future.

# Oral presentations

## OP-PN16 Molecular Biology and Biochemistry II

### DIETARY NITRATE SUPPLEMENTATION PREVENTS TRANSIENT REDUCTIONS IN MITOCHONDRIAL, BUT NOT MYOFIBRILLAR, PROTEIN SYNTHESIS RATES FOLLOWING SINGLE-LIMB IMMOBILIZATION IN MICE

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INTRODUCTION: Skeletal muscle disuse rapidly decreases muscle mass, muscle protein synthesis, and mitochondrial content/function. The overexpression of mitochondrial calcium transporter has been shown to attenuate muscle denervation-induced atrophy, suggesting a relationship between mitochondria, calcium, and protein metabolism. Since dietary nitrate can alter cellular calcium homeostasis, we aimed to determine if nitrate supplementation could prevent immobilization-induced skeletal muscle maladaptations in mice.
METHODS: Female C57Bl/6N mice were subjected to unilateral hindlimb casting and randomized to consume standard drinking water (H2O) or water supplemented with 1 mM sodium nitrate (NO3). All water throughout the immobilization period (3- or 7-days) contained 4% deuterated water (2H2O). Red gastrocnemius was excised to measure mitochondrial respiration, protein content, reactive oxygen species (ROS) emission, and myofibrillar 2H-alanine enrichment. Vastus lateralis was excised for isolation of subsarcolemmal (SS) and intermyofibrillar (IMF) mitochondria. Data were analyzed using paired Student's t-tests at each time point (control vs. immobilized limb within H2O or NO3 mice) and expressed as mean±SD.
RESULTS: Immobilization (I) rapidly increased mitochondrial ROS, decreased mitochondrial respiration, and reduced mitochondrial protein content ~15-30% compared to the control limb (C) at both 3- and 7-days. Nitrate prevented these responses, suggesting a preservation of mitochondrial bioenergetics. Regardless of nitrate consumption, immobilization decreased myofibrillar 2H-alanine enrichment ~3-fold (3- and 7-days) and induced muscle atrophy. Given the preservation of mitochondrial bioenergetics, we aimed to examine if nitrate had beneficial effects on mitochondrial-specific protein synthesis. In the absence of nitrate, 2H-alanine enrichments in SS and IMF mitochondria were lower following both 3-days (H2O SS, C: 0.84±0.34 vs. I: 0.57±0.16 mole percent excess (MPE), p=0.006; H2O IMF, C: 0.62±0.22 vs. I: 0.42±0.10 MPE, p=0.03) and 7-days (H2O SS, C: 1.90±0.25 vs. I: 1.72±0.12 MPE, p=0.04; H2O IMF, C: 1.79±0.24 vs. I: 1.58±0.22 MPE, p=0.05) of immobilization. While nitrate did not prevent this response at 7-days, nitrate preserved mitochondrial 2H-alanine enrichments following 3-days of immobilization in SS (NO3 SS, C: 0.72±0.12 vs. I: 0.66±0.14 MPE, p=0.44) and IMF (NO3 IMF, C: 0.52±0.12 vs. I: 0.45±0.12 MPE, p=0.11) mitochondria.
CONCLUSION: Dietary nitrate mitigated the immobilization-induced impairments in mitochondrial bioenergetics (3- and 7-days) and mitochondrial protein synthesis rates (3-days) in female mice. While nitrate was not sufficient to prevent reductions in myofibrillar 2H-alanine enrichment or muscle atrophy, these data nonetheless suggest that nitrate supplementation may represent a promising therapeutic strategy to preserve mitochondrial function during skeletal muscle disuse.

### SINGLE-NUCLEUS RNA-SEQ OF THE HUMAN MUSCULOTENDINOUS UNIT REVEALS NEW COMPONENTS OF THE MYOTENDINOUS JUNCTION.

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INTRODUCTION: The myotendinous junction (MTJ) is a highly specialized region of the musculotendinous unit, designed to transmit high force from muscle to tendon. Yet, paradoxically, the MTJ is also a common site of muscle strain injuries. Strain injuries are among the most frequent sport related injuries, and despite prolonged rehabilitation, these injuries are associated with a high risk of recurrence, indicating suboptimal healing at the MTJ.
Despite the high risk of injury, our knowledge on the molecular composition of the MTJ remains limited. Recent studies in mice report a specialized sub-cluster of myonuclei at the MTJ (MTJ-myonuclei), suggesting a requirement for transcriptional heterogeneity between myonuclei at the MTJ and the rest of the muscle. Here we sought for the first time to explore the MTJ-myonuclei in human tissue, and we hypothesized that examination of their transcriptional profile could lead to the discovery of new proteins at the MTJ.
METHODS: Using single nuclei RNA-sequencing, we profiled nuclei from semitendinosus muscle-tendon biopsies from 3 healthy males undergoing anterior cruciate ligament reconstruction surgery.
RESULTS: We identified 47 significantly upregulated pre-mRNA transcripts in MTJ-myonuclei, of which 24 have been reported in MTJ-myonuclei clusters in mice. Next, we examined by immunofluorescence if enriched pre-mRNA transcripts in MTJ-myonuclei translates to an enrichment at the protein level at the MTJ. This lead to the discovery of several new MTJ-enriched proteins, which together improves insight into the molecular composition of the MTJ, and further supports the idea that many proteins at the MTJ are produced locally by the MTJ-myonuclei. We also observed transcriptional heterogeneity within myonuclei in the MTJ-myonuclei cluster, and a further examination revealed 4 distinct MTJ-myonuclei sub-clusters. Interestingly, the MTJ-specific marker collagen XXII was only significantly upregulated in two of these four sub-clusters, suggesting different roles among the myonuclei belonging to this specialized domain of the myofiber.
CONCLUSION: Together, our results adds to the knowledge of the molecular composition of the MTJ and the role of the specialized MTJ-myonuclei, and provide the first transcriptomic resource of human MTJ-myonuclei that will contribute to advance the understanding of this complex region and its failure during injury and repair.

### VICIA FABA PEPTIDE SUPPLEMENTATION DOES NOT DIFFER FROM MILK PROTEIN IN MODULATING MUSCLE MASS LOSS DURING IMMOBILIZATION AND RECOVERY, BUT INCREASES MUSCLE PROTEIN SYNTHESIS RATES DURING RECOVERY

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INTRODUCTION: Muscle mass and strength rapidly decrease during short periods of immobilization (<7 d), after which they slowly recover during remobilization. Recent artificial intelligence applications have identified natural peptide networks (NPNs) within raw food materials

that appear to possess anabolic properties in in vitro assays. This study assessed the impact of dietary supplementation with plant derived NPN on muscle mass, muscle strength, and myofibrillar protein synthesis rates during 7 d of disuse and 14 d of subsequent remobilization.
METHODS: Thirty healthy, young (24±5 y) men were subjected to 7 d of one-legged knee immobilization followed by 14 d of ambulant recovery. Subjects were randomly allocated to ingest either 10 g milk protein concentrate (MPC; n=15) or 10 g Vicia faba NPN (NPN_1; n=15) twice daily throughout the study protocol. One day before casting, directly after cast removal, and 14 d after cast removal, quadriceps cross sectional area (CSA) was assessed using single-slice CT scans and knee extension strength was assessed using one-repetition maximum (1-RM) tests. Subjects ingested deuterium oxide (2H2O) daily with saliva and muscle biopsy samples being collected to measure myofibrillar protein synthesis rates during the immobilization and recovery periods. The primary outcome variable was quadriceps CSA. A two-way repeated measures (time x group) ANOVA was used to compare changes in quadriceps CSA, knee extension strength, and myofibrillar protein synthesis rates during immobilization and recovery. Data represented as mean±SD.
RESULTS: Leg immobilization decreased quadriceps CSA from 7.5±1.1 to 7.1±1.0 cm2 and from 8.1±1.0 to 7.6±0.9 cm2 in the MPC and NPN_1 group, respectively (P<0.001), with no differences between groups. Remobilization partially recovered quadriceps CSA (MPC: 7.3±1.0, NPN_1: 7.7±0.9 cm2, P=0.009), with no differences between groups (P>0.05). Knee extension 1-RM decreased during immobilization (P<0.001) and partially recovered during remobilization (P=0.008), with no differences between groups (P>0.05). During immobilization, myofibrillar protein synthesis rates were lower in the immobilized leg (MPC: 1.10±0.24, NPN_1: 1.07±0.24 %/d) compared with the non-immobilized leg (MPC: 1.52±0.20, NPN_1: 1.55±0.27 %/d, P<0.001), with no differences between groups (P>0.05). During remobilization, myofibrillar protein synthesis rates in the immobilized leg increased significantly in the NPN_1 when compared with the MPC group (1.53±0.38 vs 1.23±0.36 %/d, respectively: P=0.027).
CONCLUSION: Vicia Faba peptide supplementation does not differ from milk protein supplementation with regard to the decline in muscle mass and strength during short-term immobilization, or the regain in muscle mass and strength during remobilization. Vicia Faba NPN supplementation does not differ from milk protein supplementation in modulating myofibrillar protein synthesis rates during immobilization, but increases myofibrillar protein synthesis rates during remobilization.

### AMINO ACID TRANSPORTERS IN HUMAN SKELETAL MUSCLE ARE ALTERED WITH REGULAR RESISTANCE TRAINING IN YOUNG AND OLD

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INTRODUCTION: The postprandial availability of amino acids in the skeletal muscle is dependent on transmembrane bound amino acid transporters (AAT) transporting amino acids from the blood to the cell interior and its compartments. Increased intracellular amino acid availability facilitates and increases muscle protein synthesis (MPS). Metabolic dysregulation is proposed to cause attenuated anabolic muscle response to feeding in elderly and in sedentary adults, termed anabolic resistance, where the role of AATs may be critical. Therefore, this study investigated possible differences in AATs in young and old and whether regular resistance training changes the appearance of AATs and its regulators.
METHODS: Healthy young (n=15, 20-40 yrs) and old (n=12, 70-80 yrs) adults completed a 12-week whole-body strength training intervention (3/week). Before and after the intervention, lean leg mass (LLM) measured by dual energy X-ray absorptiometry and strength as one repetition maximum (1RM) in the leg press was tested. Muscle biopsies were obtained from m. vastus lateralis and fractionated and analyzed with western blots in the cytosolic (C), membrane (M) and nuclear (N) fractions for the AATs: CD98(C,M,N), SLC38A9(M,N), LAT3(C); and the regulator eIF2α (C,M,N). Data was analyzed using a two-way ANOVA for repeated measures.
RESULTS: For absolute changes, it was observed a time and age interaction effect (p<0.05) in 1RM and a time effect (p<0.0001) in 1RM and LLM. The young increased 1RM more than the old (78±32 kg vs 50±20 kg, p<0.0001). LLM increased similarly in young and old (1.0±0.6 kg and 1.0±0.6 kg) and there were no differences in the relative changes between the young and old. Before training, there were no differences between young and old in the levels of AATs in any fraction. For changes is protein levels, there was an interaction effect between time and age in CD98-M (p<0.01) and eIF2α-N (p<0.05), and a time effect in CD98-N (p<0.0001), eIF2α-N (p<0.0001) and SLC38A9-M (p<0.01). CD98-N levels increased for both groups (young: 66±123%, old:45±53%, p<0.05), whereas only the old increased in eIF2α-N (92±125%, p<0.001) and decreased in SLC38A9-M (-46±41%, p<0.01). The protein levels of LAT3-C did not change and no differences were found between the groups in the relative changes for neither protein. A correlation was found in the relative changes between SLC38A9-M and LAT3-C for the old (r=0.75, p<0.05) and between CD98-N and eIF2α-C (r=0.59) and eIF2α-N (r=0.66), eIF2α-N and eIF2α-C (r=0.63) and eIF2α-M and SLC38A9-M (r=0.60) for the young (p<0.05).
CONCLUSION: Resistance training induced increases in muscle mass and muscle strength which were accompanied by changes in CD98, eIF2α and SLC38A9 in both young and old. The observed changes in AATs and eIF2α may be related to alteration in stress response regulation or regulation of amino acid uptake. The increase in CD98 and eIF2α in the nuclear fraction was unexpected and the functional importance is currently unclear

### PHARMACOLOGICAL ACTIVATION OF AMPK ACUTELY INCREASES MITOCHONDRIAL ADP SENSITIVITY, BUT THE MECHANISM IS NOT CONSERVED IN FASTED MICE.

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INTRODUCTION: The transport of ADP across the inner mitochondrial membrane influences rates of oxidative phosphorylation and reactive oxygen species (ROS) production, representing a key control point affecting mitochondrial bioenergetics. Despite the importance of mitochondrial ADP transport/sensitivity to cellular homeostasis, very little is known about the regulation of this process. In the present study we aimed to investigate the possibility that 5'-AMP-activated protein kinase (AMPK), a key enzyme that has been shown to reside on mitochondrial membranes in response to cellular stress, regulates adenine nucleotide translocase (ANT), the inner mitochondrial membrane ADP/ATP counter-transport protein.
METHODS: C57Bl/6N mice were subcutaneously injected with either AICAR (500mg/kg) to pharmacologically activate AMPK or an equal amount of saline (n=10/group). After 60 minutes, permeabilized fibers from the red gastrocnemius were prepared for mitochondrial respiration (maximal respiration and ADP sensitivity) and the remainder of the tissue was snap frozen for further analysis. An additional cohort of C57Bl/6N mice (n=48) were randomized into an 18h-fasted group (8:00am-2:00am) or a 24h-fasted group (8:00am-8:00am) to assess

mitochondrial bioenergetics and Western blotting in the red gastrocnemius muscle, compared to a time-matched fed group. Known ANT amino acid sequencing was also utilized to predict AMPK binding motifs.
RESULTS: Although mitochondrial content and maximal ADP-supported respiration remained comparable between saline and AICAR treated mice, AICAR decreased the apparent ADP Km ~25% indicative of greater ADP sensitivity. Fasting for 18hrs did not alter pAMPK, maximal oxidative phosphorylation or ADP sensitivity. Mice fasted for 24h displayed a strong trend for increased AMPK phosphorylation (p=0.075), but surprisingly displayed a decrease in ADP sensitivity (+25% ADP Km) in the absence of changes in maximal oxidative phosphorylation, suggesting AMPK does not directly regulate ANT/ADP sensitivity. In further support of this assertion, ANT does not possess a known AMPK binding motif, however we identified possible binding motifs for protein kinase A (PKA) and calcium calmodulin-dependant kinase (CaMK). While mitochondrial ROS and acetylation have also previously been implicated as regulators of ANT, mitochondrial ROS emission, acetylation and CaMK-phosphorylation were not affected by fasting suggesting these mechanisms are not contributing to the changes in mitochondrial ADP sensitivity.
CONCLUSION: The present data provides evidence that pharmacological and biological activation of AMPK has diverse consequences on mitochondrial ADP sensitivity suggesting other/additional mechanism(s) are responsible for regulating this key moderator of metabolism. Future studies are required to elucidate additional regulatory components of mitochondrial ADP transport as these appear independent of CaMK, acetylation, and changes in redox balance.

# Oral presentations

## OP-AP30 Performance analysis and training optimization

### PERFORMANCE INDICATORS THAT PREDICT WINS AND LOSSES IN THE UNITED RUGBY CHAMPIONSHIP.

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INTRODUCTION: In recent years, advanced data analytic techniques have been utilised to determine performance indicators in professional rugby union. Typically, these studies report 20+ key PI's that collectively can be used to predict match outcome. Whilst, acknowledgement of the PI's is strategically important, their high number can impede the deployment of actionable interventions by practitioners. No key research has investigated the use of variable selection methods to build and validate simplified models capable of predicting successful performances. Equally, there has also been no evidence of research within the United Rugby Championship (URC). Therefore, the primary aim of this study was to investigate team level PI's associated with winning performances within the URC, through machine learning and feature selection methods. Secondary aims included to test differences between individual team PI's (isolated data) and team PI's relative to their opposition (relative data) and to examine whether variable selection can be used to simplify modelling processes.
METHODS: A range of 27 PI's were taken from all 96 matches within the 2020-21 URC season (formerly known as the PRO14). These PI's were selected to characterise different areas of the game, including attack, defence, set piece and infringements. Random forest classification modelling was completed on both isolated and relative datasets, using the binary match outcome (win/lose) as the response variable. Maximum relevance and minimum redundancy was used to locate an optimal subset of PI's that are mutually and maximally dissimilar and can represent the response variable effectively. Models were used in prediction on 53 unseen matches from the 2021-22 season.
RESULTS: Within the 2020-21 datasets, the full models correctly classified 83% (CI 77%-88%) of match performances for the relative dataset and 64% (CI 56%-70%) for the isolated set. When models were optimised by reducing the number of variables, these values were 85% (CI 79%-90%) and 66% (CI 58%-72%). In prediction, the reduced relative model successfully classified 90% of previously unseen match performances (CI 82%-95%). Within the relative data model, 5 PI's were significant in differentiating between wins and losses: kicks from hand, metres made, clean breaks, turnovers conceded and scrum penalties.
CONCLUSION: Indicators of success within the URC include increased kicks from hand, metres made, and clean breaks compared to the opposition, as well as less scrum penalties and turnovers conceded. Relative PI's are more effective in predicting match outcomes than isolated data. Simplifying to a smaller number of key variables does not degrade model accuracy, suggesting that smaller groups of PI's may be used as replacement for the wider dataset. In practical applications this could allow practitioners to focus on a select number of PI's, to allow for a more manageable approach to training and monitoring tactics.

### ARE THEY IN SYNC? A MACHINE LEARNING APPROACH TO OPTIMIZE TRAINING SCHEDULES

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INTRODUCTION: Coaches design training programs consisting of a variety of training types to optimally prepare their athletes. However, previous studies showed a possible misalignment between coaches' intentions and athletes' physiological reactions to training session. To investigate this misalignment, Machine Learning (ML) techniques were used to compare physiological responses between different training types, possibly revealing unique training type characteristics and allowing coaches to optimize their training programs design. Therefore, training types were predicted by classification models using internal and external training load parameters.
METHODS: Heart rate data, lap times and session Rating of Perceived Exertion (sRPE) were collected from 17 elite short track speed skaters during the 2019-2020 season. A Kruskal-Wallis test with Dunn post hoc test was performed to analyze differences between the short track speed skating specific TRaining IMPulse Short Track (TRIMPST) and the speed zone-based Speed Score between training types. Using TRIMPST and Speed Score along additional training load parameters, a K-Nearest Neighbors (KNN), Decision Tree Classifier (DTC), Random Forest Classifier (RFC) and Logistic Regression (LR) were computed. These classification models were used to predict training type using internal and external training load parameters. The models were evaluated using accuracy, precision, recall and F1 scores.
RESULTS: A Kruskal-Wallis test showed significant differences in TRIMPST and Speed Score between training types, $\chi^2(6) = 86{,}37$, $p<0.001$ and $\chi^2(6) = 126{,}71$, $p<0.001$, respectively. Accuracy scores for the classification models for external load were 0.75, 0.75, 0.71 and 0.49 for the KNN, RFC, DTC and LR models, respectively. Accuracy scores for the classification models for internal load were 0.37, 0.44, 0.38 and 0.46 for the KNN, RFC, DTC and LR models, respectively. The classification models using external load parameters performed well in predicting extensive interval (EXT INT) and intensive interval (INT INT) trainings, whereas the classification models using internal load parameters performed well in predicting extensive endurance (EXT END).

CONCLUSION: Our approach opens a novel perspective on training program evaluation and training load monitoring. Using external training load parameters, training types can be accurately predicted. However, our findings show that training types cannot be accurately predicted using internal load parameters. Furthermore, since there was high internal intraclass variance in the internal load parameters, physiological responses to training load appear to be highly individual. Since the internal and external load classification models are unable to predict training types with accuracy, there appears to be a misalignment between coaches and athletes. It appears more intense training sessions cannot be accurately predicted using internal load measures.

**EFFECTS OF THE COACH SUBSTITUTION ON THE TECHNICAL – TACTICAL AND PHYSICAL PERFORMANCE OF PROFESSIONAL TEAMS IN LALIGA.**

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INTRODUCTION: High-performance football is demanding and depends on several factors (1). The role of the coach is to achieve high levels of performance according to the club´s objectives, which are related with results (2). When the performance is not optimal, one of the strategies to address the problem is to change the coach, looking for a "winning effect" (3) in the following matches to improve the results achieved. The aim of the study is to analyse the effects of replace the coach, in the technical, tactical, and physical aspects, with the hypothesis that these performance variables would be increased.
METHODS: The coach substitutions were made during the 2020-2021 season in LaLiga Santander, Spanish 1st football division (n = 7). To compare the performance of the team with the old coach and the new one, the last 8 and 4 matches before and the 4 and 8 after the change of coach was taken, analysing a total of 103 matches. Variables per match of each of the teams were provided by LaLigaTM and extracted using Mediacoach® and TRACAB®. These variables were related with performance (points per game, goals for and against), technical (nº of possessions, passes, shots on goal and shots received), tactical (width and length team average, offensive and defensive centroid) and physical performance (total distance, sprint, and high sprint, the number of efforts in each category and speed in team and opponent own). To make the comparison, a paired t – test was carried out between the 4 and 8 weeks before and after.
RESULTS: An increase in the points achieved, the total distance travelled, and the number of sprints after the change of coach was observed in both situations (4 and 8 weeks). The number of efforts at high sprint and the sprint and high sprint distance presented an increase with the new coach in the comparison between 4 weeks, while in the 8 weeks comparison, teams scored more goals, shots on goal, and greater speed in their own field when the coach changed.
CONCLUSION: Although high sports performance can be influenced by many factors, coach substitution could be an effective strategy when the expected performance of the team is not obtained, giving rise to different technical and physical performance variables.

**BLOOD FLOW RESTRICTION TRAINING FOR STRENGTH, HYPERTROPHY AND ENDURANCE: A NETWORK META-ANALYSIS**

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INTRODUCTION: Blood flow restriction (BFR) training is a complementary exercise mode in which the blood flow of extremities is partially restricted. The resulting effects of blood pooling have been linked to greater gains of strength [1, 2], muscle mass [1, 2] and aerobic capacity [3] compared to work and intensity
matched non-restricted training interventions. The objective of this network meta-analysis is to directly and indirectly compare and rank the effect magnitudes of different BFR interventions on measures of maximal strength, skeletal muscle hypertrophy and aerobic capacity.
METHODS: PubMed, Web of Science, Cochrane and SPORTDiscus were searched starting from journal inception until December 2021. (Randomized) controlled trials comparing pre- to post-test changes for strength, hypertrophy and aerobic endurance outcomes between intervention and control groups in healthy adults aged 18 to 55 years were included. Study quality was rated using the PEDro scale. Eligible interventions lasted at least one week and at least three sessions. Three distinct networks for strength, hypertrophy and endurance were synthesized and interventions were ranked for their efficacy using the P-score. Relative effects of the interventions were displayed via the standard mean difference (SMD) and 95% confidence intervals.
RESULTS: Ninety-Five trials (strength = 83; hypertrophy = 53; endurance = 10) with 2,376 subjects (strength = 2156; hypertrophy = 1421; endurance = 263) and 304 pairwise comparisons (strength = 171; hypertrophy = 107; endurance = 26) were analyzed. High load resistance training interventions with or
without BFR are most beneficial for maximal strength gains (SMD = 0.80 – 1.04; P-score = 0.779 – 0.962). BFR amplifies the effect of low load resistance training on maximal strength gains (SMD = 0.34vs. 0.64). Eccentric resistance training and low load, high volume resistance training with BFR are
most beneficial for skeletal muscle hypertrophy (SMD = 1.02, 0.96; P-score = 0.830, 0.917). BFR slightly amplifies the effect of low load resistance training on hypertrophy (SMD = 0.51 vs. 0.60). High intensity endurance training with and without BFR is most beneficial for the aerobic capacity (SMD = 1.04, 0.86; P-score = 0.842, 0.751). BFR amplifies the effects of low intensity endurance training (SMD = 0.21 vs. 0.68).
CONCLUSION: A BFR provides notable effects on maximal strength, hypertrophy and the aerobic capacity, especially when low training intensities are used. While a high resistance training load seems to be most important for the gain of maximal strength, a high training volume regardless of the load seems to be most beneficial for hypertrophy. High intensity endurance training or low intensity endurance training with BFR seem to be most beneficial for the improvement of the aerobic capacity.
REFERENCES:
1. Takarada et al., (2002) 2. Abe et al., (2006) 3. Held et al., (2020)

# Oral presentations

## OP-SH09 Management and doping

### IMPORTANCE-PERFORMANCE ANALYSIS(IPA) ON SERVICE QUALITY OF YOUTH SPORTS TRAINING PROVIDERS: THE CUSTOMERS PERSPECTIVE

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Introduction
Youth sports training is an important way to relieve stress of diversified development needs. It plays an significant role in enriching youth sports activities and all-round development for health[1]. After the Chinese government introduce incentives, a large number of youth sports training providers have grown rapidly. At the same time, the customers have given them greater expectations, so they need to be more high-quality. Scholars have discussed the market governance and sustainability of them, but there are few based on quality evaluation from the perspective of customers[2]. So we plan to build a service quality evaluation system for it base on China's policy orientation and situation.
Methods
After the field research and deeply interviews with representatives of various participators in service process, the final system was designed as 6 aspects through the Delphi survey, includes management specifications, venue facilities, manpower allocation, curriculum design, ability training, security assurance. Then, 50 elements under these dimensions are made into questionnaires, which distributed nationwide, covering 26 provinces, 65 providers and 19 kinds of sports. There are 630 valid questionnaires were collected, the statistics passed the Confirmatory Factor Analysis(CFA) and Internal Consistency Analysis(KMO≥0.9,α≥0.9). Then, put it into the IPA model to analyze the relationship between the importance and satisfaction of consumers, used as grounds for prioritization.
Results
The average score of importance for the service quality is 4.327, and the satisfaction is 4.423. Among them, curriculum design(I:4.459/P:4.3535) and ability training(I:4.42/P:4.351) are showed by both high. Safety assurance(I:4.439/P:4.301）, site facilities(I:4.41/P:4.311), management norms(I:4.403/P:4.317), and manpower allocation(I:4.409/P:4.329) showed high importance and low satisfaction. At the same time, there are 30 elements in area of quadrant A(continuous maintenance), 11 in B(high priority improvement),7 in C(low priority improvement), 2 in D(excessive supply).
Discussion
Customers believe that the service quality of Chinese youth sports training is well, but there is still gap between the supply and demand. The advantages of curriculum design and ability training should be maintained, the dimensions of security, facilities, management, and manpower allocation should be supplement. Specifically , it should be improved in three points: (1) Enhance standardization and security; (2) Establish the supervision and management mechanism; (3) Optimize the service elements purposefully.
1. Liu M Y, et al., Policy Opportunities and Governance Strategies of China's Youth Sports Training Industry in the New Era, Journal of Tianjin University of Sport,2021,36(01):p.12-19.
2. Zou J F, et al., Collaborative Governance Path of Youth Sports Skills Training Market from the Perspective of Stakeholders, Journal of Tianjin University of Sport,2021,36(06):p.682-689.

### THE IMPACTS OF EVENT SERVICE QUALITY, ATTITUDE, AND PAST EVENT PARTICIPATION ON OCR PARTICIPANTS' BEHAVIOURAL INTENTIONS: THE MEDIATING ROLES OF SATISFACTION

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INTRODUCTION: As the popularity of amateur-level competitive sport events has increased these years, participatory sport-related travel has become a growing trend in the literature on sport tourism [1]. Active sport tourism has also been attributed to sport event participation, such as obstacle course racing (OCR), as the case discussed in this study. Behavioural intentions, such as destination/event revisit intentions and word-of-mouth recommendations, have been consistently discussed as it appears that they could evaluate the success of destination/event [2][3]. Understanding the variables that influence active sport tourists' behaviours within the context of participatory sports events still needs more empirical investigations. The purpose of this study was to investigate active sport tourists' behavioural intentions by examining the relationships among event service quality, attitude toward the event, satisfaction with the event, and past event participation.
METHODS: Data were collected from 182 runners in an obstacle course racing held in Madrid, Spain. On-site questionnaires were used to collect the immediate responses. A research model was proposed by using path analysis in which five hypotheses were developed.
RESULTS: The fit indices indicated an excellent fit of the path analysis model to the data. The overall model explained 52% of the variance on behavioural intentions while event service quality and attitudes explained 73% of the variance on satisfaction. The results revealed the mediation effects of satisfaction between event service quality and behavioural intentions, and attitude and behavioural intentions. This study also explored event service quality and satisfaction with the event that positively influenced behavioural intentions. Past event participation has no impact on behavioural intentions.
CONCLUSION: Theoretical relationships were examined in this study between event service quality, attitudes toward the event, satisfaction with the event, past event participation, and behavioural intentions by proposing a structural model. Satisfaction with the event was also found to be an important variable to influence behavioural intentions directly. Event service quality is critical for the evaluation of satisfaction and a direct predictor of behavioural intentions.
Reference:
[1] Kaplanidou, K., & Gibson, H. J. (2010). Predicting behavioral intentions of active event sport tourists: The case of a small-scale recurring sports event. Journal of Sport & Tourism, 15(2), 163-179.
[2] Shonk, D. J., & Chelladurai, P. (2008). Service quality, satisfaction, and intent to return in event sport tourism. Journal of sport management, 22(5), 587-602.

[3] Koo, S. K. S., Byon, K. K., & Baker III, T. A. (2014). Integrating Event Image, Satisfaction, and Behavioral Intention: Small-Scale Marathon Event. Sport marketing quarterly, 23(3), 127-137.

### HUMAN RESOURCES ARCHITECTURE MODEL FOR MANAGING VOLUNTEERS IN SPORT EVENTS

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The growing emphasis on the importance of a more professional approach to the management of volunteers in sport events has led event organizers to implement human resources management methods and tools that have the potential to facilitate volunteer' engagement, commitment and performance. In this regard, the purpose of this study was to identify the affecting components and to determine how to use the Human Resources architectural model to manage volunteers in sports events.
The present study is a field-research in terms of data collection method. The study population was experts in the field of human resource management, volunteering and event management and 19 interviewees were selected as the research sample using snowball sampling method. The main method of data collection was semi-structured in-depth interviews. The validity of the research was confirmed by showing the process of analyzing the interviews to the experts and the research reliability in terms of methodology and content, the accuracy of different aspects of research from collection to analysis was confirmed by two experts in this field who had no connection to the research. By their confirmation on the procedures and methods of collecting and interpreting data, the research audit was approved.
Based on the interviews, 84 initial codes were obtained and divided into five main categories, including human resource management architecture drivers, human resource management architecture elements, human resource architecture development barriers, strategic human resource architecture systems, and human resource management architecture functions.
Based on the research findings, implementing the human resource architecture model in managing volunteers in sports events, through the optimal knowledge of the elements and drivers of volunteer human resource architecture, by using strategic systems of volunteer human resource architecture and trying to overcome Barriers in development of volunteer human resource architecture can lead to achievement of volunteer human resource architecture functions for event stakeholders. Eventually, by maintaining the motivation and commitment of the volunteers, the process of socialization of the volunteers will be facilitated, they will have sufficient expertise and will feel valuable. On the other hand, by improving the performance of volunteers, the efficiency and effectiveness of the event increases and a more favorable experience of the event is provided to the participants in the event.

### MORAL DISENGAGEMENT, SOCIAL NORMS, AND MOTIVATIONAL PROFILES INFLUENCE ON ATTITUDES TOWARDS DOPING AMONG SPANISH COACHES.

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INTRODUCTION
Coaches strongly influence athletes' attitudes toward doping and can shape athlete's beliefs, behaviors, and decisions to be for or against doping. Coached-centered studies examining multiple factors affecting coaches' doping attitudes and behavior are scarce. The Sport Drug Control Model (SDCM) is applied for the first time in coaches with the aim of assessing the reproducibility of the model in athlete support personnel (ASP). Secondary study purpose was to determine the factors in the SDCM that most influence coaches' attitudes and susceptibility toward doping, and their doping prevalence.
METHODS
Participants completed a cross-sectional online survey. 201 Spanish athletics competitive level coaches completed the survey, from whom 11.4% were female and 62.2% were aged between 30 and 59 years. The Spanish SDCM questionnaire which was previously used on athletes and provided validity and reliability, has been adapted for coaches. Structural equation modeling (SEM) was carried out to test the SDCM in coaches.
RESULTS
Coaches reported on average negative doping attitudes and low levels of susceptibility to doping and moral disengagement. Coaches stated on average a high self-efficacy to refrain from doping and moderate ego-oriented goals. Regarding social norms, they reported a high subjective norms. They believed that, on average, reference groups would disapprove doping behaviors. With respect to descriptive norms, coaches perceived an average doping prevalence of 19.5% (1.95 ± 1.74 [mean ± SD]). SEM showed a good fitness of the SDCM. Self-reported doping prevalence in coaches was 4.5%. Positive attitudes toward doping predicted high susceptibility to doping ($B = 0.39$, $p < 0.001$). Moral disengagement ($B = 0.58$, $p < 0.001$), descriptive norms ($B = 0.42$, $p = 0.001$), ego-oriented goals ($B = 0.34$, $p < 0.05$), and self-efficacy to refrain from doping ($B = 0.26$, $p < 0.05$) displayed a significant influence on attitudes toward doping.
CONCLUSION
These variables should be considered when designing anti-doping research projects and educational programs aiming at modifying coaches' attitudes toward doping. In the complex context of elite sport in which the influences of sport environment and reference group on athletes are crucial, the absence of doping prevention may involve the presence of risk of its use. Perhaps it is time to focus more efforts on coaches, without putting aside the athletes, and therefore turn coaches into reliable doping prevention factors. To this end, it is necessary to enhance coach-centered research, provide more assistance to sport coaches, and establish effective and mandatory anti-doping education in them so that they can perform their role as anti-doping educators in an effective, committed, and proactive manner.
References
1. Barkoukis et al., J. Sports Sci, 2019.
2. García-Grimau et al., Front. Psychol, 2021.
3. Jalleh et al., J. Sci. Med. Spor, 2013.
4. Ntoumanis et al., Br J Sports Med 2021.

### INVESTIGATING NARCISSISM AND COMPASSION IN THE CONTEXT OF DOPING

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INTRODUCTION: Doping is a goal-directed behaviour influenced by a range of psychological factors including personality traits. However, to date, little research attention has been received in

understanding the role of self in the use of banned substances for performance enhancement.
In this study, we conducted the first investigation into the two competing self-concepts, i.e., narcissism (reflecting a willingness to construct and maintain a positive self-image) and compassion (reflecting a motivation to approach and accept negative self or related distress in a
peaceful mind), in the context of athletes' doping. We hypothesized that narcissistic personality is a risk factor and compassion is a protective factor of intentional doping.
METHODS: We recruited a cross-sectional sample of 178 athletes (M age = 24.44, M years of training = 7.1, all competing at regional level or above), involving male (n = 99) and female (n = 79), individual (n = 24) and team sport (n = 154), competing at regional level (n = 147) or national level and above (n = 31). All participants completed measures on grandiose and vulnerable narcissism, self-compassion, fears of compassion, and risks for doping.
RESULTS: Multivariate moderation analysis revealed a significant grandiose × vulnerable narcissism interaction in increased doping risks. Specifically, participating athletes reported higher-level doping moral disengagement and doping willingness when they were either high in grandiose or vulnerable narcissism or indeed both. Moreover, low self-compassion and fears of compassion also contributed to increased doping risks. High self-compassion appeared particularly beneficial in protecting against grandiose narcissism's risk of doping moral disengagement and against vulnerable narcissism's risk of doping willingness regardless of
one's fearful feeling towards self-compassion. However, fear of compassion from others towards oneself was detrimental to athletes' resistance to doping willingness even when their dispositional self-compassion was high.
CONCLUSION: Narcissistic personality traits are risks factors for doping. Self-compassion mitigates narcissism's doping moral disengagement and doping willingness. However, fear of receiving compassion from others magnify the risk of narcissism in doping, even when dispositional self-compassion is high. The findings offer new knowledge of narcissism-related doping risks and insights into integrating compassion for anti-doping.

## Oral presentations

### OP-SH13 Coaching and Gender

#### NORMALISING THE CONVERSATION: PLAYER AND STAKEHOLDER PERCEPTIONS OF MENSTRUAL HEALTH SUPPORT IN ELITE WOMEN'S SOCCER

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INTRODUCTION: On the basis of varying symptoms (1) associated with menses and trivial reductions in exercise performance during the early follicular phase of the menstrual cycle (2; MC), it has been recommended that a personalised approach is adopted for menstrual health support in athletes. However, a standardised practical approach to managing menstrual health has yet to be developed. Therefore, the aim of the present study was to qualitatively explore the perceptions of female soccer players and associated stakeholders in relation to menstrual health support.
METHODS: Semi-structured interviews were conducted with 47 participants from the Women's Super League and English Football Association, inclusive of players (N=12), parents (N=9), coaches (N=9), sport scientists (N=7), nutritionists (N=5) and medical staff (N=5). Interviews were audio recorded, with questions centred on determining participants' perceptions of menstrual health support. All interviews were transcribed verbatim, and an inductive approach was employed for data synthesis and analysis.
RESULTS: Four themes were established that provide an insight into the current state of menstrual health support within the women's soccer: 1) Menstrual symptomology is not a "one-size-fits-all" approach, as players reported varying MC symptoms, some of which they perceived to impact performance. Whilst parents and staff also acknowledged these varying symptoms, some coaches did not perceive any impact on performance. 2) There was confusion about the purpose of MC tracking, as despite this practice being widely reported by all stakeholder groups, there was a lack of understanding as to how this should be practically applied. 3) Participants from all groups reported that the MC is still a taboo topic of conversation and identified a need for this dialogue to be normalised. Additionally, most players reported that they would be more likely to discuss the MC with a female staff member. 4) There were mixed levels of awareness about menstrual irregularities; sport scientists, nutritionists and medical staff consistently perceived secondary amenorrhea to be common amongst players, which was in stark contrast to the views of coaches, parents and the players themselves.
CONCLUSION: These findings identify a lack of menstrual health support (i.e., imposing an inappropriate "one size fits all" approach, tracking data without using it to influence practice, a taboo culture where MCs and menstrual irregularities are not discussed), despite a need for individualised support due to varied symptomology. This lack of support and awareness of the negative health implications of an irregular MC is underpinned by a culture where conversations about the MC are not normalised. Therefore, this identifies the need for organisational, stakeholder and player centred education programmes, in order to promote conversations about the MC and create an environment where players receive personalised menstrual health support.
1. Parker et al. 2021
2. McNulty et al. 2020

#### UNDERSTANDING FEMALE COACHES' AND PRACTITIONERS' EXPERIENCE AND SUPPORT PROVISION IN RELATION TO THE MENSTRUAL CYCLE

BROWN, N., KNIGHT, C.J.

*SWANSEA UNVERSITY*

INTRODUCTION: As female coaches and sport science practitioners have likely experienced the menstrual cycle and some associated symptoms, it may be assumed they have greater awareness, understanding, or empathy for female athletes and that issues around discussing the menstrual cycle are specific to male coaches. However, personal experiences across the menstrual cycle may influence female coaches and practitioners' understanding and subsequent support provision for athletes due to societal embarrassment about the menstrual cycle,

which leads to secrecy about this topic. Yet, to-date, the impact of personal menstrual cycle symptoms and understanding of female coaches and practitioners' performance in relation to supporting female athletes has not been considered. This study aimed to develop an understanding of female coaches' and sport science practitioners' experience and support provision in relation to the menstrual cycle when working with female athletes.
METHODS: Following receipt of institutional ethical approval, 14 female coaches and practitioners (32.9±6.9 yrs) participated in individual semi-structured interviews. Interviews focused on questions ranging from participants' knowledge and understanding of the impact of the menstrual cycle in sport, their own menstrual cycle symptoms and experiences and the steps they took to support athletes. Each participants transcript was analysed by the first author using qualitative analysis procedures.
RESULTS: Following analysis, two themes were developed: 1) Knowledge and awareness, and 2) Support and management. Overall, it appeared that participants varied in their understanding and awareness of the impact of the menstrual cycle on sport performance, somewhat influenced by their own personal experiences. Participants' knowledge and awareness subsequently impacted the support they provided to female athletes. Additionally, individual experiences and perceived secrecy relating to the menstrual cycle impacted on the informational and emotional support participants provided.
CONCLUSION: Overall, the findings highlighted a variance in participant knowledge and awareness of the menstrual cycle in relation to sport, with individual experiences influencing and impacting tangible, informational, and emotional support provided to athletes. Consistent with recommendations that we need to create a society in which menstruation is less stigmatised, within sport, coaches and practitioners need to address their own discomfort regarding the menstrual cycle conversations and challenge against the need for secrecy. This highlights the importance of all coaches and practitioners to enhance their knowledge and understanding regarding the menstrual cycle and proactively providing support to athletes. Education to enhance coaches' and practitioners' knowledge and understanding will help to create a more open and supportive environment in sport, hopefully allowing for personal discomfort regarding the menstrual cycle to be addressed.

### WHEN UNPLEASANT BECOMES PLEASANT AND PLEASANT BECOMES UNPLEASANT: A LONGITUDINAL INTERPRETATIVE PHENOMENOLOGICAL ANALYSIS OF COMPETITIVENESS IN ELITE DISC GOLF

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*UNIVERSITY OF AGDER, KRISTIANSAND, NORWAY.*

INTRODUCTION: Disc golf, as golf, is a low intensity, fine motor skill sport with long lasting rounds which require shift of focus to prevent fatigue. Through a competitive season, the athletes' experiences of events and social situations can fluctuate due to contextual changes and development over time. During competitions in sport, athletes may appraise an array of potential stressors, such as demands of the sport being played and psychological demands. To understand the dynamic factors of perception and performance during a competition, it is important to gain an inside perspective of an elite athlete during a competitive season. Therefore, the purpose of the present study was to investigate how elite disc golf athletes experience and perform during competitions through a disc golf season.
METHODS: Participants were purposive homogeneous sampled through Norway's American Sports Association, with both male and female perspectives. Two elite disc golf athletes (n=1 male; n=1 female) took part in semi-structured interviews and were observed during three different competitions over the course of a competitive season. The participants were interviewed three times connected to each competition: before (T1=2 days), straight after (T2=15 minutes to 2 hours), and after (T3=4 to 9 days). They were also interviewed before (T1=45 minutes) and after (T2=15 minutes) a training session. Observation was done from an onlooker's point of view at the three competitions (M = 10 holes each per round) with instant commentary in a Dictaphone. The data available for data analysis were 26 semi-structured interviews (13 per participant) and descriptive and reflective field notes related to observation in the three competitions. A longitudinal interpretative phenomenological analysis (LIPA) was used to capture temporal and dynamic changes of the participants' experiences.
RESULTS: Three themes with sub-themes stood out from the LIPA analysis: The perception of competitions (unpleasant and pleasant); the experience of performing during disc golf competition (importance of confidence, ability to reset, and difference in feelings but not in result); and evaluating disc golf competition. Findings showed that the level of confidence affects the perception of and mindset in competition, which affects the performance. Confidence is gained through mastery in training and competition.
CONCLUSION: The findings showed how elite disc golf athletes perceived and performed during a competitive season. Whereas the female athlete went from an unpleasant to a pleasant experience, the male athlete went from a pleasant to an unpleasant experience during the competitive season. The difference between these two elite athletes were appraisal of the competition setting and demands. Indeed, our findings provide an inside perspective of elite athletes' performance during competition and provides empirical evidence on how performance is perceived at the elite level in a fine motor skilled sport.

### A MIXED-METHOD INVESTIGATION OF YOUTH FOOTBALL COACHES´ BEHAVIOURS AT HALF-TIME

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Introduction
Invasion games involve limited opportunities to affect performance during competition. Half-time breaks have been suggested as appropriate occasions to intervene, with coaches' non-verbal expressions changing players' perceptions of first-half performance (Van Kleef et al., 2019). Moreover, coaches' verbal communication at game breaks have typically been analysed during time-outs, end of quarters, and half-times in combination or have been examined qualitatively (Avugos et al., 2018). Therefore, a mixed-method approach was employed to explore the verbal behaviours of youth-elite coaches and their underpinning knowledge exclusively during half-time talks.
Method
Three qualified, youth-elite Spanish coaches (Miguel, Manuel, and Joaquín) working with U9, U13, and U18 players, respectively; consented to participate. Four half-time talks per age-group were filmed and coded using an adapted version of the CAIS, and coaches were interviewed to explore their behaviour rationales. Mean percentage time (%) of behaviours were calculated for each coach individually and interviews were analysed utilising thematic analysis procedures.
Results and discussion
Manuel and Joaquín were engaged in 'instruction' (35.72, 45.58 %) and 'feedback' (16.93, 12.77 %) for longer compared to 'player-talk' (10.00, 2.43 %), whereas Miguel exhibited an opposite tendency (instruction: 23.52, feedback: 7.85 %; and player-talk: 27.17 %). This behaviour was greater for coaches who displayed higher 'divergent' than 'convergent' questions (Miguel: 7.02, 3.90 %; Manuel: 4.32, 3.43 %).

Miguel and Manuel suggested 'divergent questioning' enabled understanding of players' emotions, whereas Joaquín rationalised his lower values (3.11 %) as an approach 'for avoiding divided opinions within the group'. Coaches highlighted their tone and volume regulation suggesting the 'level of play' and 'score' as the main factors strengthening or attenuating their message's intensity. Only Manuel's assistant was actively involved during talks and was purposefully empowered to provide instructions or complement Manuel's messages when required.
Conclusion
These results suggest similarities and differences in coaches' behaviour due to a combination of their individual beliefs, contextual factors, and age-groups coached. Questioning behaviours and player-talk were employed more frequently by Miguel and Manuel and vocal factors seemed to be more relevant that actual behaviour type for inferring meaning to messages.
References
Avugos et al. (2018). An intimate glance into "The Holiest of Holies": An exploratory study of the half-time talk. International Journal of Sport & Exercise Psychology, 18, 129-142.
Van Kleef et al. (20019). Emotional games: How coaches' emotional expressions shape players' emotions, inferences, and team performance. Psychology of Sport & Exercise, 41, 1-11.

**AN EXPLORATION OF RECIPROCITY AMONG TEACHER AND STUDENTS IN FEMALE PRE-ELITE BALLET: A SHARED REALITY THEORY PERSPECTIVE**

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*UNIVERSITY OF AGDER*

Introduction
The teacher-student relationship is acknowledged as the heart of performance coaching, and a good quality relationship is deemed essential to enhance well-being and performance development. To establish such a quality relationship, a shared reality of mutual understandings, interests, and goals, as well as established trust and good communication appear vital. Despite the importance of this relationship, within the context of dance, it appears that there is an inconsistency between the ideal and actual in dance teaching, where teachers seem to overestimate the quality of their own teaching behaviors compared to their students' perceptions of the same teaching behaviors. However, there is a lack of theoretical understanding as to how and why such differences in perceptions arise and develop. Therefore, developing a more in-depth understanding of the establishing and quality of shared realities in asymmetric relationships, such as those between teachers and students in the performing arts, is particularly warranted.
Methods
A longitudinal narrative design with multiple interviews was adopted over an eight-month period. Three female pre-elite ballet dancers between 17-18 years (Mage = 17.3) and their primary ballet teacher were recruited to the study using purposive sampling. The interview guides were guided by the conceptual framework of Shared Reality Theory and previous research focusing on interpersonal trust. Hence, a theoretical lens was used deductively. Data were analyzed using narrative thematic analysis to interpret in what ways the participants made sense of ongoing episodes, actions, and relations in their life story as teacher or student.
Results
Findings indicated that there was established shared reality only on the epistemic level (i.e., a professional, but not on an emotional/personal level) across the teacher-student relationships. This was achieved by a common perception of what matters in the world of ballet education and that the students found their teacher trustworthy. It appeared that achieving a shared reality between the teacher and the students at a relational level might be challenging within the authoritarian apprenticeship culture in ballet. Hence, the culture set the frame for a professional and distanced relationship where teachers should give clear instructions and feedback, and where the students' role is to adapt to the teacher's feedback.
Conclusion
Extending earlier research in performance psychology, the findings demonstrated the influence of ballet culture on the perceptions of what constitutes a relationship that develops between students and teacher. It appears that greater consideration of relationship quality is needed within ballet education and further research is warranted to understand the perception of shared reality in more depth and its implication for the physical and psychological well-being of young ballet dancers.

## 18:15 - 19:15

## Conventional Print Poster

### CP-AP12 Equipment / Analysis

**SMART ALPINE SKIS**

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INTRODUCTION: Nowadays all the sports are introducing new technologies to improve the technique or to avoid injuries. In alpine skiing for example, information about acceleration, angles and times is essential to evaluate each turn as well as the overall performance of the skiers. This information can be obtained using an Inertial Measurement Unit (IMU) attached to the ski [1,2].
Our research group have developed and validated in a ski simulator previously an inertial system [3]. This system includes a sensor board per ski based on the 9DoF Razor IMU (SparkFun Electronics, Niwot, CO, USA). Therefore, the aim of this work was development a smart ski with the system embedded.
METHODS: DEVELOPED PROTOTYPE:

In the current work, a smart ski prototype with the electronic embedded has been developed. The electronic consisted of an IMU, pre-processing electronics, a Bluetooth module, and a rechargeable power supply. It is inserted into the ski during the fabrication process, carried out in collaboration with a ski manufacturer (Kustom Skis, Spain). All the elements were placed under the ski boots bindings, therefore, are protected from water to prevent damages in the system. A button and three LEDs were included as user interface as well as an USB connector to recharge the battery and reprogramme the board, which is the unique visible part of the electronic system.
RESULTS: Our first instrumented skis pair has been developed successfully, and the preliminary results obtained in the tests carried out in the indoor ski slope are promising. Alpine skiing runs were conducted in an indoor ski slope (Madrid SnowZone, Spain). The system has been working over 3 hours without any problems reporting the kinematics variables continuous.
CONCLUSION: The current work is focus on the development of a smartphone application to improve usability of the system and provide immediate feedback to the users. In conclusion, this system with the APP would help coaches and skiers to achieve faster and better training results in real conditions.
ACKNOWLEDGMENTS:
This work was partly supported by Consejo Superior de Deportes through projects Sensor for Sport Monitoring and Sensor Sport Lab, "Redes de Investigación en Ciencias del Deporte" years 2021 and 2022, and European Regional Development Funds (ERDF). Thanks also to Kustom Skis for allowing the prototype ski manufacturing at their facility.
BIBLIOGRAPHY:
[1] J. Spörri, et al., Turn characteristics of a top world class athlete in giant slalom: A case study assessing current performance prediction concepts, Int. J. Sports Sci. Coach. 7 (2012) 647–659. https://doi.org/10.1260/1747-9541.7.4.647.
[2] J. Spörri, et al., Course Setting as a Prevention Measure for Overuse Injuries of the Back in Alpine Ski Racing: A Kinematic and Kinetic Study of Giant Slalom and Slalom, Orthop. J. Sports Med. 4 (2016) 1–8. https://doi.org/10.1177/2325967116630719.
[3] I. Ruiz-García, et al. Analysis of Alpine Skiing Performance, Sensors. 21 (2021). https://doi.org/10.3390/s21072480.
Code: 07/UPB/22

### VALIDITY OF SKIN TEMPERATURE AND ELECTROCARDIOGRAM USING VITALPROBE WEARABLE DEVICE

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INTRODUCTION: Vital signs such as heart rate, heart rate variability (i.e., the variation between beats), and body temperature are key baseline measures for an individual's health and fitness status (1). A novel chest-based wearable device, VitalProbe (2020) [VP], provides continuous data on vital signs including the aforementioned parameters. These vital signs help monitor physical fitness, fatigability and possibly early predictors of illnesses. However, this information is only as useful as its accuracy. Therefore, the aim of the study is to validate VP for vital signs monitoring including R-R intervals and skin temperature.
METHODS: Twenty individuals (Age: 31.9±12.4 years; Females:Males: 12:8; BMI: 23.3±5.5 Body Fat %: 20.46±8.6 %) participated in the study. During the supine measurements, participants were concurrently connected to a 12-lead ECG and VP. VP was attached to the participants via a customized adhesive gel-pad placed on the participants sternum, just above the xiphoid process. The device measured skin temperature and single-lead ECG. The R-R intervals (RRI) between the ECG and VP were compared for a 30-second window while the participants were lying down. Skin temperature was measured for 5 minutes at an interval of 1 sample/minute. Mean ± standard deviation and mean average error (MAE) and confidence interval of the error (CI) is presented for all the vitals. Additionally, paired t-test and intra-class correlation (ICC) were run for each datapoint from VP and the criterion devices.
RESULTS: A total of 565 heart beats were collected from the supine measurements, with both ECG and VP producing similar results for RRI (ECG:0.961±0.117s;VP:0.968±0.118s;p-value:0.282; ICC:0.957;MAE:0.007±0.034s). A total of 100 samples were collected for skin temperature, and both the devices output similar results (Thermistor:33.51±0.657ºC;VP:33.46±0.797 ºC;p-value:0.587; ICC:0.359; MAE:0.056±0.828 ºC).
CONCLUSION: Collected data from the study provided similar measures for both parameters. RRI measured by VP showed no significant differences compared with the ECG. Furthermore, skin temperature measurements were also similar to the thermistor. These results have practical implications in clinical settings for detecting abnormalities for both body temperature and RRI. Thus, such a device could help in managing the risk of morbidity and mortality and improving the quality of life for the individual. Further research needs to look at the performance of this device for longer periods.
Reference-
1] Gorny, A. W., et al (2017). Fitbit charge HR wireless heart rate monitor: Validation study conducted under free-living conditions. JMIR mHealth and uHealth, 5(10), e157. 10.2196/mhealth.8233

### FAIR STARTS FOR ALL: EXPLORING MULTISENSORY REACTION TIMES IN DEAF AND HEARING POPULATIONS TO DEVELOP A NOVEL ATHLETICS STANDARDISED STARTING SYSTEM.

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*BANGOR UNIVERSITY*

INTRODUCTION: At present in Deaf sport, no standardised starting system exists that allows for fair and equal competition between Deaf and hearing athletes. Typically, Deaf athletes are required to compete alongside hearing athletes with variable starting systems. Whilst using alternative stimuli such as lights or vibrating armbands supports the inclusion of Deaf athletes to compete alongside hearing athletes, the opportunities for fast reaction times (RTs) - an integral part of a fast start in the 100m sprint - are not equitable. Subsequently Deaf athletes, who are not eligible to compete in the Paralympic pathway can become marginalized. To enhance the equality for Deaf athletes in sport, an interdisciplinary approach focusing on both the empirical and sociocultural requirements of a standardised starting system is necessitated. A series of studies investigating sensory RT differences (auditory, visual, haptic, and bimodal stimuli) across Deaf and hearing populations will inform the optimal sensory conditions that create the smallest discrepancies in RT across populations.
METHODS: The rationale behind Study 1 was to determine the optimal stimulus effector location for haptic RTs. As such, we investigated RTs at different effector locations (unilateral hands, both hands and both legs) in Deaf and hearing populations. The aim of Study 2 was to investigate multisensory RTs (unimodal and bimodal) between Deaf and hearing populations. Both experiments required participants to perform a rapid arm movement towards a target upon stimulus presentation on a manipulandum.

RESULTS: Study 1 results highlight that adopting bimodal stimuli at a high-set compatible location i.e. both hands, promote significantly faster RTs than other effector locations. Preliminary findings from Study 2 indicate that bimodal auditory-visual stimuli promote significantly faster RTs than other unimodal and bimodal conditions along with no significant difference between populations.
CONCLUSION: Findings so far support existing stimulus effector location RT literature (1) and create an interesting parallel between the benefits of bimodal stimuli in hearing populations (2) and visual facilitation effects in Deaf populations (3) and RT discrepancies. Future research includes focus groups and interviews to address opportunities, systemic barriers and marginalisation experienced by Deaf athletes at different stages of the participation and performance pathways to inform policy and societal change to enhance equality and inclusivity for Deaf athletes. Adopting this interdisciplinary, evidence-based approach will allow a holistic and comprehensive overview and understanding of the empirical and sociocultural requirements of a starting system to accelerate accessibility and opportunity for Deaf athletes to participate in all sport.
(1) Ho and Spence (2014). (2) Diederich and Colonius (2004). (3) Scott et al. (2014).

**EFFECTS OF THE NIKE ZOOMX VAPORFLY NEXT%2 SHOES ON INTERVAL TRAINING PERFORMANCE.**

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INTRODUCTION: In 2017, the "Breaking2" project (an event aimed to run the first marathon under 2 h) introduced a new advanced shoe technology, the Nike ZoomX Vaporfly (VPF). This type of footwear changed the footwear design conception by using a curved carbon-fibre plate inserted into a very light midsole composed of a novel compliant and resilient ZoomX foam. It has been shown that this model improves running performance by improving running economy (1). However, the effect of this type of footwear during training is unknown. Therefore, the purpose of this study was to analyse the influence of VPF shoes on interval training performance and neuromuscular fatigue.
METHODS: Eleven trained distance runners (mean ± SD: age 32.91 ± 7.83 years, weight 69.29 ± 7.26 kg, height 172.73 ± 5.68 cm) completed an interval training (5x 1000m with 1 min 30s of recovery) with two different conditions (Nike VPF and control condition [the own competition's shoe without carbon fiber plate]) separated by 7 days. Subjects performed a countermovement jump (CMJ) pre and post training session.
RESULTS: Subjects ran 1.84 % (3.64s, $p \leq 0.05$, partial $\eta 2 = 0.47$) faster with VPF shoes (197.30 ± 13.06s) compared to the control condition (200.90 ± 13.67s). Moreover, the Bonferroni post-hoc showed that there was a significant increase (5.2s, $p \leq 0.05$) between the first and fourth repetition in the control condition, without differences in the VPF condition. Fatigue index (%) was higher in the control condition (2.62%) than the VPF (1.98%). There was no significant difference between the CMJ heigh loss in VPF (1.35 ± 1.88cm) and control (1.98 ± 1.47cm) conditions ($p = 0.21$, partial $\eta 2 = 0.16$).
CONCLUSION: The results suggest that the use of VPF shoes allows display a slightly more constant pace (less fatigue index) and faster average time than control condition. In addition, neuromuscular fatigue assessed with the CMJ height loss appeared to be lower in the VPF although without significant differences. This type of footwear aids running performance around ~1% (2) mainly influencing on metatarsal–phalangeal and ankle joint mechanics (3) increasing stride length and contact time (1). These alterations could influence in the increasing of running speed and to delay fatigue (more constant pace) during interval training.
REFERENCES
(1) Rodrigo-Carranza V, González-Mohíno F, Santos-Concejero J, González-Ravé JM. The Effects of Footwear Midsole Longitudinal Bending Stiffness on Running Economy and Ground Contact Biomechanics: A Systematic Review and Meta-analysis. Eur J Sport Sci. 2021;1–14.
(2) Rodrigo-Carranza V, González-Mohíno F, Santos del Cerro J, Santos-Concejero J, González-Ravé JM. Influence of advanced shoe technology on the top 100 annual performances in men's marathon from 2015 to 2019. Sci Rep. 2021;11(1):1–9.
(3) Ortega JA, Healey LA, Swinnen W, Hoogkamer W. Energetics and Biomechanics of Running Footwear with Increased Longitudinal Bending Stiffness: A Narrative Review. Sport Med. 2021;51(5):873–94.

**A DIGITAL RUNNING COACH FOR GUIDED RUNNING-STYLE EXPLORATION AND FEEDBACK IS BOTH TECHNOLOGICALLY AND CONCEPTUALLY FEASIBLE**

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INTRODUCTION: In recent years, the development of wearable systems and their use by runners has taken a leap forward. Among these, instrumented wireless earbuds form a promising emerging technology, for which we are developing a digital running coach, which guides runners through various running styles based on the principle of learning through exploration [1]. Different runners exhibit different running styles at a certain speed, which according to the dual-axis model [2] can be comprehensively described using just two variables: 1) cadence and 2) duty factor (reflecting the stance-to-flight-time ratio). The envisioned digital running coach will 1) drive runners through different running styles by modulating the cadence (through acoustic pacing) and/or duty factor (through instructions about stance time or flight time) and 2) provide feedback about the performed running styles by parameterizing cadence and duty factor from earbud data. The aim of this study is to examine the technological and conceptual feasibility of such a digital running coach.
METHODS: To assess the technological feasibility of the digital running coach, we analysed the reliability and concurrent validity for cadence and duty factor variables derived from earbud data [3]. As regards its conceptual feasibility, we compared and analysed the effectiveness of various forms of acoustic pacing [4,5] and different verbal instructions to modulate these variables.
RESULTS: Cadence and duty factor can both be reliably and validly derived from instrumented wireless earbuds [3]. Cadence can be modulated best with step-based acoustic pacing [4], without adversely affecting the impact force [5]. Duty factor can be modulated with verbal instructions about changing stance time as well as flight time.
CONCLUSION: We conclude that the envisioned digital running coach, providing runners feedback about their running style and guiding them through different running styles, is technologically and conceptually feasible. That is, the earbud data can be used to parameterize the key running variables of the dual-axis model [3] while acoustic pacing and verbal duty-factor instructions are effective in modulating runners' cadence and duty factor, respectively [4,5]. Based on these findings, we created a guided exploration protocol which instructs runners to explore the different running styles of the dual-axis model. This protocol is currently evaluated in both lab (to examine its effect on running kinetics and kinematics) and field studies (to examine the feasibility of running-style exploration). In addition, we are imple-

menting the running-style instructions, as well as feedback about the effect of such instructions for modulating running styles, in the instrumented wireless earbuds to create the first iteration of the digital running coach.

REFERENCES:
[1] Uehara et al. J Neurophysiol (2019)
[2] van Oeveren et al. Sports Biomech. (2021)
[3] Nijs et al. Sensors (2021)
[4] Nijs et al. Brain Sci. (2020)
[5] Nijs et al. Gait Posture (2021)

### EFFECTIVENESS OF A MUSCLE LOAD FEEDBACK APPLICATION FOR STRENGTH TRAINING ATHLETES IN IMPROVING TRAINING SESSION MUSCLE LOAD BALANCE

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INTRODUCTION: Strength training (ST) athletes are at risk for injuries, especially at their muscles and tendons (59% of all injuries) [1]. While the exact causes of these injuries remain largely unknown, the most common reason mentioned by strength training athletes is overload [1]. Muscle overload injuries could be the result of an excessive overall training intensity or the result of typically observed imbalanced strength training routines, which overload certain muscle groups while neglecting others [2]. Muscle overload and imbalances in training sessions may be prevented if strength training athletes are more aware of their personal muscle load during their workout. Therefore, the objective of this study was to assess if a muscle load feedback application could aid ST participants in achieving a more balanced muscle load during their workouts.
METHODS: Thirty healthy participants were randomly allocated over three groups: control, 'partial feedback' and 'full feedback'. The one-repetition maximum (1RM) of all participants was estimated for 18 exercises [3]. Subsequently, all participants performed eight ST sessions, wherein they were instructed to perform eight exercises of their choice from the 18 preselected exercises, while attempting to load all muscles evenly. Performed exercises, sets, repetitions, and weights were tracked by the Gymstory sensor and app [4]. Based on these data combined with the 1RM's and anatomical knowledge of primary and secondary muscle contributions per exercise, the cumulative, individual muscle load of participants was estimated. The feedback groups received a visualization of this estimation as a muscle load body map after each exercise in the app, while the control group did not. The 'full feedback' group additionally received a list with suggestions for next exercises, targeting muscles that had not or little been loaded. The muscle load standard deviation (STD) per session was used as indicator of muscle load balance (a lower STD meant a more balanced load distribution over all muscles) and compared between groups and workouts using Generalized Estimation Equations.
RESULTS: The 'full feedback' group had a significantly lower muscle load STD compared to the control group ($p<0.001$) and the 'partial feedback' group ($p=0.038$). There was no significant effect of workout number or interaction.
CONCLUSION: ST athletes who receive feedback including a personalized muscle body map and next exercise suggestions can achieve a more balanced (estimated) muscle load in their workout. This application can provide ST athletes with more insight into their individual muscle load and may potentially aid in preventing muscle overload injuries. Future research should focus on improving the accuracy of the muscle load feedback by measuring actual muscle loads on-site instead of using anatomical estimations.

[1] Kemler et al., 2022 (submitted)
[2] Kolber et al., J. Strength Cond. Res., 2009
[3] Mayhew et al., Int. J. Appl. Sports Sci., 1992
[4] https://www.yourgymstory.com

### CONSUMER VIRTUAL REALITY: FROM ENTERTAINMENT TO MOTION ANALYTICS

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INTRODUCTION: After the release of autonomous virtual reality headsets such as Meta Oculus Quest or HTC Vive Focus in the recent years, immersion technologies have become more affordable. With the announced rise of the metaverse, Virtual Reality (VR) will be a game changer within the entertainment industry but not only. Indeed, many VR applications are dedicated to physical activity, addressing sports like boxing, fencing, climb or fitness. The potential, in terms of motion analytics, has been underinvestigated knowing that the headset and the two hand controllers provide 6-axis positional data at a 60Hz frequency at least. Coupled with an external depth camera, 3D positions of skeleton joints can be agregated to the realtime data flow. With an appropriate software architecture, consumer virtual reality could move from pure entertainment to a flexible platform for motion analytics.
METHODS: In order to develop an open and device-agnostic software platform for motion analytics in virtual reality, we chose to embrass the open standards defined by the World Wide Web Consortium (W3C) such as WebSockets and WebXR. Acting as the back-end component, a Node.js application serves VR applications as web applications based the open source framework A-Frame. As a consequence, any device running a web browser (desktop computer, mobile phone, VR headsets) can launch such VR applications. The same server-side application, acts also as a WebSockets server enabling realtime communication between clients (devices playing the VR application) and other software components. This functionality allows, for instance, broadcasting data over the World Wide Web (WWW) for wireless monitoring and recording positional data for realtime or offline motion analytics.
RESULTS: We developed a fencing test application to validate the whole infrastructure. With the VR headset on, the user sees a virtual foil in place of his controller. He must hit several targets that appear randomly in the virtual environement. The time to reach each target is sent with positional data over the WWW. A desktop web browser connected to the same server is able to stream the VR content thanks to the broadcasted data flow. Plus, another web interface is able to draw charts to visualize motion analytics.
CONCLUSION: Following the massive adoption of virtual reality on a consumer level, we developed a software architecture relying on open standards defined by the W3C to move this technology from entertainment to motion analytics with a device-agnostic approach. This is the guaranty to deploy this solution on a large scale without any restrictions coming from manufacturers. The positional data, underinvestigated for the moment, could provide relevant information in terms of motion analytics.

**SOFT-TISSUE VIBRATIONS IN RESPONSE TO IMPACT FORCE CHARACTERISTICS IN RUNNING**

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INTRODUCTION: Ground reaction forces (GRF) are input signals that initiate soft-tissue vibrations (STV) in the lower limb soft-tissue compartment (1,2). GRF and STV can be modified by changing midsole hardness (3,4). Whether GRF parameters are closely linked with STV remains unknown. This study aimed at (i) investigating the effects of midsole hardness on GRF and STV and (ii) determining potential relationships between GRF and STV variables. It was hypothesized that lower inputs signals would lead to less STV.
METHODS: After 10 minutes of warm-up, three midsole hardness conditions were tested (Asker-C 40, Asker-C 55 and Asker-C 65, hereinafter called 'soft', 'medium' and 'hard', respectively). 123 subjects (51 females, 65.4 ± 9.7 kg, 171 ± 8 cm) ran at their preferred running speed (8.93 ± 5.14 km·h-1) on a motorized treadmill for 8.5 minutes in each condition. GRF and STV of the gastrocnemius medialis were collected at minute 8. Ten consecutive steps per shoe condition were analysed to extract variables of interest. Vertical loading rate and impact peak were extracted to GRF. Peak to peak amplitude and damping, defined as the decay of the initial vibration power over time (5), were calculated to characterize STV. Effects of midsole hardness were examined using Friedman analysis ($p<0.05$) including partial eta square calculation ($\eta$). Simple linear regressions with Spearman coefficient calculation ($r_s$) were performed to determine significant relationships between GRF and STV variables ($p<0.05$).
RESULTS: In hard condition, damping and vibration amplitude were respectively greater by 6.7% ($p<0,001$; $\eta=0.069$) and 9% ($p<0,001$; $\eta=0.121$) than medium and soft shoes. In hard condition, loading rate was 3.4 % higher ($p=0.010$; $\eta=0.038$) and impact peak significantly lower by 2.8% ($p=0.009$; $\eta=0.083$). For all conditions, vibration amplitude was correlated with loading rate ($r_s=0.24$, $p=0.008$) and impact peak ($r_s=0.35$, $p<0.001$). Neither the loading rate nor the impact peak were correlated with damping.
CONCLUSION: Midsole hardness affects both GRF and STV variables. At foot strike, lower loading rate and impact peak result in a smaller muscle vibration amplitude. The absence of significant relationships between GRF and damping suggests damping as an adaptation strategy to minimize STV. These results have methodological implications for the stress quantification and the understanding of the underlying adaptation mechanisms in running.
REFERENCES:
1) Boyer et al., J. Biomechanics, 2004
2) Khassetarash et al., Human Movement Science, 2015
3) Baltich et al., Plos One, 2015
4) Giandolini et al. MSSE, 2019
5) Behling et al., Plos One, 2021

**VALIDITY OF HEART RATE AND RESPIRATION RATE USING VITALPROBE WEARABLE DEVICE**

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INTRODUCTION: Physiological markers measured both at rest as well as during physical activity give a comprehensive overview of the individual's physical health (1,2). VitalProbe (2020) [VP] is a novel chest-based wearable device that allows for continuous measurement of physical activity, heart rate and respiration rate. These vital signs not only help monitor physical fitness status, but possibly be early predictors of illnesses. The purpose of the study is to validate VP for vital signs monitoring of heart rate and respiratory rate.
METHODS: Twenty participants (Age: 31.9±12.4 years; Females:Males: 12:8; BMI: 23.3±5.5 Body Fat %: 20.46±8.6 % ) participated in the current study. Participants wore a polar HR monitor along with VP, while connected to a metabolic cart (MET-C). VP was attached to the participants via a customized adhesive gel-pad placed on the participants sternum, just above the xiphoid process. ECG-derived respiration rate (RR) and heart rate (HR) were compared against the criterion devices for a 3-minute window, with samples averaged every 15 seconds. Mean ± standard deviation, confidence interval (CI) and mean average error (MAE) was presented for all the vitals. Additionally, paired t-test and intraclass correlation (ICC) were run for each datapoint from VP and the criterion devices.
RESULTS: During the seated test, 320 samples were collected for each of HR and RR, with results for HR being similar between two devices. The Polar measured 75.78±15.44 beats/min whereas the VP measured 77.33±17.40 beats/min, showing no significant difference between the two (p-value:0.650) with ICC:0.758. The MAE seen was 1.548±11.66 beats/min (CI: 0.283 to 2.814).
However the RR was significantly different between MET-C and VP. The MET-C measured 15.80±5.713 breaths/min while VP measured 18.36±4.656 breaths/min, showing a significant difference (p-value:<0.001) with ICC:0.304. The MAE seen was 0.263±6.533 breaths/min (CI: 1.947 to 3.293).
CONCLUSION: Based on the results the VP showed no significant difference in the readings measured for HR (beats per minute) using the polar device,while the RR showed significant difference in the measure. The validity of the VP helps in strategizing exercise prescription intensities for both athletic and non-athletic populations, by giving objective measure for heart rate. However, respiration rate from VP is not currently viable to use by practitioners. Additionally, further research needs to look at the performance of this device for longer periods.
References
1] Gorny, A. W., et al (2017). Fitbit charge HR wireless heart rate monitor: Validation study conducted under free-living conditions. JMIR mHealth and uHealth, 5(10), e157. 10.2196/mhealth.8233
2] Sallis, R. E. (2009). Exercise is medicine and physicians need to prescribe it. British Journal of Sports Medicine, 43(1), 3-4. 10.1136/bjsm.2008.054825

**INFLUENCE OF THE CURRENT SCORE ON THE FINAL RESULT IN JUDO FIGHTS**

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INTRODUCTION: In order to further the analysis of judo match and quantify competitive demands, it is important to estimate the influence of some match parameters [1], [2]. The purpose of the study was to develop a technical-tactical model of judo match in order to determine the probability of the outcome based on any given score throughout the match duration.
METHODS: We collected and tagged 1,291 male and female judo matches from the 2017 international judo circuit. We analyzed 13,055 combat sequences with 81 different score combinations. In order to determine the probability of a fight's outcome from the score, we

used a statistical analysis based on the multi-state model derived from the Markov process. A transition matrix provided an overview of the overall evolution of the 81 states in which a match could exist.
RESULTS: The probability of completing a match increases as the score and time progress. After two penalties, there is a 62% probability that the match will end in the next state. The probability of winning through the different mechanisms changes as the scores progress over time, at 0-0 it is through ippon (26%) while at 2-0 it is through a difference in points at the end of time (41%).
CONCLUSION: These initial results of the fighting patterns within competitions can help analysts and coaches understand and improve athletes tactical performance. Further analysis with additional co-variates (weight categories, round of competition, etc..) is necessary to better understand the evolution of specific match.

## Conventional Print Poster

### CP-PN01 Strength, stiffness and power of muscle

#### MUSCLE ARCHITECTURE AND SPRINT PERFORMANCE: ROLE OF MUSCLE SIZE

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INTRODUCTION: Muscle architectural features (MAF) have been reported to be determinants of sprint performance (SP). Nevertheless, previous studies are based on a small number of subjects and muscles, generally limited to males. Part of the differences in muscle architecture between subjects could be explained by differences in muscle mass, which is known to play a crucial role in SP. Therefore, this study aimed to determine if muscle architecture has an independent influence on SP after accounting for muscle mass in males and females. We hypothesized that some MAF unrelated to muscle size would impact SP differentially in males and females.
METHODS: Muscle architectural features of rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM), biceps femoris (BF), semitendinosus (ST), medial and lateral heads of the gastrocnemius (GAM and GAL) muscles, and patellar and Achilles tendon thickness were assessed by ultrasonography (Philips CX50, Netherlands) in 110 volunteers (65 males and 46 females (age:23±3 and 23±3 yo, VO2max:45±6 and 39±6 ml/kg/min). Body composition (DXA) and SP (isokinetic 30-s Wingate test at 80 RPMs, WT) were assessed. Mean (Wmean) and peak (instantaneous, Wpeaki; and 1-s averages, Wpeak1-s) power outputs were recorded in the WT. Statistics: ANCOVA, bivariate correlations and multiple linear regression.
RESULTS: Although males developed a higher Wpeaki, Wpeak1-s, and Wmean than females in absolute values, these were similar when expressed per lower extremities lean mass (LLM) (Wpeaki: 54±9 and 55±7, Wpeak1-s: 43±6 and 44±5, and Wmean: 31±4 and 31±4, W/kg LLM) (all $p>0.17$). In males and females, Wpeaki, Wpeak1-s, and Wmean in absolute values were associated with the muscle thickness of RF, VL, VM, BF, ST, GAL, and GAM ($r=0.37$-$0.66$), the pennation angles and fascicle lengths of the same muscles ($r=0.2$-$0.4$) and the cross-sectional area (CSA) of the Achilles ($r=0.65$-$0.70$) and patellar tendons ($r=0.42$-$0.52$). Multiple regression analysis showed that the Achilles tendon CSA, VL and GAL thickness, and GAL pennation angle had the highest predictive value for Wpeak1-s ($R2=0.75$, $p<0.001$). When normalized to the LLM, Wmean per LLM could be predicted from VL thickness, the fascicle length of GAL and VL ($R2=0.22$, $p<0.05$).
CONCLUSION: The present findings show that when differences in muscle size are accounted for, the impacts of muscle architectural features and sex on sprint performance are minimal, leaving muscle volume as the main variable determining sprint performance during exercise on the cycle ergometer. Nevertheless, the combination of VL thickness, VL fascicle length and GAL fascicle length could explain up to 22% of the variability in LLM normalized Wmean but does not contribute to explaining the variability in peak power output. The novelty of this study resides in the large sample size (n=110) and the measurement of multiple muscles and tendons in males and females, making predictive models consistent.
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#### PASSIVE MUSCLE STIFFNESS IS ACUTELY DECREASED BY ECCENTRIC EXERCISE AT LONG MUSCLE LENGTHS WITH A LONG DURATION

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INTRODUCTION: Passive muscle stiffness has been reported to be acutely increased by resistance exercise (1). Meanwhile, our pilot study showed that muscle stiffness acutely decreased after eccentric-only exercise with a wide range of motion. However, the magnitude of the decrease in the stiffness was not large (−7.2 kPa). It was shown that the muscle stiffness was greatly decreased after stretching exercise at long muscle lengths with a long duration (2). Therefore, eccentric-only resistance exercise with a combination of long muscle lengths and a long duration may largely decrease muscle stiffness. This study aimed to investigate acute changes in passive stiffness of the individual hamstring muscles after eccentric-only resistance exercise with different combinations of muscle lengths and exercise durations.
METHODS: Thirteen healthy young male participants performed three sessions of eccentric-only exercises that comprised of stiff-leg deadlift with different muscle lengths (0–50% [short] or 50–100% [long] of maximal range of motion of deadlift) and repetition durations (2 s [short] or 5 s [long]) on separate days. The sessions were 1) short muscle lengths with a short duration (SS), 2) long muscle lengths with a short duration (LS), and 3) long muscle lengths with a long duration (LL). In each session, the participants performed three sets of 10 repetitions of the deadlift with a load of 60% of their body mass. The shear modulus of the individual hamstring muscles was measured using shear wave elastography before and 3, 30, and 60 min after each session. Time-course changes in the shear moduli were analyzed using the Friedman and Wilcoxon signed-rank tests.
RESULTS: In LL, the shear modulus of the semimembranosus (SM) was significantly lower at 3 min post-exercise (129.8 ± 22.7 kPa) than at pre-exercise (140.5 ± 19.1 kPa, $p < 0.01$); however the modulus at 30 and 60 min post-exercise was not significantly different from that at pre-exercise. No significant differences were observed in the shear modulus of SM at any time point in SS or LS. There were no significant differences in the shear moduli of the biceps femoris long head and semitendinosus between pre-exercise and 3 min post-exercise in any session.
CONCLUSION: This study showed a decrease in the shear modulus of SM after LL, but not after SS or LS. These results suggest that eccentric-only resistance exercise with a combination of long muscle lengths and long duration effectively decrease the stiffness of a specific

muscle. This result may be related to the architectural characteristics of SM (i.e., the shortest fascicles among the hamstrings [3]). Further studies are needed to clarify whether the acute change in the stiffness of SM in our study extends to a chronic change after resistance training.

REFERENCES:
1) Akagi et al., Acta Radiol, 2015
2) Freitas et al., Eur J Appl Physiol, 2015
3) Woodley & Mercer, Cells Tissues Organs, 2005

**JUMPING VS. RUNNING: EFFECTS OF EXERCISE MODALITY IN A SIX-WEEK HIGH-INTENSITY INTERVAL TRAINING ON AEROBIC CAPACITY AND NEUROMUSCULAR PERFORMANCE**

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INTRODUCTION: High-intensity interval training (HIIT) has been the focus of research for some decades already. It has proven to be effective at improving endurance capacity and muscle endurance. And when compared to moderate-intensity continuous training, it possesses the additional advantage that it requires less volume and time commitment. However, its potential to improve other aspects of physical performance such as strength and power has not yet been well explored, and most research studies have used only running and cycling as exercise modalities. Therefore, this study aimed to determine the efficacy of a 6-week HIIT using jumping as the exercise modality compared to running.

METHODS: 47 participants (24 +-3 years, 172 +-9 cm, 68 +-13 kg, 22 women) were randomly allocated to one of three groups: jump training (JT), running training (RT), or control (CON). The two training groups underwent a six-week HIIT with 3 training sessions per week. Both training protocols were identical in volume, and work and rest intervals, but different in exercise modality. JT performed countermovement jumps (CMJ) as exercise modality (with two slightly different ways of execution: repositioning and continuous), and RT performed running sprints as exercise modality. Immediately after every training session, the rate of perceived exertion (RPE) was recorded for every participant. Before and after the training period, all subjects were tested for maximal isometric voluntary contractions (MVC) of knee extension (KE) and plantar flexion (PF) in custom made ergometers, as well as maximal leg power during CMJ on a force plate, and maximal aerobic capacity (VO2max) during a ramp test on a cycle ergometer.

RESULTS: Analyses of variance revealed a significant group*time interaction effect for VO2max (p=0.004), and subsequent post hoc analyses showed a significant increase only in RT (p<.001, +7.6% for RT, +2.6% for JT). Analyses of MVC revealed an effect of group*time for PF and KE (p=0.006 and p=0.007, respectively) but post hoc tests showed only a significant increase in JT for PF (p=0.02, +12.8%). No interaction effects were found for maximal power during a CMJ (p=0.72). Average RPE scores of the training sessions were significantly different between training groups (p<.001), with no significant difference between groups in those sessions that consisted of the continuous type of jumps.

CONCLUSION: Despite identical programming, the choice of exercise mode profoundly impacted the training adaptations: RT significantly increased aerobic capacity, and JT significantly increased maximal leg strength. These results underline the importance of exercise modality in physical performance adaptations. In addition, the differences in RPE between the two slightly different jump training sessions suggest that not only exercise modality, but also subtle differences in how the exercise is performed can play a role.

**THE ROLE OF HAEMOGLOBIN MASS AND BLOOD VOLUME ON CRITICAL POWER IN ATHLETES**

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INTRODUCTION: The amount of haemoglobin (Hbmass) and the total volume of blood (BV) are important factors contributing to O2 delivery capacity to the muscle. Indeed, both Hbmass and BV are typically reported to positively and strongly correlate with the maximal rate of oxygen consumption ([dot]VO2max) during exercise 1. However, the association between Hbmass and BV with other important indices of endurance performance, such as critical power (CP), has yet to be explored. Therefore, the aim of this study was to investigate the association between Hbmass and BV with CP in a group of young athletes.

METHODS: Seventeen young males (n = 13) and females (n = 4) provincial level speed skaters participated in this study. Dual-energy x-ray absorptiometry (DXA) was used to quantify lean body mass (LBM). [dot]VO2max was assessed through a step-incremental test (30 Watts every 2 min for males; 25 Watts every 2 min for females). CP (watts; W) was determined following three time to exhaustion trials and computed using a 2-parameter hyperbolic (CP2-hyp) model. Hbmass and BV were assessed through the carbon monoxide (CO) rebreathing technique in triplicate measurements. Pearson's correlation coefficients were calculated to assess the relationship between Hbmass and BV with [dot]VO2max and CP. Values were expressed in absolute units as well as normalized to body mass (kg) and total LBM. Significance was set at $P < 0.05$.

RESULTS: Average [dot]VO2max and CP were 58.1 ± 4.6 mL·kg-1·min-1 and 243 ± 36 W, respectively. Hbmass and BV were 846 ± 99 g and 6105 ± 607 mL, respectively, and were both strongly correlated with [dot]VO2max (L·min-1) (r=0.91, P<0.001; r=0.75, P=0.001, respectively) and with CP (W) (r=0.90, P<0.001; r=0.75, P=0.001, respectively). When normalized to body mass, Hbmass (g·kg-1) remained strongly correlated with [dot]VO2max (mL·kg-1·min-1) and CP (W·kg-1) (r=0.76, P<0.001; r=0.77, P<0.001, respectively), whereas BV (mL·kg-1) did not (r=0.31, P=0.232; r=0.39, P=0.126, respectively). Similarly, when normalized to LBM, Hbmass (g·kg-1-LBM) was strongly correlated with [dot]VO2max (mL·kg-1·min-1-LBM) and CP (W·kg-1-LBM) (r=0.67, P=0.003; r=0.65, P=0.004, respectively), but BV (mL·kg-1-LBM) was not (r=0.29, P=0.256; r=0.21, P=0.410, respectively).

CONCLUSION: The novel finding of this study was that, in addition to the expected strong association between Hbmass and BV with [dot]VO2max, Hbmass and BV were also strongly associated with CP. However, when [dot]VO2max and CP were normalized to body mass or LBM, Hbmass but not BV, remained strongly correlated to CP. Thus, while both Hbmass and BV are important haematological underpinnings of the maximal aerobic capacity, only the former seems to contribute to determine CP. This finding highlights the critical role of O2 blood carrying capacity for endurance performance.

1. Lundby, C., Montero, D. & Joyner, M. Biology of [dot]VO2max: looking under the physiology lamp. Acta Physiol. 220, 218–228 (2017).

### THE VALIDITY AND RELIABILITY OF THE JUMP HEIGHT MEASURED WITH THE POLAR VANTAGE V2 SPORTS WATCH

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INTRODUCTION: Reduced muscle power of the lower extremities has been shown to be a major risk factor for injuries and numerous diseases (Powers et al., 2016). In this context, the jump height of a countermovement jump (CMJ) represents a valid and simple measure for testing the muscle power of the leg extensor muscles (Markovic et al., 2004). The evaluation and interpretation of performance data in-field and in a real environment using inertial measurement units (IMU) built into sports watches is becoming increasingly popular. The purpose of the present study was to assess the validity and reliability of the jump height measured by the Polar Vantage V2 sports watch in comparison to a gold-standard force plate measurement.
METHODS: Fifteen physically active participants (8 males and 7 females), age 20–42 years performed six sets of three CMJs over a two-day testing period. The participants wore the Polar Vantage V2 sport watch (Polar Electro Oy, Kempele, Finland) whilst performing the jumps on two force plates (AMTI, Watertown, Massachusetts, United States). Jump height was calculated with the data extracted from the watch and the force data provided by the force plates. To assess validity and left-right reliability of the results for the jump height measured by the Vantage V2 we calculated Pearson's r correlation coefficients as well as the coefficient of variation (CV). Intraclass correlation coefficient (ICC) was calculated to test day to day test-retest reliability of the "leg recovery test".
RESULTS: Mean jump height was 30±7 cm measured by the AMTI force plate and 30±7 cm, measured by the Polar Vantage V2, respectively. Pearson's r showed a very good correlation between the jump height measured by the force plates and with the Polar sports watch. The jump height measured by the Vantage V2 showed a good test-retest (day-day) reliability and a high correlation between the measurement whilst wearing the watch on the left arm with the measurement whilst wearing the watch on the right arm.
CONCLUSION: The present study has shown valid and reliable data for measuring vertical jump height with the Vantage V2 sports watch. The Polar Vantage V2 provides an easy-to-perform jump test that can be used in future studies to measure jump height in the field when laboratory-based measurements are not available. This opens new possibilities for intervention studies focusing on strength and performance of the lower extremities.
Markovic, G., Dizdar, D., Jukic, I., and Cardinale, M. (2004). Reliability and factorial validity of squat and countermovement jump tests. J. Strength Cond. Res. 18, 551–555. doi: 10.1519/00124278-200408000-00028
Powers, S. K., Lynch, G. S., Murphy, K. T., Reid, M. B., & Zijdewind, I. (2016). Disease-Induced Skeletal Muscle Atrophy and Fatigue. Medicine and science in sports and exercise, 48(11), 2307–2319. https://doi.org/10.1249/MSS.0000000000000975

### THE INFLUENCE OF TRUNK INCLINATION ON THE COUNTERMOVEMENT JUMP TAKE-OFF VELOCITY IN OLDER WOMEN

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INTRODUCTION: The physiological age-related functional ability decrements in older adults are more evident during high velocity coordinated movements (1) such as vertical jumps. The Countermovement Jump (CMJ) test is one of the most commonly used protocols to evaluate maximal vertical jump height and overall lower limbs power in older adults. It has been suggested that due to forward trunk inclination in the CMJ take-off, knee extension is delayed to avoid forward rotation of the body and subsequent loss of balance throughout the completion of the take-off phase (2). Therefore, forward trunk inclination at the CMJ take-off might influence subsequent take-off velocity, thus having an impact on the estimation of maximal jump height and lower limbs power. This study aimed at investigating the influence of trunk inclination on the CMJ take-off velocity in older women.
METHODS: Sixteen old women (age: 73±6.6 yrs; body mass: 57.1±7.2 kg; height 160±0.0 cm; BMI 23.0±3.2 kg/m2) were assessed during CMJ testing session. During the execution, take-off velocity and forward trunk inclination were recorded by a wearable inertial measurement unit (Sensorize, Rome, Italy) positioned on the trunk at L5 level (3). A polynomial least square fit with the highest adjusted $R^2$ was selected for the assessment of nonlinear relationship between trunk inclination performance and Take-Off Velocity at the jump. Root mean square error (RMSE) was also calculated. Significance level was set at P-value of 0.05.
RESULTS: A very strong significant (P=0.0001) 2nd order curvilinear relationship ($R^2$=0.96; RMSE=0.03) between trunk inclination (10.1±7.9°) and take-off velocity (1.1±0.2 m/s) was found. To clarify the relationship between take-off velocity and forward trunk inclination, the following equation was developed: take-off velocity = - 0.0032(trunk inclination2) + 0.0839(trunk inclination) + 0.7115
CONCLUSION: The correct kinematic execution of jumps has been mainly defined by the relative angular joint motion of the hip, knee and ankle, and muscle moments patterns (2). Accordingly, in older women, the forward trunk inclination influences the correct execution of the CMJ and take-off velocity, and consequently the estimation of maximal jump height. For these reasons, to maximize take-off velocity, it was identified that forward trunk inclination should range between 8° and 18°.
References
1) Cortis et al., J. Strength Cond. Res. 2011
2) Vanrenterghem et al., J. Strength Cond. Res. 2008
3) Strath et al., Med Sci Sports Exerc. 2012

### PHYSICAL PREPARATION OF A WORLD-CLASS LIGHTWEIGHT MEN DOUBLE SCULLS TEAM FOR THE TOKYO 2020 OLYMPICS

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INTRODUCTION: This research was designed to analyze the physical profile and training program of a world-class lightweight double sculls rowing crew for the Tokyo 2020 Olympics.
METHODS: A case study in which both rowers performed physical testing in November 2020 and April 2021 (anthropometrics, incremental rowing test and power profiling). The training program (38 weeks) in the building up to the Olympics was analyzed providing insight into training characteristics (volume; contribution of rowing, alternative, and strength training; training intensity distribution (TID)). The entire period was split into three phases: preparation period (PP:18 weeks), race period 1 (RP1:11 weeks) and race period 2 (RP2:9 weeks), and training characteristics were compared.
RESULTS: In the April 2021 testing, Rower A (height: 1.89m, weight: 74.6kg, fat percentage: 4.4%) had a VO2peak of 5.8L.min-1 (77.8mL.min-1.kg-1) and a peak power output of 491W. Rower B (height: 1.82m, weight: 70.6kg, fat percentage: 7.8%) had a VO2peak of

5.5L.min-1 (77.9mL.min-1.kg-1) and a peak power output of 482W. The mean weekly training volume was 14h47min ± 4h5min, of which 58.5±14.6% consisted of rowing, 13.4±6.8% strength training, and 28.1±12.6% alternative training. TID of rowing (power output) was 94.1±2.6% zone 1, 3.1±2.2 zone 2, and 2.8±2.6% zone 3. The contribution of zone 1 decreased (p=0.042) between PP (95.9±2.3%) and RP2 (92.0±2.6%), whereas the contribution of zone 3 increased from PP (1.1±1.2%) to RP1 (3.8±2.6%, p=0.044) and RP2 (5.2±2.4%, p=0.009). CONCLUSION: The crew combined a high volume of rowing, alternative and strength training in a pyramidal TID that shifted towards more polarized during the race periods.

**IS IT TRAINING VOLUME A CRITICAL VARIABLE DETERMINING THE ADAPTATIONS TO STRENGTH TRAINING?**

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INTRODUCTION: Resistance training (RT) is recognized as the mosteffective method to improve muscular strength. Manipulation of different RT variables (e.g. exercises, relative intensity, volume, rest interval, among others) characterizes the type and magnitude of the stimulus and, consequently, the physiological adaptations to RT (1). Regarding RT volume, recent research has compared 4 different velocity loss (VL)thresholds(VL0 vs. VL10 vs. VL20 vs. VL40) using the same relative load (from 70 to 85% one-repetition maximum [1RM]) over 8 weeks in the full-squat (SQ) exercise. Training with low VL magnitudes (VL20-VL10) induced greater strength and jump gains than training with higher VL (VL40).However, using VL as independent variables rises the problem that RT programs differ in volume and level of fatigue induced during the set. By contrast, research analyzing different volumes has also accumulated distinct levels of fatigue (3). Therefore, the aim of this study was to investigate the effect of three RT programs with different volume, but trying to isolate the effect of fatigue, on the evolution of the 1RM strength in the SQ exercise in each training session
METHODS: Thirty-six resistance-trained men were randomized in three RT interventions: low (LOW), moderate (MOD), and high (HIG) volume. The three groups trained twice a week (training sessions being 48–72 h apart) for 8 weeksthe SQ exercise, usingrelative intensities-from 70% to 85% 1RM and only one set was conducted per session. The only difference between groups was the volume accumulated by each group: LOW performed only three repetitions per session with every load; MOD performed 12, 10, 8, and 6 repetitions with 70%, 75%, 80%, and 85% 1RM, respectively; and HIG performed 24, 21, 18, and 15 repetitions with70%, 75%, 80%, and 85% 1RM, respectively. To isolate the effect of RT volume, that is trying to minimize the fatigue accumulation during the training session, 10 seconds of rest were introduced between repetitions when the difference in the mean propulsive velocity (MPV) between the best repetition and the successive repetitions was higher than 0.03 m•s-1. If the difference was higher than 0.06 m•s-1regarding the best repetition, 10 extra-seconds rest between repetitions were added. The evolution of 1RM strength throughout the training program was analyzed.
RESULTS: There was a significant “time” effect (p<0.001), but no significant “protocol x time” interactions (p=0.570) were observed. MOD showed significant 1RM improvements from session 2, while LOW attained significant enhancements from session 5, and HIG showed significant gains from session 8. Moreover, MOD showed significantly greater 1RM values than the other groups in some sessions (e.g.session 2, 6, and 11)
CONCLUSION: The three groups showed improvements in RM strength, however, a moderate volume resulted in faster and similar or even greater strength increases.

## Conventional Print Poster

### CP-PN02 Hypoxia / Oxygenation

**MODULATION OF ANTIOXIDANT ENZYMES BY ACUTE EXERCISE IN HUMAN SKELETAL MUSCLE IN NORMOXIA AND SEVERE HYPOXIA: ROLE OF METABOLITES AND PO2**

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INTRODUCTION: Intense exercise increases RONS in skeletal muscle, an effect exacerbated in hypoxia (Hyp), upregulating gene expression of antioxidant enzymes. However, the acute effects of exercise on protein levels of antioxidant enzymes and their molecular regulatory mechanisms remain largely unknown in human skeletal muscle (HSM). Previously, we showed NFkB-signaling activation by incremental exercise to exhaustion (IE), and animal and cell studies have shown that NFkB induces the expression of antioxidant enzymes, but whether this is the case in HSM remains to be elucidated. CaMKII has been implicated in NFkB regulation, particularly via deltaD isoform phosphorylation, a mechanism untested in HSM. Thus, we aim to determine the role of metabolite build-up and low tissue PO2 during IE on CaMKII activation and its downstream antioxidant enzymes. We hypothesized an upregulation of CaMKII and some antioxidants enzymes with a more marked response in Hyp.
METHODS: Eleven active men performed IE in normoxia (Nx) and Hyp (PIO2=73mmHg). Immediately after IE, circulation of one leg was instantaneously occluded (300mmHg). Muscle biopsies from vastus lateralis were taken before (PRE), 10s (POST, occluded leg) and 60s after IE from the occluded (OC1M) and non-occluded (nOC1M) legs simultaneously, and femoral vein blood drawn. Protein expression (WB) and muscle metabolites were measured. Statistics: ANOVA and linear mixed model.
RESULTS: At POST, muscle lactate augmented 25% in OC1M. PCr was reduced 94 and 48% in OC1M and nOC1M, respectively (P<0.05), regardless of PIO2. Femoral vein PO2 was 21.1 (Nx) and 10.6mmHg at exhaustion (Hyp). Glutathione reductase (GR) increased ~2-fold after IE (P=0.002) regardless of FIO2, being 52% lower in nOC1M. Trx1 descended ~15% (P<0.05), while Gpx1 and TrxR1 were unchanged after IE. Thr287 phosphorylation of CaMKII isoforms BetaM, DeltaA and Gamma increased ~1.6 and ~1.7-fold, while DeltaD increased 2.0 and 2.5-fold at POST and OC1M, respectively (P<0.05), regardless of PIO2. Phosphorylation levels of all isoforms returned towards PRE levels in nOC1M. A positive linear association was observed between pThr287CaMKIIdeltaD and pIKK, NFkBp105, NFkBp65+p50 and GR (all R2>0.74).

CONCLUSION: This research indicates that IE selectively upregulates the expression of antioxidant enzymes in HSM, and it does so to a similar extent in Nx and Hyp. These findings support a CaMKII-dependent activation of the exercise-induced upregulation of antioxidant enzymes in HSM. The specific regulation of antioxidant enzymes likely reflects the nature and cellular compartmentalization of RONS production. Metabolite recovery and reoxygenation for 1min at exhaustion downregulate CaMKII isoforms´activation and GR, suggesting that low PO2 and/or a high metabolite build-up are essential to trigger RONS-sensitive signalling. Our data support a mechanistic link between CaMKIIdeltaD isoform activation and NFkB-mediated upregulation of the antioxidant system, particularly GR.

**OVERNIGHT AND EARLY-MORNING PERIPHERAL OXYGENATION ARE NOT EQUAL DURING ASCENT TO ALTITUDE.**

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INTRODUCTION: Acute mountain sickness (AMS) plagues many individuals ascending to high altitude each year. Clinical presentation of AMS can be evaluated using Lake Louise Scores (LLS), albeit the criteria are highly subjective. Oxygen saturation has therefore been investigated as a more objective marker; however, results have been inconclusive with methodologies varying greatly between studies. The purpose of this study was to compare arterial(ised) oxygen saturation (SaO2) with peripheral oxygenation (SpO2) measurements collected in the morning and overnight during ascent to 4,800 m.
METHODS: Peripheral oxygenation was measured continuously (1 Hz) overnight (nSpO2) and momentarily (~60 to 90 seconds, i.e., until measurement stabilised) each morning (mSpO2) using portable oximeters (3150 Model, WristOx, Nonin Medical). Arterial(ised) oxygenation was analysed from blood collected from the earlobe using the iSTAT blood gas analyser (Abbott Laboratories). Comparisons between SaO2 and nSpO2 or mSpO2, as well as nSpO2 vs mSpO2 were facilitated using Bland-Altman (B-A) plots (bias and 95% limits of agreement, LOAs) and mixed-effects analysis. All statistical tests were two-tailed with significance set to $p < 0.05$.
RESULTS: Bias (–2.04 ± 4.40%) and 95% LOAs (–10.67 to 6.59%) for nSpO2 vs SaO2 were lower than those for mSpO2 vs SaO2 (bias: –5.56 ± 5.56% and 95% LOAs: –16.45 to 5.34). The x-intercept of the best fit line plotted from B-A data for SaO2 vs nSpO2 (91.3% [CIs: 88.5 to 95.8%]) was lower than that for SaO2 vs mSpO2 (96.5% [94.2 to 99.9%]), indicating that nSpO2 was more consistent with SaO2 at lower levels of oxygenation compared to mSpO2.
CONCLUSION: During ascent to altitude, nSpO2 rather than mSpO2 was more consistent with SaO2, indicating that mSpO2 may overestimate oxygenation and underestimate the degree of desaturation exhibited overnight. Notwithstanding the ease and practicality of mSpO2, further investigation of nSpO2 is warranted, particularly, in relation the onset and progression of AMS.

**PHYSIOLOGICAL DIFFERENCES BETWEEN A TRAINING MASK AND AN ALTITUDE SIMULATION MASK DURING SUBMAXIMAL LOADING**

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INTRODUCTION: Altitude/hypoxic training offers the chance to improve athletic performance. In sports and athletic training, training masks are often sold as altitude masks, promising comparable effects. However, the potential benefits haven't been hardly proven so far [1][2]. Therefore, this pilot study aimed to investigate the physiological differences between wearing a training mask and an altitude mask during submaximal exercise.
METHODS: In this randomized crossover pilot-study, n=6 healthy, recreational active women (22.0±3.0 years old, 57.6±10.2 kg, 162.0±6.9 cm) performed the modified Harvard step protocol under three different conditions, separated by 2 weeks: In the training mask condition (TM), participants wore a mask (phantom athletics, AT). In the altitude mask condition (AM), participants wore a mask and were exposed to normobaric hypoxia (FiO2: 14.4 %, cloud9, sportingedge, UK). In the control condition (CM), participants wore a mask that allowed normal breathing and were exposed to normoxia (FiO2: 20.9 %). After acclimatization, baseline measurements were conducted after which, the participants performed the step-protocol and rested afterwards in a seated position for 15 min, where the follow-up measurements were conducted. The following parameters were analyzed to evaluate potential differences over the entire time period.
Capillary oxygen saturation (SpO2), muscle tissue oxygenation index (mTOI) of the quadriceps femoris muscle and heart rate (HR) were assessed to investigate the physiological changes. Ratings of perceived exertion (RPE) and dyspnea (DYS) were investigated to objectify the subjective ratings.
RESULTS: SpO2 was lower in AM (SpO2: 89.1±4.3 %) compared to TM (ΔSpO2: 6.9±2.3 %) lower in AM compared to CM (ΔSpO2: 6.8±1.9 %; both p≤.005). There was no difference between TM (SpO2: 96.1±2.1 %) and CM (SpO2: 98.9±2.5 %). The study revealed that there are no differences between the conditions for mTOI (AM: 66.7±4.3 %, TM: 70.4±3.4 %, CM: 68.4±4.0 %, p=0.06). Heart rate significantly differed between groups (p<0.001) with the highest values in AM (127±26 bpm) followed by CM (121±22 bpm) and TM (117±24 bpm). There were no differences between conditions at any specific time point for RPE and DYS (all p>0.05). The TM and CM groups did not differ significantly in any variable.
CONCLUSION: The present study shows that the SpO2 reductions and HR increases are significantly pronounced in the AM condition compared to the TM and CM condition. There were no differences between conditions for mTOI and perceptual measures. This study demonstrates, that the physiological impact of AM is higher compared to TM for SpO2 and HR.
1. Biggs et al., Effects of simulated altitude on maximal oxygen uptake and inspiration fitness, Int. J. Exerc. Sci. 2017. 10(1)
2. Romero-Arenas et al., Oxygenation Response While Wearing the Elevation Training Mask During an Incremental Cycling Test. J strength cond. res. 2021. 35(7)

**EFFECTS OF ENDURANCE EXERCISE UNDER NORMOBARIC HYPOXIC CONDITION ON INTESTINAL CELL DAMAGE AND GASTRIC EMPTYING RATE.**

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INTRODUCTION: The importance of quick nutrition intake during post-exercise is widely accepted among athletes (1). While endurance exercise attenuates transiently digestive and absorptive function (2,3,4), changes in these variables following endurance exercise in hypoxia remain unknown. Two previous studies (5,6) presented that endurance exercise in hypoxia resulted in a greater level of exercise-induced intestinal cell damage compared to the exercise in normoxia under the same absolute intensity. However, the comparison using the same relative intensity between hypoxia and normoxia has not been conducted. Therefore, the purpose of the present study was to compare the intestinal cell damage and the gastric emptying rate following endurance exercise between “hypoxia” and “normoxia“ under at the same relative intensity.
METHODS: A randomized, single-blind crossover design was selected. Eleven active males (age, 23±0.4 years; weight, 66.4±1.8 kg; height, 174±1 cm; body fat, 14.2±0.9 %) completed this study. Participants initially evaluated maximal running velocity (vMax) during incremental running test under hypoxia (FIO2 : 14.5%) and normoxia (FIO2 : 20.9%). Then, they conducted two trials on different days, consisting of 60 min run on a treadmill at 70% of vMax while inspiring either hypoxia (FIO2 : 14.5%; HYP) or normoxia (FIO2 : 20.9%; NOR). Venous blood samples were collected to evaluate plasma intestinal-fatty acid binding protein (I-FABP) as an indication of exercise-induced intestinal cell damage. The gastric emptying rate was also determined using 13C-sodium acetate breath test.
RESULTS: Running velocities at vMax and 70% vMax were significantly lower in HYP compared to NOR ($P<0.0001$). Relative change in plasma I-FABP concentration did not differ significantly between two trials ($P=0.96$). However, maximum 13C excretion time (an indication of gastric emptying rate) was significantly delayed in HYP trial ($P=0.01$).
CONCLUSION: Endurance exercise in normobaric hypoxia delayed gastric emptying rate compared to the exercise in normoxia under the same relative exercise intensity. However, hypoxic exposure during endurance exercise did not affect exercise-induced intestinal cell damage.
REFERENCE:
1. Ivyn et al. (1988)
2. Neufer et al. (1989)
3. Horner et al. (2015)
4. van Wijck et al. (2013)
5. Lee et al. (2017)
6. Hill et al. (2020)

**PHYSIOLOGICAL AND PERFORMANCE RESPONSES TO REPEATED WINGATE SPRINTS WITH 2.5- OR 4.5-MIN RECOVERIES UNDER ACUTE HYPOXIA**

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INTRODUCTION: Repeated Wingate sprints (RW), a popular form of sprint interval training, is a promising training strategy in normoxic conditions (Gibala et al., 2012). RW training under hypoxia can increase physiological adaptation (Puype et al., 2013), but whether it can improve exercise performance or not is controversial (Warnier et al., 2020). This uncertain performance outcome by RW under hypoxia is possibly due to long rest intervals, leading to a small hypoxic stimulus (Takei et al., 2020). Therefore, adjustment to shorter rest intervals is a possible option to increase hypoxic stimulus. In this study, we compared physiological and performance responses between RW with 2.5- and 4.5-min recovery in acute hypoxia.
METHODS: In this study, hypoxic training sessions (April to July 2021) in a university athletics club were recorded and analyzed. Eight university athletics sprinters (4 male and 4 female athletes) participated in the hypoxic training sessions. The hypoxic condition was generated by environmental chamber as normobaric hypoxia (15% O2). On training day, athletes performed one out of the two RW (5×30-s cycle sprints) with 2.5- (RW-2.5) or 4.5-min (RW-4.5) recovery in randomized order. SpO2 and heart rate were recorded immediately after each sprint. Mean power outputs (MPO) were recorded by cycle ergometer for each sprint.
RESULTS: During the experimental period, total of 90 hypoxic training sessions (11.3±6.1 sessions per athlete) were performed. SpO2 and MPO significantly decreased in RW-2.5 sessions compared to RW-4.5 ($p<0.01$ and 0.05, respectively). There was no significant difference in heart rate between RW-2.5 and RW-4.5 in either sprint repetition ($p=0.68$) or rest interval ($p=0.58$).
CONCLUSION: In this study, adjustment to shorter rest intervals (4.5- to 2.5-min) for RW training led to increased hypoxic stimulus (lower SpO2) and larger power outputs decrement. On the other hand, there were no effects of recovery duration on heart rate responses. Therefore, hypoxic RW with short rest intervals, compared to long rest intervals, is a possible option to increase hypoxic stimulus (e.g., increased HIF-related adaptations) with the same cardiovascular and less mechanical stress.

**AEROBIC FITNESS, BUT NOT AGE AND SEX, DETERMINES THE LEVELS OF ANTIOXIDANT ENZYMES AND ITS MAIN UPSTREAM REGULATORY TRANSCRIPTION FACTORS NRF2/KEAP1 IN HUMAN SKELETAL MUSCLE**

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INTRODUCTION: Ageing, sedentarism and chronic inflammation are associated with increased oxidative stress (OS), which promotes endothelial dysfunction, hypertension, insulin resistance and cancer. Increased OS in human skeletal muscle (HSM) has been reported in COPD and diabetic patients and after immobilization. It has been suggested that regular exercise enhances the antioxidant capacity of skeletal muscles. Nevertheless, no attempt has been made to determine if higher aerobic fitness associates with increased expression of antioxidant enzymes (AE) and its regulatory transcription factor in HSM. Theoretically, oestrogens could contribute to the greater life span of females via reducing OS and sex differences have been reported at the transcriptomic level. Thus, the aim was to determine the basal

protein expression of key AE in HSM from 189 volunteers and to ascertain if VO2max and sex explain the observed variation. We hypothesize that a greater VO2max and female sex would be associated with higher expression of AE
METHODS: Skeletal muscle biopsies from the m. vastus lateralis obtained from 120 men (age:31±10yo, weight:91±18 kg, Fat%:29±9, BMI:29±5; VO2max:38±10 ml/kg/min) and 69 women (age: 33±11yo, weight: 82±17kg, Fat%: 43±8; BMI: 30±6; VO2max: 28±7 ml/kg/min) were analysed to assess protein expression (WB) and myosin heavy chain composition. VO2max (ergospirometry) and body composition (DXA) were determined. Statistics: ANCOVA, bivariate correlations and multiple linear regression with interaction
RESULTS: Women had higher fat % and lower VO2max than men even when expressed per kg of lower extremities lean mass (VO2max/LLM). Protein levels of NRF2, pSer40NRF2, Keap1 and NRF2/Keap1 ratio were similar in both sexes, even after accounting for sex differences in VO2max/LLM (all p>0.20). Protein levels of the AE Catalase, Glutathione Reductase (GR), SOD1 and SOD2 were similar in both sex after accounting for differences in VO2max/LLM. VO2max/LLM was positively associated with protein levels of SOD2 (r=0.55,p<0.001), NRF2 (r=0.21,p=0.003) and Keap1 (r=0.30,p<0.001). NRF2/Keap1 ratio was positively associated with the protein levels of GR (r=0.38,p<0.001) and Catalase (r=0.65, p<0.001). Multiple regression analysis showed that SOD2 is the AE more strongly associated with VO2max
CONCLUSION: These findings suggest that NRF2/Keap1 signalling likely plays a role in the regulation of the basal levels of several AE in HSM. Previous studies with lower sample sizes have shown temporary increases of AE (mostly SOD2) with training, with few reporting increased resting levels of SOD2. Our data suggest that at the population level, higher aerobic fitness associates with increased basal expression of muscle AE, which may contribute better metabolic health of subjects with higher VO2max. Aerobic fitness is a main determinant of the antioxidant capacity of HSM via mechanisms likely involving NRF2/Keap1/SOD2, GR and Catalase.
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### DIFFERENCES IN MUSCLE OXIDATIVE CAPACITY BETWEEN YOUNG AND ELDERLY: A COMPARISON BETWEEN NEAR INFRARED SPECTROSCOPY AND HIGH-RESOLUTION RESPIROMETRY.

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INTRODUCTION: Ageing is characterized by a progressive functional decline associated with substantial reduction in peak oxygen consumption (V'O2peak). In addition to reduced O2 supply to skeletal muscle, impairments in muscle oxidative metabolism and mitochondrial function are two of the hallmarks of ageing [1]. Muscle oxidative capacity is typically estimated "ex-vivo" using high-resolution respirometry (HRR) from permeabilized myofibers obtained from muscle biopsies, and "in-vivo" by 31-phospate magnetic resonance spectroscopy. Recently, near infrared spectroscopy (NIRS) has been demonstrated effective in measuring non-invasively muscle oxidative capacity in young subjects with different training status [2], subjects undergoing to bed-rest [3] and patients [4]. The aim of this study was to evaluate whether NIRS technique is capable of detecting differences in muscle oxidative capacity between young and elderly comparing results with HRR data.
METHODS: Eleven elderly (E, age:68±5 ys) and ten young (Y, age:23±2 ys) participants visited the laboratory in two different occasions. Each subject performed an incremental exercise test on a cycle ergometer up to exhaustion to determine V'O2peak. Muscle oxidative capacity of vastus lateralis (VL) was estimated by NIRS as muscle oxygen consumption (mVO2) recovery rate constant (k) obtained by changes in tissue saturation index during intermittent occlusions of femoral artery [5]. Muscle biopsies were collected from VL and HRR measurements were performed in saponin-permeabilized muscle fibers using saturating substrates for complexes I+II combined (CI+II).
RESULTS: V'O2peak was lower in E compared to Y (24.6±3.7 vs 34.6±5.0 ml/min/kg; p<0,001). k for mVO2 was slower in E than Y (1.79±0.56 vs 2.47±0.74min-1; p=0.028). O2 flux for CI+II in maximal ADP-activated state of oxidative phosphorylation (OXPHOS) was lower in E than Y (35.42±13.72 vs 51.00±4.43pmol*s-1*mg-1; p=0,004). V'O2peak correlated to k and O2 flux for CI+II OXPHOS (r=0.55 and r=0.63, respectively; all p<0.015). A correlation was also found between k and O2 flux for CI+II OXPHOS (r=0.58, p=0.014).
CONCLUSION: Elderly showed a reduced exercise tolerance compared to young subjects which was at least partially attributable to an impairment in the muscle oxidative capacity as demonstrated by both "in-vivo" and "ex-vivo" data. The present results demonstrate NIRS technique to be an effective non-invasive approach to detect differences in muscle oxidative capacity between young and elderly people.
BIBLIOGRAPHY
[1] M. Gonzalez-Freire et al., 2018
[2] M. J. M. Austin T Beever et al., 2020
[3] L. Zuccarelli et al., 2021
[4] A. Adami et al., 2020
[5] A. Adami et al., 2018

### HIITING AGEING WHERE IT HURTS: HIGH INTENSITY INTERVAL TRAINING AS A COUNTERMEASURE TO THE HALLMARKS OF HUMAN AGEING

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INTRODUCTION: The aim of the present investigation was to investigate whether 6 weeks high intensity interval training (HIIT) would affect biochemical hallmarks of ageing in older men. A secondary aim was to establish whether lifelong exercisers (LEX) exhibited a younger phenotype than sedentary older males (SED).
METHODS: Twenty-two males (62±2 years) comprised the SED group and 17 males (60±5 years) were enrolled as LEX. Individuals were tested at enrolment (phase A), following 6 weeks' preconditioning (SED) or maintenance of habitual training (LEX; phase B), and post-HIIT (6 x 30 s sprints at 40% peak power, once every five days; phase C). Blood draws were conducted at rest at the same time of day.
RESULTS: No difference between groups was observed for total testosterone or free testosterone throughout (P>0.05). Total testosterone increased in SED following preconditioning (P=0.007) and remained elevated post-HIIT compared to enrolment (P<0.001). Free testosterone in SED was greater post-HIIT than at enrolment (P=0.023). Total testosterone in LEX was unchanged throughout (P>0.05) but there was a small increase in free testosterone following HIIT (P=0.05). IGF-I was greater in LEX compared to SED at baseline (P=0.007), but not after preconditioning or post-HIIT (P>0.05). IGF-I increased in SED post-HIIT compared to baseline (P=0.002) and compared to preconditioning (P=0.005). LEX experienced no change in IGF-I throughout the study (P>0.05). Insulin was lower in LEX compared to SED at all phases (P<0.05). SED and LEX insulin was unchanged throughout (P>0.05). Glucose was not significantly different between groups at any phase (P>0.05). SED glucose was unchanged by preconditioning (P=0.598) but decreased following HIIT which was remained lower than enrol-

ment (both P<0.05). LEX glucose was unchanged throughout (P>0.05). IL-6 was significantly lower in LEX compared to SED at all phases (P<0.05). SED IL-6 decreased following preconditioning (P=0.001), without further change post-HIIT (P>0.05). However, SED IL-6 was significantly lower post-HIIT compared to enrolment (P=0.001). LEX experienced no change in IL-6 throughout (P>0.05). Homocysteine was not different between LEX and SED throughout (P>0.05). The only change within-groups occurred in LEX, whereby homocysteine was greater post-HIIT compared to enrolment (P=0.023). C-reactive protein (CRP) was significantly lower in LEX compared to SED throughout (P<0.05), and neither group experienced a change in CRP (P>0.05).
CONCLUSION: These data suggest that lifelong exercise promotes a younger phenotype compared to sedentarism (E.g. greater IGF-I, lower insulin, lower proinflammatory cytokines). Yet, some hallmarks of ageing can be attenuated with short-term HIIT. For example, post-HIIT free testosterone increased in both groups, whilst in SED IGF-I increased, and glucose and proinflammatory cytokines decreased.

**FERTILE IMPAIRMENT AFTER TREKKING AT HIGH ALTITUDE: A PROOF OF MECHANISMS ON REDOX AND METABOLIC CHANGES IN SPERM**

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INTRODUCTION: Many authors described the negative and reversible effects of high-altitude hypoxic exposure on animal and human fertility in terms of sperm concentration, function and biochemical alterations. In this line of research, the aim of this study was to evaluate the acute and chronic effects of high-altitude exposure on classical seminological parameters together with redox status and membrane composition in a group of Italian travellers.
METHODS: Five males, all healthy Italian lowlanders not accustomed to the altitude, were evaluated in response to a 19 days-trekking "Kanchenjunga Exploration & Physiology" through low, moderate and high altitudes. Participants completed a circuit of 300 Km distance, with over 16,000 meters of difference in altitude, covering an average daily walk of 6 hours. Sperm samples were collected before (Pre), 10 days after (Post) and 60-70 days after (Follow-up) the end of the expedition. Sperm concentration, cholesterol and oxysterols membrane content, and redox status by TOSCA and by EPR methods were measured. The blood content of hormones was determined using the immuno-chemiluminescence assay in the ADVIA Centaur XP Immunoassay System. Thyroid function – free triiodothyronine (FT3), free thyroxine (FT4), thyroid-stimulating hormone (TSH), the hypothalamus pituitary-gonadal axis – total testosterone, follicle-stimulating hormone (FSH), luteinizing hormone (LH), estradiol, and the prolactin cortisol pathways were assayed as well.
RESULTS: Hypoxic trek led to significant reduction in sperm concentration ($p < 0.001$, $\eta 2p = 0.91$, $\omega 2p = 0.88$), with a reduction from Pre to Post (71.33±38.81 to 60.65±34.63 ×106/ml, $p = 0.025$) and a further reduction at Follow-up (to 37.13±39.17 × 106/ml, $p < 0.001$ compared to Pre). Spermatic volume was significantly affected by the hypoxic trek ($p = .001$, $\eta 2p = 0.75$, $\omega 2p = 0.70$), with a significant reduction from Pre to Post (2.86±0.75 to 1.68±0.49 ml, $p = 0.001$) and a partial recovery at Follow up (to 2.46±0.45 ml, $p = 0.013$). Moreover, subjects had an increase in ROS production, and a decrease of antioxidant capacity at Post with a partial recovery at Follow-up analysis. Overall, the key result concerning the endocrine system was the impairment of the Hypothalamic-hypophyseal axis, which affect the functioning of sexual hormones significantly.
CONCLUSION: An uncontrolled ROS production, rather than a compromised antioxidant activity, was likely the cause of impaired fertility, triggered by damage to sperm quality. The reduction in fertility status observed in this study could have an evolutionary Darwinian explanation: limiting reproduction due to the "adaptive disadvantage" in terms of survival and reproduction offered by exposure to high altitude hypoxia combined with daily low to medium intensity exercise.

**MONTE ROSA EXPLORATION & PHYSIOLOGY 2021: RESULTS AND META-RESULTS TO MAKE FIELD RESEARCH FLOURISH**

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INTRODUCTION: INTRODUCTION: Traveling at high altitude has become popular and altitude expeditions represent valuable ecological models to evaluate the human response to the combined stressors of physical exercise and hypobaric hypoxia [1]. Involving learners, researchers, and enthusiasts in such field research may constitute an intriguing paradigm for fostering multidisciplinary research and providing original education tools.
METHODS: The multidisciplinary "Monte Rosa Exploration & Physiology" project has been carried out involving a group of scholars, student, and mountain enthusiasts (15 participants, 8 males and 7 females, most of them familiar with mountain hiking, but unfamiliar with high altitude exposure) who all trekked up to the European highest mountain hut and were actively engaged in the design and/or conduction of scientific tests. Meteorological data were collected with the mini weather station MeteoTracker [2]. Vital signs of blood pressure (BP), peripheral saturation (SpO 2 ), resting heart rate (HR), waist circumference, and weight were acquired at the lowest (1,191 m) and highest (4,554 m) point. Acute mountain sickness (AMS) was verified with the Lake Louise AMS score [3].
RESULTS: All the participants successfully completed the trek encountering a range of temperature from –3.5 to 31.3 °C and of humidity from to 36 to 95%. Among the vital signs, the greatest percentage difference was found for HR (from 67.9 ± 13.0 to 88.5 ± 11.6 bpm, $p<0.001$, d unb =1.35) and similarly increases were found at high altitude in all the metrics of BP, while SpO 2 decreased (from 98.5 ± 0.8 to 84.1 ± 3.1 %, $p<0.001$, d unb =4.14). AMS was diagnosed in 6 participants. Waist circumference and weight were both reduced at high altitude, although very slightly (mean difference of 1.47 cm, $p=0.032$, d unb =0.58 and 0.62 kg, $p=0.014$, d unb =0.69, respectively). As meta-results, scholars confirmed the exchange of research interests, students moved their first steps into field research, and enthusiasts experienced research up close.
CONCLUSION: Students and scholars experienced and verified in the field the expected physiological response due to hypoxic stress, the likely physical over-stress and the possible emergence of mountain sickness. Participants were moved by the different purposes for taking part in the expedition, and their exchange of ideas and interests nurtured the research possibilities and the expedition itself. Moving motivated stakeholders to altitude field research, mixing several research lines, taking advantage of technological advancements, structuring a medically adequate ascent plan (and having a bit of luck) as in the present successful trial can foster multidisciplinary research and scientific education while providing novel opportunities for public engagement.
References:
1. Bondi et al., Nutrients, 2021

2. https://meteotracker.com/en/home/
3. Roach et al., High Altitude Medicine & Biology, 2018

## Conventional Print Poster

### CP-AP13 Endurance performance

#### DO THE BEST ENDURANCE ATHLETES HAVE THE HIGHEST LACTATE THRESHOLD MEASURED AS %VO2MAX (LT%)?

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INTRODUCTION: LT expressed relative to absolute work output, e.g. as watt (LTW) among cyclists, show positive correlation with performance level (1). In contrast, the importance of LT expressed as %VO2max (LT%) in endurance sports has been unclear. Elite athletes are expected to have higher LT% than non-elite athletes (2), and data from cyclists imply differences between elite and regional athletes (3). On the other hand, another study in a small cohort of cyclists did not find a correlation between LT% and performance (1). The aim of the study was to assess whether there are differences in LT% between a large cohort of endurance athletes representing three different sports at the elite, national and regional levels.
METHODS: LT and VO2max data were collected from 292 athletes in three different endurance sports (75 long-distance runners, 95 cross-country skiers and 122 cyclists). LT was defined as the warm up [La−]b value (i.e., measured after the lowest running velocity) + 2.3 mmol · L −1, using the Arkray Lactate Pro LT-1710 analyzer. Performance level was divided into elite (N=71), national (N=158) and regional (N=63), based on history of competition level. A General Linear Model (GLM) with Tukey's post hoc test was performed to detect possible differences in VO2max and LT% between the three groups divided by competition level. A p-value ‹ 0.05 was accepted as statistically significant.
RESULTS: In total, the average VO2max among elite, national and regional athletes were 71.1 ± 6.5, 64.2 ± 8.0 and 58.1 ± 6.4 mL·kg-1·min-1 respectively, with significant differences between the three groups (p‹0.01). However, LT% were 79±6, 80±7 and 80±7 % respectively, with no significant differences between either of the three groups. In the order elite, national and regional level, VO2max results for males were 72.1±6.1, 68.0±7.1 and 60.6±5.5 mL·kg-1·min-1 respectively, with significant differences between all groups (p‹0.01). VO2max results for females were 64.8±5.2, 58.2±5.1 and 55.4±6.2 mL·kg-1·min-1 respectively, with significant differences between all groups (p‹0.01). LT% results for men were 77.9±6.3, 79.0±6.8 and 78.9±7.4% respectively, with no significant differences between groups. LT% results for women were 84.4±4.7, 82.6±5.4 and 81.9±6.7% respectively, with no significant differences between groups.
CONCLUSION: This study showed that LT% was similar between elite, national and regional endurance athletes, and therefore supports studies indicating that LT% is not a performance determining variable in endurance sports.
1: Støren Ø et al., J Strength Cond Res. Sep;27(9):2366-73, 2013. 2: Joyner MJ and Coyle EF. J Physiol 586: 35–44, 2008. 3: Støren Ø et al., J Strength Cond Res. Mar;28(3):622-9, 2014.

#### PREDICTING THE RATE OF FATIGUE DURING SKIING ON A SKI TREADMILL BASED ON ERGOSPIROMETRIC DATA

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INTRODUCTION: Explaining the rate of fatigue (ROF) [1] during skiing is of high interest to prevent injuries [2]. Former studies explained the ROF via blood lactate [3,4] or heart rate [3]. In order to derive the ROF without directly measuring it during skiing, we apply a Random Forest to predict the ROF as a function of features obtained from ergospirometric data.
METHODS: For the analysis we used data of three female and six male junior ski racers (age: avg = 13.2, sd = 0.4; height: avg = 157.8 cm, sd = 7.7; weight: avg = 45.9 kg, sd = 7.9). The experiment took place on a ski treadmill where participants were asked to ski as long as they were able to maintain a certain turning frequency (1.2 Hz). Participants rated their ROF every two minutes on a Likert scale from 0 (not at all fatigued) to 10 (total fatigue and exhaustion) [1]. For classification purposes, we grouped the ROF into three groups: mild fatigue (ROF: 0-3), moderate fatigue (ROF: 4-7) and severe fatigue (ROF: 8-10). To calculate features that would explain these three groups, we took the mean value of a respective feature 30 seconds before the ROF was assessed in a given time window. We collected 40 variables to use for feature selection [5], resulting in seven variables for the final analysis that were most important for predicting the ROF: Breathing rate, energy expenditure per kg, inspiratory tidal volume, carbohydrate oxidation (kcal/day), oxygen uptake per kg, METS and dead space to tidal volume ratio. For the tuning of the hyperparameters, we performed a 10-fold cross-validation. To split the data into test and training data, we applied a leave-one-subject-out cross validation, resulting in eight test data sets.
RESULTS: The mean accuracy of the eight test data sets was 47.9% (sd = 0.29) with a mean Cohens Kappa of 0.16 (sd = 0.29). The results varied greatly depending on the participant used as the test data set, ranging from 0.04 to 93.3% in terms of accuracy and 0 to 0.87 in terms of Cohens Kappa.
CONCLUSION: The results of this pilot study are promising for certain participants. We note that it is possible to use features based on ergospirometric data to predict the ROF for certain participants in the study. However, more data are needed to increase the performance of the proposed approach. For example, with more data, clustering approaches could be used to identify groups for which ROF prediction models could be applied separately. In addition, it would be interesting to include data from a wider variety of sources - i.e. kinetic and kinematic sources.
[1] Micklewright et al., Sport. Med., 2017
[2] Spörri et al., Br. J. Sports Med., 2012
[3] Seifert et al., J. Strength Cond. Res., 2009
[4] White & Wells, J. Strength Cond. Res., 2015
[5] Diaz-Uriarte, BMC Bioinformatics, 2007

**FACING THE ANAEROBIC THRESHOLD – A FACIAL ELECTROMYOGRAPHY APPROACH FOR PHYSIOLOGICAL THRESHOLDS IDENTIFICATION DURING AEROBIC EXERCISE TESTING**

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INTRODUCTION: Non-invasive, real-time monitoring of athletes' fatigue during exercise is crucial for performance enhancement and to avoid over-training and exercise-related injuries. Facial expressions quantification through facial surface electromyography (sEMG) have a great potential in fatigue evaluation and in quantifying fatigue related outcomes. Yet, despite increased interest and the great potential [1,2], this topic has not been widely studied, apparently due to a technical gap in sEMG technology that does not allow convenient and accurate measurement especially during dynamic exercise. Recently, a novel sensor of multiarray electrodes was introduced. The sensor was already used for long term recording in freely behaving humans [3] and for emotional affect sensing [4] and demonstrated the ability to measure "masked" smiles, and to detect diverse facial expressions for emotional affect recordings. In the current study we measured and analyzed facial muscle activity in response to the anaerobic threshold during a graded exercise test.
METHODS: 5 young, healthy, and recreationally active participants (2 females) performed an incremental cycling exercise test consisting of 3 min stages, below the lactic-acid based threshold, and increasing resistance every 1 min until exhaustion. Facial sEMG which was applied on the participant's left side of the face, covering the forehead, zygomatic, buccal, nasal, and labial regions by 16 embedded electrodes was recorded continuously throughout the exercise test. Blood lactate and heart rate were documented at each exercise stage. The envelope root mean square (eRMS) of the facial EMG signal at natural-expression, recorded from each electrode, was calculated, and then averaged for each stage, including during a 3 min recovery period. sEMG data was then transformed into heatmaps and correlated with exercise intensities. Paired T-test and Pearson's correlation coefficients were used to analyze differences between eRMS and facial expressions.
RESULTS: Average eRMS (obtained from 5 subjects X 16 electrodes each) showed a stepwise increase with exercise intensity, reaching a maximal value of 2.12±1.03 [μV], versus 1.22±0.437 [μV] for light intensity ($p<0.05$). After reaching maximal value, a gradual and significant decrease in eRMS values was measured during the recovery period: 1.09±0.601 [μV] versus the maximal value, $p<0.05$. eRMS values were highly correlated with blood lactate and exercise intensity ($r=0.975$, $p<0.05$).
CONCLUSION: Our novel multiarray sEMG electrodes is highly stabilized during dynamic exercise. In addition, facial expressions are correlated with exercise intensity and can predict the anaerobic threshold. This technology may be used under various exercise protocols to further understand the role of facial expressions during exercise.
REFERENCES:
1. de Morree & Marcora (2010) 2. Chen & Chung (2004) 3. Inzelberg, Rand et al. (2018) . 4. Inzelberg et al. (2018)

**COMPARISON OF THE CARDIO-RESPIRATORY RESPONSE DURING DEEP WATER RUNNING TRAINING VS INDOOR CYCLING TRAINING IN HEALTHY ATHLETIC SUBJECTS**

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INTRODUCTION: Running sports often lead to lower limb mechanical injuries, such as ligament rupture or cartilage wear. During the recovery phases, it is often advised to practice unloaded sports such as indoor cycling (IC), to maintain a good physical condition with limited mechanical stresses1. However, despite these recommendations, the injured athletes often lose cardio-pulmonary capacity and suffer from physical deconditioning when returning to the field. Therefore, we studied an alternative training that can be proposed: deep water running (DWR). DWR has previously been showed to reduce low-limb overload, improve muscle strength2 and balance3, while water resistance forces the subject to exert greater force than moving in air4. We therefore compared the cardio-pulmonary parameters during two types of continuous trainings: DWR and IC.
METHODS: Eight active healthy subjects were enrolled in the study; 23±3 yo, 50% women, maximal oxygen consumption (VO2max) measured during a cyclo-ergometric cardio-pulmonary exercise test (CPET) of 42±5 ml/min/kg. All subjects performed randomly a DWR and an IC continuous training session, with a minimum 24h between both sessions. Training sessions consisted of a 5-minutes warm-up at 80% of HR at first ventilatory threshold (VT1), followed by 10 minutes training at 100% HR at VT1, 2 minutes rest and again 10 minutes at 100% HR at VT1. For the DWR session, subjects wore a flotation belt (Nabaji) and two "pool noodles" below their arms, to maintain their head and shoulders above water. Heart rate (HR), gas exchange and ventilation (VE) were measured continuously during CPET and DWR/IC training sessions with lactate levels measured 30s after exercise. Oxygen consumption (VO2), VE and lactate during DWR and IC training were compared, with VO2 and VE averaged during the last minute of the training session.
RESULTS: At same HR, VO2 was significantly ($p=0.0002$) higher during DWR (40±7 ml/min/kg; 97±15% of VO2max) as compared to IC training (29±5 ml/min/kg; 69±13% of VO2max). At same HR, VE was significantly ($p=0.0016$) higher during DWR (81±20 L/min, 67±18% of VE max) as compared to IC training (55±18 L/min, 45±11% of VE max). However, lactate did not significantly differ between DWR (3.9±1.6 mmol/L; 43±22% of lactate max) and IC training (2.9±2.3 mmol/L; 33±30% of lactate max).
CONCLUSION: The present results showed that when training is calibrated by HR, the VO2 and VE are higher during DWR compared to IC. This might be related to smoothened chronotropic response in a context of lower limb hydrostatic compression increasing venous return and stroke volume. Regarding the fact that DWR training is less stressful for lower limb joints and can adequately stimulate the cardio-respiratory system, DWR can be proposed as an appropriate training for injured patients in recovery.
1 Glass & al., 1995
2 Foley & al., 2003
3 Simmons & Hansen, 1996
4 Miyoshu & al., 2004

**IMPACT OF ECCENTRIC EXERCISE-INDUCED MUSCLE DAMAGE ON ENDURANCE PERFORMANCE AND RUNNING BIOMECHANICS.**

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INTRODUCTION: The occurrence of exercise-induced muscle damage (EIMD) can affect the running pattern and endurance performance. However, the EIMD-induced changes in biomechanical and physiologic parameters remain poorly understood. The aim of this study was to

examine the effects of a single isokinetic eccentric (ECC) exercise and ensuing Delayed-Onset Muscle Soreness on running biomechanics, muscle activity and physiologic measures during an exhaustive endurance run performed 48h later.
METHODS: Fourteen healthy, moderately active men completed two treadmill running tests (at 85% maximal aerobic speed) until exhaustion, with a week interval between both tests. The subject's running kinematics (using a 3D motion system), heart rate, pulmonary gas exchange, muscle activity and perceived exertion were recorded during both endurance tests (ETs). Forty-eight hours before the second test (ET2), participants were submitted to a bilateral isokinetic eccentric (ECC) protocol on the knee extensors. Indirect markers of EIMD were assessed before and 48h after the ECC exercise.
RESULTS: The ECC protocol induced EIMD as indicated by a significant increase in plasma CK (x12.52 ±33.15%), muscle pain (4.53±2.73a.u), a significant reduction in maximal isometric contraction (-19.54±14.75%) and in vertical jump performance (-17.94±17.19%, p<0.01). The running time to exhaustion was shorter (-29.30±24.10%, p<0.05) while the perceived exertion was higher (-10.1±s6.86%) for ET2 (with EIMD) compared to ET1 (p<0.01). The physiological data showed no significant difference between both ETs, except for the lactate level and heart rate measured at the end of the run which appeared significantly lower at ET2 (p<0.05). A higher step frequency (2.56±2.32%) coupled with a decrease in stride length (-2.51±2.4%) was observed during ET2 compared to ET1 (p<0.05). Articular amplitudes showed no significant differences between ETs although changes in the running pattern (i.e., vertical pelvis oscillation) were identified from the start to the end of both ETs (p<0.05). The electromyography data revealed increased muscle activity of the knee extensors during stance phase during ET2 but it did not reach significance.
CONCLUSION: Our data suggest that the knee extensors EIMD altered the running biomechanics and endurance performance without significative changes of the physiological parameters. Further investigations are required to explore whether the EIMD-induced biomechanical modifications are the result of pain perception or impaired muscle function.

## CONVERSION OF VO2 TARGETS INTO EQUIVALENT LOADS FOR EXERCISE PRESCRIPTION AND TRAINING: VALIDATION OF A STRATEGY THAT ENSURES NOTHING IS LOST IN TRANSLATION

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INTRODUCTION: Aerobic exercise is medicine, able to induce specific health/fitness benefits in a dose-response manner. Adequate implementation of the intensity element of the exercise dose relies on the accurate conversion of oxygen consumption (V̇O2) targets, typically derived from incremental testing (RI), into an equivalent external load for a constant work rate session (CWR). We recently proposed a strategy that, by accounting for the gap between the VO2/load relationships from the RI vs. the CWR, ensures that nothing is lost in the translation between these exercise paradigms. The evaluation of accuracy and precision of the above strategy outside of the original male-only sample is the aim of this study.
METHODS: 14 adults (7 females, 25 ± 3 yrs.) performed on a cycle ergometer a RI to detect the mean response time (MRT) and V̇O2/Power output (PO) relationship in the moderate (i.e., GET and < respiratory compensation point (RCP)) domains of exercise. For each participant, a total of four intensity targets from the RI exercise paradigm (V̇O2RItarget), two GET RESULTS: V̇O2CWR elicited in the heavy was significantly higher than the moderate-intensity trials (respectively 2602±588 and 1271±389 ml·min-1, p<0.001). These intensities corresponded to 68±5 and 34±8 %V̇O2max for the heavy and moderate domain, respectively. Independent of the intensity domain (main effect of interaction p=0.230), V̇O2CWR did not significantly differ from the intended metabolic target i.e. from V̇O2RItarget (main effect of exercise paradigm p=0.590). A very strong, significant correlation was found between V̇O2CWR and V̇O2RItarget (R2 = 0.98; p < 0.001), while there was a very small, not significant bias and small imprecision between measures ((bias -9.68ml·min-1; Z-score = 0.62; precision 115.19 ml·min-1).
CONCLUSION: Our data confirm that the correction strategy proposed by Caen K., based on individual MRT and domain-specific V̇O2/PO correction coefficients derived from RI testing, maintains its accuracy and precision outside of the male-only sample used for the development of the method. This valid and time-efficient approach allows to identify the equivalent workload associated with a desired metabolic target, granting that the intensity element of the exercise dose will be appropriately implemented for training sessions in both the moderate and heavy domain of exercise.

## CUT OFF VALUE IN PREDICTION OF SUCCESS IN TRIATHLON MIXED RELAY

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INTRODUCTION: The mixed team triathlon relay first occured in the program of the Olympic Games in Tokyo 2021. National teams of 4 triathletes compete with every athlete running the super sprint distance (300 m swim, 7km cycle and 1,5 km run) in the Women / Men / Women / Men order. Until now, only one conference paper enlight this event (Pöller, 2015) on one event race. Recent developments on WTCS relays increase the number of events and offers the possibility to analyze more races.
To determine which placements along the race lead to the podium, we investigated athletes time on every sequence of the races. As a result, it helps staffs optimizing the composition of their relay.
METHODS: The dataset come from the World Triathlon database, range from 2009 to 2021 and contains 12 280 entries for a total of 38 races and 56 national teams. International races i.e. World Championships, the World Triathlon Series Championship relay, the continental Championship and the Major Events are included. Records were divided into 4 groups according to the final ranking of the teams: "Winner" (rank 1), "Medalists" (rank 2-3), "Finalist" (rank 4-8) and "Finisher" (rank 9 & +). A transition matrix based on three discrete-time Markov processes was used to estimate the probability of winning the race, finishing on the podium (TOP3) and finishing among the TOP 8. The probabilities are estimated at each stage end of the relay without taking transition times into account, (i.e. 12 stages, 3 per athlete).
RESULTS: The results show an increase in the probabilitý of winning the race when triathletes rank first as the race progresses, starting at 28.9%. Similarly, for each group, the probabilities increase for triathlete that succeed at staying in their groups at the end of the race. For the Finisher group, we observe a strong decrease of the probability to be classified in the finalists, from the first triathlete, starting at 29,0%.
We notice that the probability to win the race increases for the first three triathletes in the swim stage, ( 6,6% at SwimLeg1 vs 17,1% at the SwimLeg2). As well as an increase in the probability of being on the podium when staying in the Top 8 until the third relay, BikeLeg1 16,3% vs BikeLeg2 18,0%.
CONCLUSION: These results highlight intrinsic specificities of the mixed triathlon relay. (i) the podium is not defined from the first relay but starting too far from the leading group condemns the team. (ii) Within a relay team, the first two triathletes seem to constitute a strategic role of placement while the last two triathletes are more likely to carry out solitary time trial type efforts. Time differences between posi-

tions, which are maintained at the beginning and then increase throughout the race, suggest that a drafting effect loss (swimming and cycling only) could lead to abrupt breaks in the probability of reaching a higher state. This study allows to optimize the order and the composition of the relays for the national staffs during the world level events.

**OCCURRENCE OF GASTROINTESTINAL SYMPTOMS DURING EXERCISE IN ATHLETIC POPULATIONS**

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INTRODUCTION: Gastrointestinal (GI) symptoms are common in endurance athletes. Indeed, exercise induced GI distress has been reported to occur in 30-90% of distance runners (de Oliveira et al., 2014). However, there is limited data on the prevalence of GI symptoms in other sports. Therefore, the purpose of this study was to collect information on the history of GI discomfort in a wide range of athletes.
METHODS: 340 athletes (258 males; age = 26 ± 8 years, 82 females; age = 27 ± 8 years) completed a GI history and nutrition habits survey. GI symptoms were categorised into upper and lower abdominal symptoms. Athletes rated the frequency and severity of each symptom experienced during exercise. Information on food intolerances was also collected. Participants competed in a variety of sports and ranged in competitive level (recreational (14%), competitive (46%), national (25%), elite (12%) and occupational (2%)). A 5-sample proportion test was used for sports with participants N ≥ 25 (cycling, rugby union, running, soccer and triathlon) to determine associations between sport type and GI symptoms. A 2-proportion hypothesis test was used for association between gender and GI symptoms. Chi-Square associations were used to test for relationships between GI symptoms and: level of athlete, type of sport, frequency of competitions and self-reported food allergies.
RESULTS: The most common GI symptom reported was flatulence (59%). Approximately half of athletes reported “severe” symptoms of bloating (50%), urge to defecate (50%), upper abdominal cramp (48%) and nausea (48%). Males had a greater incidence of GI symptoms compared to females ($P < 0.001$). There was no association between the level of athlete and the occurrence of GI symptoms ($Z = 3.31$, $P = 0.930$). Incidence of GI symptoms differed between sport; 76% of triathletes had a history of GI symptoms compared to 48% of soccer players, 46% of runners, 38% of cyclists and 24% of rugby union players. A negative correlation was found between frequency of competitions and GI problems ($X2$ (4, $N = 329$) = 11.5, $P = 0.021$). Self-reported food allergies (not independently validated) were correlated to GI symptoms ($X2$ (1, $N = 334$) = 5.1, $P = 0.026$).
CONCLUSION: Approximately half of all athletes had experienced GI symptoms during exercise. Frequency of competition and type of sport may influence the incidence of GI symptoms. Future priorities should focus on educating athletes with strategies to reduce the frequency and severity of GI symptoms during exercise.
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References
1. de Oliveira EP et al. (2014). Gastrointestinal Complaints During Exercise: Prevalence, Etiology, and Nutritional Recommendations. Sports Med. 44(1), 79-85.

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### CP-MH14 Physical activity, health and injury prevention

**CARDIOPULMONARY EXERCISE IN FINE DUST ENVIRONMENT DOES NOT ACUTELY DETERIORATE PULMONARY FUNCTION IN HEALTHY YOUNG ADULTS**

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INTRODUCTION: Air pollution is a major environment issue and attributed to 11.65% of deaths globally. Especially fine dust is one of the first-class carcinogens and related to impaired pulmonary function and inflammation. Previous studies reported that fine dust reduces pulmonary function. However, there are a handful of studies to investigate the effect of cardiopulmonary exercise on pulmonary function in fine dust environment. Therefore, the purpose of this study was to examine the effects of acute cardiopulmonary exercise on pulmonary function in young adults under high-concentration fine dust environment.
METHODS: In cross-over design, seven participants (24.6 ± 0.5 years) visited our laboratory twice in both the high particulate matter (HPM) and low particulate matter (LPM) conditions. We measured fine dust concentrations by using AM520 SidePak Personal Aerosol Monitors. Participants performed indoor treadmill running for 30 minutes at 70% of each participant’s peak heart rate. Basic pulmonary function parameters and pulmonary diffusing capacity for carbon monoxide (DLco) were measured by using Quark PFT system including a respiratory chamber before and after the exercise.
RESULTS: The average concentration of fine dust in HPM was significantly higher than that in LPM (151.0 ± 31.0 vs. 11.1 ± 2.6 μg/m3, $P < 0.001$). There were no significant changes in FVC (forced vital capacity), FEV1 (forced expiratory volume in 1 second) and FEV1/FVC, DLco, and DLco/VA (alveolar volume) after the exercise under HPM level ($P > 0.409$). Under LPM level, FEV1 was increased after exercise (4.45 ± 0.16 vs. 4.53 ± 0.17 L, $P = 0.033$), but the other basic pulmonary function and diffusing capacity measures were not changed ($P > 0.134$).
CONCLUSION: In conclusion, moderate intensity cardiopulmonary exercise under high-level fine dust environment does not negatively affect pulmonary function in young adults, but may offset its positive influence under low-level fine dust environment.

### PHYSICAL ACTIVITY, MOTOR SKILLS AND AEROBIC FITNESS IN CHILDREN WITH ADHD

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INTRODUCTION: Although Children with Attention Deficit Hyperactivity Disorder often show fidgeting and excessive motor Behaviour, limited evidence suggests that their physical activity levels are lower in comparison to healthy peers. We investigated whether motor skills and aerobic fitness also differed between these groups, when physical activity differences were accounted for.
METHODS: Based on age, sex and socio-economic status, propensity scores were calculated and used for matching 60 children with ADHD (18 girls; mean age: 10.5 years) from the JETPAC to 60 healthy peers (21 girls; mean age 11.1 years). All participants completed an age-appropriate version of the Movement Assessment Battery for Children (2nd edition) and the Physical Work Capacity at 170 bpm Test. Additionally, they reported their physical activity using 7 day recall protocols and filled in the Family Affluence Scale.
RESULTS: In comparison to healthy controls, children with ADHD showed lower physical activity at vigorous intensity, but had similar levels of activity at moderate intensity. Analysis of variance further revealed that children with ADHD had lower scores on all subscales of the motor test battery (manual dexterity, ball handling and balance) and a reduced physical work capacity at 170 bpm. Group differences in all assessed aspects of physical fitness remained, even when vigorous physical activity was accounted for.
CONCLUSION: In addition to developmentally inappropriate levels of hyperactivity, impulsivity and inattention, children with ADHD show pronounced impairments in motor skills and aerobic fitness. These impairments do not seem to be due to a lower engagement in physical activity only. Given that motor skills and aerobic fitness both contribute to physical health and development, ADHD treatments need to be enriched by intervention components that target these aspects.

### STRENGTH TRAINING PROGRAM WITH EMPHASIS ON ECCENTRIC ACTIONS: DO THEY IMPROVE PHYSICAL PERFORMANCE IN WOMEN THE SAME WAY AS MEN?

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INTRODUCTION: Traditionally, strength coaches prescribed resistance training based on constant and concentrically oriented goals. However, most movements in the field require players to produce forces in variable and unpredictable contexts, with an emphasis on the eccentric (ECC) component. If movement repetition varies during competition, it makes sense to conduct training programs that prepare athletes for new movements that they will undergo in the future. In this sense, some studies used rotary inertial devices (RIDs) for improving physical performance and obtain an optimal transference to sports, since they offer specificity and variability in force vector application with emphasis on ECC phase of the movement. When comparing male and female subjects, both may benefit in similar ways from using RIDs during strength training. However, most of these studies have focused on strength and hypertrophy responses. Therefore, the aim of this study was to compare the effects of a RID variable and unpredictable strength training program with emphasis on ECC actions on sprint, counter-movement jump (CMJ) and change of direction (COD) performances in male and female athletes.
METHODS: Forty-two athletes (females n=21 and males n=21) volunteered for this study. The study lasted 8 weeks. During weeks 1 and 8, CMJ, 10 and 20m sprint and COD abilities were measured as pre- and post-test. The strength training program was carried out biweekly for 6 weeks (week 2 to 7), where subjects had to perform 4 sets of 7 repetitions of the half-squat exercise with an electric motor RID, which allows the use of different inertias for the concentric (CON) and ECC actions. With the aim of increasing the variability and unpredictability of the load, the subjects did not know the magnitude of the load in each set, so different inertial units (IU) loads were established randomly for each set having an average of 2:4 IU for CON:ECC, respectively, from week 1 and 2, and an average of 4:8 from week 3 to 6. In order to achieve ECC overload, the load of the ECC action was greater that the load chosen for the CON.
RESULTS: No significant time x group interaction was observed in this study. A significant main effect of time ($p < .001$; $\eta 2p = 0.424$) was observed for CMJ performance with moderate changes for both groups (ES> 0.7). No significant changes were observed for sprint and COD performances.
CONCLUSION: Male and female athletes may benefit in similar ways when using RIDs during strength training. The increased of the variability and unpredictability of the RID load during a squat exercise modifies CMJ performance, and appears no modify sprint and change of direction in women and men. Thus, it is recommended to choose exercises with similar force vectors applied in order to achieve greater training transference to sport-specific movement. In addition, the ECC overload stimulus achieved in each session allowed for greater positive magnitude of changes (ES> 0.7) on CMJ than those showed in literature for RIDs squat training.

### MONITORING PULSE PRESSURE, RATE PRESSURE PRODUCT AND MEAN ARTERIAL PRESSURE ALONG A 6-MONTH SUPERVISED PROGRAM IN PERIPHERAL ARTERY DISEASE

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INTRODUCTION: A controlled Systolic (SBP) and diastolic blood pressure (DBP) is an important directive to risk reduction in several cardiovascular diseases. Some literature warns that the target blood pressure of 130/80 mmHg for the general population and nearly all patients with hypertension may not be optimal with regard to lower-extremity peripheral artery disease (PAD) events [1]. Related cardiovascular disease risk and arterial stiffness markers, such as the rate-pressure product (RPP), the pulse pressure (PP), as an indirect marker of arterial stiffness, and the mean arterial pressure (MAP) can potentially add relevant information to this complex disease. To a safer condition is recommended to maintain the RPP lower than 10.0 mmHg/bpm and PP below 60 mmHg in resting condition. On the other hand, the MAP must stay close to 60 mmHg to perfuse vital organs and prevent the risk of ischemia. Study aims to examine the impact of a 6-month supervised program, focus on exercise and lifestyle changes, in RPP, PP and MAP in subjects with lower-extremity peripheral artery disease.
METHODS: Nineteen male patients with PAD and claudication in stage II of Fontaine classification (age= 63.8±5.6 years; ankle-brachial index below 0.90, hypertension= 74%, diabetes=58% and smokers and past-smokers= 74%) were grouped into Walking Group (WG, n=8) and Control Group (CG, n=11). Both, the WG (supervised 40-min treadmill walking, plus 3 sets of 15 repetitions of 3 lower-limbs resistance exercises, 3 times per week) and the CG (advise to walk 40-min, 3 times per week, control risk factors and change lifestyle) were enrolled in a 6-month supervised program. SBP, DBP and heart rate (HR) were measured after 15-min in a lying rest position at 0, 3 and 6-months. The RPP was determined by SBP*HR/100, the PP was set as the difference between SBP and DBP, and the MAP, determined by DBP+1/3*(PP).

RESULTS: Repeated measures ANOVA revealed no significant differences along the intervention, neither between WG and CG in PP, RPP or MAP at 0, 3 or 6-month. In CG, PP was 70.7±16.5 and 67.4±13.8 mmHg and, in WG was 60.1±14.8 and 59.6±15.7 mmHg (0 and 6 months, respectively). In CG, RPP was 10.1±2.3 and 9.6±2.1 mmHg/bpm, and in WG 10.1±1.9 and 10.2±2.6 mmHg/bpm (0 and 6 months, respectively). The MAP in CG was 107.2±14.5 and 94.6±31.3 mmHg, and in WG was 102.3±9.2 and 82.1±44.5 mmHg (0 and 6 months, respectively).
CONCLUSION: It was concluded that the variables PP and RPP more linked to cardiovascular risk remain stable, and near the target, along the 6-months supervised program. The MAP values, indirectly linked to risk of ischemia, shown an interesting decrease in both group strategies, and the threshold related to tissue perfusion was guaranteed in patients with lower-extremity PAD.
References: Itoga NK, Tawfik DS, Lee CK, Maruyama S, Leeper NJ, Chang TI. Association of blood pressure measurements with peripheral arterial disease events: reanalysis of the ALLHAT data. Circulation. 2018; 138: 1805–1814.

**HIGH INTENSITY INTERVAL TRAINING AND PAIN PERCEPTION**

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INTRODUCTION: Exercise-induced hypoalgesia (EIH) describes the reduction of pain sensitivity following physical activity. So far, little is known about EIH resulting from high intensity interval training (HIIT). The present trial aims to elaborate the effects of a 12-minute HIIT on EIH in healthy and sportive individuals on mechanical and ischemic pain perception.
METHODS: 20 subjects (12 males and 8 females aged 26±3) enrolled in this randomized controlled crossover trail. A pre-experimental session was conducted including an incremental bicycle ergometer test up to exhaustion, in which the individual maximum heart rate (HR) was determined. Subsequently, two different interventions with at least 72 hours in between were performed, in which mechanical pain pressure thresholds were assessed at the landmarks ankle, knee, and elbow joints as well as the forehead and the sternum via a hand-held pressure algometer (PPTa). Further, using a cuff pressure device wrapped around the midportion of the gastrocnemius–soleus muscles, ischemic PPTc were examined. Pain perception was examined pre and post a 12 minutes HIIT workout, consisting of whole-body exercises or 12 minutes relaxing breathing exercise as a control session, respectively.
RESULTS: The HIIT resulted in a mean HR of 166.3±9.8 1/min equaling a relative individual maximum HR of 90.7±3.3%. Regarding PPTa, results of the three-way ANOVA ('intervention' X 'time' X 'body landmark') indicate a significant 'intervention' X 'time' effect (p=0.006). Post-hoc analyses revealed that the HIIT led to hypoalgesia at the right (p=0.007) and left ankle (p=0.040), showing an increase of the PPTa from 41.9 to 48.9 Newton (N) and 42.9 to 48.1 N, respectively. Significant differences were further observed in the right knee (p=0.001; 68.0 to 80.0 N), and at the sternum (p=0.026; 34.4 to 37.7 N), while the control session did not induce changes of the PPTa at any landmark. Considering PPTc, the results of the three-way ANOVA indicate a main effect for the factor 'time' (p=0.041) and post hoc analyses revealed a significant hypoalgesic change after the HIIT at the left calf (p=0.046; 29.7 to 31.6 kPa) and a trend towards a significant hypoalgesic change at the right calf (p=0.058 30.3 to 33.9 kPa). The control session did not induce any changes.
CONCLUSION: EIH occurred at the primarily engaged joint landmarks (PPTa at ankle and knee and also in response to the PPTc), indicating that mechanical and ischemic pain stimuli were reduced by hypoalgesic effects. These phenomena are most likely induced by local pain inhibiting mechanisms, resulting from increased blood flow given the muscle activation. Further, hypoalgesia was observed at the sternum, indicating that also centrally mediated analgesic effects might be contributing processes. No changes were observed at the forehead as well as the elbow joints, most likely due to their little engagement during the HIIT.

**WEARABLE SENSOR TECHNOLOGY TO DETECT SHOCK IMPACTS IN SPORTS: A SCOPING REVIEW**

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INTRODUCTION: The majority of existing studies using wearable sensors within the sports domain have focused on total load exposure and technique. However, numerous types of sports entail events that may be harmful from just one single impact or a limited number of impacts. To assess such events, we need to know which types of sensor technology that most accurately can detect impacts in real-life settings in different contexts. Thus, the aim of this scoping review was to map existing methods for assessments of such shock impacts using wearable sensors. We aimed to identify types of wearables used, categories of sports and activities, sensor placement, outcome measures and overall knowledge gaps.
METHODS: The protocol was drafted using the PRISMA methodology and its extensions for scoping reviews (PRISMA-ScR). To be included, papers had to report shock impacts on the whole body or specific body regions with the use of wearable sensor technology, be written in English and published between 2010-2020. Wearables were limited to sensors attached to the body, to clothing, or to equipment used by the individual. Papers were excluded if they included individuals with a functional impairment, disability, or illness, or if they focused on movement quantification, total load, movement quality or technique only. The online databases MEDLINE, SportDiscus, Scopus, PubMed, Compendex, and ISI Web of Science were searched, and the software tool Covidence used for extraction of eligible papers.
RESULTS: Thirty-four papers were included in the data material. Of these, the majority were single intervention tests validating methodology (n=20) and longitudinal/observational studies (n=11). More than 20 different types or brands of sensors were used, and 25 of the 34 included studies used additional technologies like force plates or video recordings for validation. Accelerometers was the dominant type of wearable sensor technology, interpreting peak acceleration as a proxy for impact. Three main categories of assessments were identified: foot strike in running (n=12), head impacts in invasion and team sports (n=10) and jump landings (n=6).
CONCLUSION: We identified a high proportion of validation studies up against established gold standard methods. These studies suggest that wearable sensors at present do not provide the necessary accuracy as a stand-alone method for assessments of shock impacts in the field. Caution should further be made when considering the usability of wearable sensors for different sports and movement contexts, as it is unknown whether there may be differences in accuracy and validity between different brands. This scoping review revealed a lack of consensus regarding both sensor placement and interpretation of results. Furthermore, the absence of studies assessing single shock impacts other than head impacts in different invasion and team sports, as well as the overall lack of impact assessments in demanding winter sports and track and field, is stated as considerable knowledge gaps.

### CARDIAC AUTONOMIC EFFECTS OF SUBMAXIMAL EXERCISE IN ATHLETES AFTER CONCUSSION

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INTRODUCTION: Submaximal aerobic exercise is the first step in the return-to-sport (RTS) protocol after sports-related concussion (SRC) and appears to be effective in speeding up recovery. How exercise during RTS is related to cardiac dysautonomia, a prominent and often persistent feature of SRC, remains to be elucidated. The aim of this study was to explore measures of the cardiac autonomic nervous system (cANS) in response to submaximal exercise in concussed athletes during RTS.
METHODS: Thirty athletes participated in this study. 15 SRC athletes (age: 24 ± 5, BMI: 24 ± 2) were examined during RTS (days after concussion: 2-140, number of symptoms: 1-19). SRC athletes were compared to 15 matched controls (age: 25 ± 5, BMI: 24 ± 3). All athletes performed a progressive ergometer exercise protocol until reaching 70% of their age calculated maximal heart rate (HR). cANS data were collected pre and post (±10 minutes) exercise in supine position for 5 minutes using a wrist sensor (PPG). Mean HR (mHR) and the root mean square of successive differences of RR intervals (RMSSD) were analyzed. Subjective stress levels were documented pre and post exercise using the short recovery and stress scale. Wilcoxon Signed Rank Tests were used to explore statistical significance for differences between groups (concussed vs. controls) and time (pre vs. post exercise).
RESULTS: mHR increased significantly from pre to post exercise in the SRC group (median (Mdn) = 59.34 bpm, interquartile range (IQR) = 15.54 to Mdn = 66.38 bpm, IQR = 13.11, Z = - 3.41, $p < 0.001$, r = -0.622) as well as in the control group (Mdn = 58.22 bpm, IQR = 11.75 to Mdn = 66.58 bpm, IQR = 15.42, Z = -3.41, $p < 0.001$, r = -0.622). RMSSD decreased significantly from pre to post exercise only in the SRC group (Mdn = 65.00 ms, IQR = 73.72 to Mdn = 46.68 ms, IQR = 27.48, Z = -2.73, p = 0.006, r = -0.497). The submaximal exercise parameters did not differ significantly between groups in watts achieved (Mdn = 2.02 vs. 2.17 watts/kg) or duration (Mdn = 14 vs. 14 min) of exercise. Subjective stress significantly increased for the control athletes from pre (Mdn = 3, IQR = 3) to post exercise (Mdn = 2, IQR = 4, p= 0.036, r = -0.383).
CONCLUSION: Despite similar performance parameters during a submaximal exercise test, SRC athletes revealed a significant reduction in RMSSD 10 min post exercise when compared to controls, possibly indicating an altered cardiac parasympathetic recovery after submaximal aerobic exercise. High inter- and intraindividual variability of ANS parameters, the low sample size and broad range of days post injury need to be considered when interpreting these results.

### «ATHLETE FINGERPRINTING» OF ELITE ICE HOCKEY PLAYERS AND CROSS-COUNTRY SKIERS: TOWARDS PERSONALIZED SPORTS MEDICINE

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INTRODUCTION: Elite athletes regularly experience impaired performance due to upper respiratory disease (e.g., infections, asthma). Oftentimes, illness-related training interruptions happen during intense periods, such as before or during competitions, which has a major impact on the athlete's potential success. Apart from injuries, upper respiratory symptoms are the most common reason for elite athlete's presentation at their sports physician. So far, the reasons for the high prevalence remain unclear. Here, Olink proteomics can provide a better understanding of the underlying mechanisms and help the identification of potential biomarkers of susceptibility to infections, allergic disease and asthma in elite athletes.
METHODS: We assess immunological and molecular differences in serum samples of cross-country skiers (n=14) and ice hockey players (n=21), and two control groups of amateur athletes (n=29) and non-sportive persons (n=24), by means of Olink targeted proteomics, using a proximity extension assay. Measured panels included 184 proteins involved in immune response and inflammation. Information on training (e.g., weekly hours) and medical history (e.g., asthma, allergic disease) was obtained via questionnaires.
RESULTS: A substantial number of cross-country skiers and ice hockey players either suffer from asthma (14%), allergies in general (20%), allergic rhinitis (34%) and recurrent upper respiratory infections or fever (29% and 20% respectively in intense training periods). Loss of training due to infections is reported by 43% of all elite athletes. Targeted serum analyses of 184 proteins revealed that elite ice hockey players have significantly upregulated levels of proteins involved in immune response and inflammation in comparison to cross-country skiers. Those differentially expressed proteins play key roles in innate immune response to viral infection, platelet- endothelium-leukocyte interaction, apoptosis, Th cell differentiation, lymphocyte proliferation, and TREM1, interferon and Jak-STAT signaling.
CONCLUSION: Personalized sports medicine is a newly introduced concept, now allowed by targeted proteomics. Proximity extension assay-based proteomics revealed that ice hockey players exhibit an overall pro-inflammatory profile. In comparison, amateur athletes and non-sportive controls did not show any upregulation of pro-inflammatory proteins. Cross-country skiers' profiles in general are more comparable to the latter than to elite ice hockey players. Within the groups, there are athletes with different endotypes such as pro-inflammatory, hypermetabolic, strong anti-viral and/or tissue destruction, all of which remain to be further elucidated. The impact of recent physical activity, overtraining, microbiome and exogenous exposome on inflammation- and immune response-related proteins requires further investigation.

### CARDIOPULMONARY, METABOLIC, AND MUSCULAR DEMANDS OF A WHOLE-BODY WOBBLE BOARD (ICAROS CLOUD) TRAINING

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INTRODUCTION: Training on unstable surfaces requires complex motor control mechanisms and can enhance the ability to maintain balance, improve the activation of stabilizing muscles and may be a crucial protective factor against sports injuries.1,2 However, well-known wobble boards or unstable surfaces studied so far are small and only applicable for standing exercises. We investigated the effects of a new whole-body inflatable exergaming training system with digitally guided exercises on the cardiopulmonary, metabolic, and muscular systems and training enjoyment.
METHODS: Sixteen recreational athletes (f=5/m=11, 24±1 years, 176±7 cm, 71.3±10.3 kg) absolved two identical predefined interval trainings (12 minutes, six isometric and dynamic exercises) with (ICAROS Cloud; IC) and without (Control; CON) the IC exergaming system in a randomized cross-over study design. Data of heart rate (HR), maximal lactate concentration (maxLA), energy expenditure (EE), relative perceived exertion (RPE), muscle activity measured by electromyography (EMG) and normalized to maximal voluntary contraction (MVC) of

m. rectus abdominis and m. rectus femoris, as well as acute muscle soreness (AMS), and physical activity enjoyment (PACES) were recorded. Dependent t-tests were performed for treatment comparisons. Cohens d was used to estimate the effect size.
RESULTS: No differences between treatments were detected for averaged and maximal HR, maxLA, and averaged and maximal RPE (p≥.05, respectively). Slightly higher EE during training could be shown for IC compared to CON (IC: 106.6±19.6 kcal; CON: 102.3±20.3 kcal, p=.006, d=.8). Lower AMS values occurred in IC for m. rectus abdominis (IC: 2.7±2; CON: 3.4±2, p=.029, d=.61) and m. deltoideus (IC: 2.8±1.8; CON: 4.6±1.9, p=.004, d=.85) without differences between treatments in averaged EMG values normalized for MVC (p≥.05). IC showed higher scores for positive (IC: 3.5±0.6; CON: 2.9±0.4, p<.001, d=1.23) and lower scores for negative (IC: 1.5±0.6; CON: 1.9±0.6, p=.006, d=.8) related items of PACES. 81% of the subjects preferred IC training.
CONCLUSION: Training on the newly developed ICAROS Cloud system induced comparable physical stress as identical exercises performed without IC but resulted in greater enjoyment. Hence, training in IC guided with digital devices can be recommended due to overall preferences and an increase in joy and, therefore, might induce longer lasting training adherence.
1. Silva, P. B., Mrachacz-Kersting, N., Oliveira, A. S., & Kersting, U. G. (2018). Effect of wobble board training on movement strategies to maintain equilibrium on unstable surfaces. Human movement science, 58, 231–238.
2. Zemková, E. (2017). Instability resistance training for health and performance. Journal of Traditional and Complementary Medicine, 7(2), 245-250.

**CIRCULATING CELL-FREE DNA AS A BIOMARKER FOR INJURY PREDICTION?**

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INTRODUCTION: Circulating cell-free DNA (cfDNA) is considered an emerging biomarker in exercise physiology. Increases during exercise depend on exercise duration and intensity [1]. Changes in cfDNA concentrations could be associated with the onset of the overtraining syndrome [2]. This case study (n=2) investigates a possible association between cfDNA levels and the incidence of overload, which prevented one participant from completing the Salzburg 10/7 HIIT study (S10/7, NCT05067426) compared to one subject who completed the study.
METHODS: S10/7 investigates the effects of a 7-day (d) high-intensity interval training (HIIT) shock microcycle. The study consists of a baseline period (b) of 9 d with time points T0 (d 1 b) and T1 (d 8 b), an intervention period of 7 d (10 HIITs: 5x4 min at 90-95% HRmax with 2.5 min rest in between, followed by a 30-min run at low intensity below the lactate threshold (LT) of 1.5 mmol/l) with time points T2 (d 2) and T3 (d 7) and a post-intervention phase of 14 d with physiological exercise testing (PET) on three time points. Case 1 (C1; m, 23 yrs., 190 cm, 87.2 kg, LT 12.5 km/h) and -2 (C2; m, 30 yrs., 166 cm, 63.5 kg, LT 14 km/h) were analyzed. Participants complete baseline measurements (blood parameters, ECG, questionnaires) at T0 and a PET at T1. At T2 and T3, participants complete two supervised HIITs in the lab, one in the morning (AM) and the second one in the afternoon (PM). Venous cfDNA levels before and immediately after exercise and chronic changes of cytokine levels at rest were analyzed in C1 and C2.
RESULTS: C1 completed the study, whereas C2 discontinued the study on d 4 of the intervention due to iliotibial band syndrome during the intervention phase. Mean cfDNA levels (in ng/ml) were 6.8 (C1) and 7.4 (C2) before and 60.4 (C1) and 220.2 (C2) after PET at T1, with fold-changes (FC) of 8.9 (C1) and 29.6 (C2), respectively. Mean cfDNA levels were 6.7 (C1) and 5.8 (C2) before and 82.5 (C1) and 300.1 (C2) after HIITs at T2, with FC of 12.6 (C1) and 51.7 (C2). IL2 levels (in pg/ml) were 2.1 (C1) and 9.6 (C2) at T0, 2.7 (C1) and 10.7 (C2) at T1 2.4 (C1) and 11.7 (C2) at T2 AM. IL6 levels were 21.6 (C1) and 75.2 (C2) at T0, 26.1 (C1) and 87.7 (C2) at T1, 23.6 (C1) and 91.5 (C2) at T2 AM.
CONCLUSION: Absolute concentrations and changes in both cfDNA and inflammatory cytokines were more pronounced in C2, who discontinued the study because of an injury. In another study with 13 participants of almost similar aerobic fitness, PET provoked on average FC of 7.4, only [1]. Future studies need to systematically analyze larger injury-specific sample to clarify if cfDNA could be a biomarker for predicting overload and injury.
References:
1. Haller N, et al. Increases in Circulating Cell-Free DNA During Aerobic Running Depend on Intensity and Duration. Int J Sports Physiol Perform. 2017; 12: 455-462
2. Fatouros IG, et al. Cell-free plasma DNA as a novel marker of aseptic inflammation severity related to exercise overtraining. Clin Chem. 2006; 52:1820–4.

## Conventional Print Poster

### CP-BM01 Motor learning: Function of coordination networks

**A RANDOMIZED CONTROLLED STUDY TO ASSESS THE EFFECTS OF 12-WEEKS OF COORDINATIVE ACTIVITY BREAKS ON MOTOR FUNCTIONS AND BRAIN STRUCTURE OF YOUNG AND MIDDLE-AGED OFFICE WORKERS.**

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INTRODUCTION: Studies report a positive relationship between physical activity and cognitive functions over the entire lifespan [1]. Physical activity can also lead to changes in the brain structure [2]. However, most studies focused on the effects of aerobic and anaerobic exercise, and only a few studies investigated the influence of coordinative exercises. Therefore, we offered a coordinative activity break to the staff at the University of Graz. Besides the health promotion for the young to middle-aged adults, the project aimed to evaluate the effects of the training on brain structure and motor function.
METHODS: Seven men and 24 women (42.5±10.3 years) participated in the randomized controlled study. The nineteen participants of the intervention group (IG) performed the training, which consisted of 15 minutes of juggling and balancing tasks, two times per week for twelve weeks. Before the start of the intervention (week 0), six (week 6), and twelve (week 12) weeks after the start, we measured the balance (Y-Balance test), manual dexterity and bimanual coordination (Purdue Pegboard test), and reaction time (fall stick test). We as-

sessed the juggling performance (JP) with the 3-ball-cascade. Furthermore, we assessed changes in the gray matter (GM) volume of the brain with MRI (3T Magnetom Sykra scanner, Siemens Healthineers Erlangen, Germany) with a subgroup of the participants (n=26; IG=16, CG=9). The VBM-analysis was processed using SPM12 (Wellcome Department of Cognitive Neurology, London, v6906) and the Computational Anatomy Toolbox 12 (CAT12, r1113) under Matlab (The Mathworks, 2015). All results were FWE-corrected. We used analysis of variance, t-tests, and non-parametric tests with a significance level of 0.05 to analyze the data.
RESULTS: The JP increased significantly in the IG from week 0 (0.2±0.9) to week 6: (1.5±1.4 sec.; p<.05) and from week 6 to week 12 (3.8±4.2 sec.; p<.05), but did not change in the control group (CG). There was a significant difference in the JP between the IG and CG at week 6 (1.5±1.4 sec. vs. 0.0±0.0 sec.; p<.05) and week 12 (3.8±4.2 vs. 0.0±0.0 sec.; p<.05). GM volume significantly decreased in the precentral gyrus, middle frontal gyrus, Rolandic operculum (cluster size: kE=502; x=42, y=12, z=27), and insula (kE=247; x=46, y=9, z=4) of the right hemisphere at week 12. We did not observe any significant effects in the other parameters.
CONCLUSION: The training was associated with changes in the GM volume and with improvements in JP. We assume that the observed decrease in the GM volume indicates a reorganization of brain tissue, facilitating more automated and efficient coordination of voluntary movements and postural control. However, we found no effects on other motoric parameters. We had a physically active sample, which could be a reason for the lack of changes in the general motor functions.
REFERENCES
1) Etnier et al., JSEP, 1997
2) Erickson et al., Neurobiol. Aging, 2014

### VALIDITY OF A COMPUTERIZED WOBBLE BOARD FOR FINE MOTOR SKILLS EVALUATION

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INTRODUCTION: The evaluation of fine motor skills provides essential information about motor coordination, particularly in relation to age and clinical conditions. Several motor coordination assessments, such as the Grooved Peg Test (GPT), have been used to evaluate fine motor skills. Alongside, computerized wobble boards (WBs) have been suggested as accurate, reliable and valid tools to evaluate dynamic balance (1). Since WBs validity to assess fine motor skills has not been established, this study aimed to determine the validity of a computerized WB to assess upper limbs' fine motor skills in healthy young subjects.
METHODS: Thirteen young adults (age 26.9±3.9yrs; body mass 74.2±9.6kg; height 175±7.1cm) took part in two testing sessions, during which one WB test and one GPT were administered. The WB was connected to a laptop using a customized software, to visualize real time performances on a monitor through a motion marker (MM) and a Target Zone (TZ). During the WB test, the TZ displayed clockwise, counterclockwise, antero-posterior, medial-lateral motion patterns. For all WB tests the goal was to keep the MM within the TZ for as long as possible during the recording period. The WB test consisted of 4 different 15s trials (for each limb) with 30s recovery in between. Subjects were in a standing position, with the tested limb placed at 90° on the WB placed on a table and the monitor at eye level. The overall WB performance was represented by the sum of each condition per limb. The GPT (2) was carried out on a pegboard composed of a square table (10cmx10cm) with 25 holes arranged in a 5-by-5 grid, with varying keyhole orientation across the board and 25 pegs. Subjects were required to insert pegs into the board one at a time, completing the rows from left to right for right limb and from right to left for left limb, from top to bottom. The time recording started when subjects took the first peg and stopped when the last peg was inserted. The time to complete the GPT for each limb was recorded. Right and left limb times were averaged for each test and subsequently linear regression analysis (R2) was used to assess the relationship between WB and GPT. Root mean square error (RMSE) was also calculated. Statistical significance was set at p<0.05.
RESULTS: A very strong significant (p<0.0001) linear relationship (R2=0.85; RMSE=4.25) between WB (43.2±8.6s) and GPT (69.2±10.4s) was found. To clarify the relationship, the following equation was developed: GPT= -1.1216(WB) + 117.65.
CONCLUSION: The strong relationship between WBs and GPT indicated that WBs might be valid tools to assess fine motor skills in young adults. Considering that WBs include different motion patterns and joint range of movement, they could provide further information on fine motor skills, not only related on execution velocity and total time, particularly in patients with neurological disorder as Parkinson.
References
1. Fusco et al J Strength Cond Res 2020
2. Petrigna et al Heliyon 2020

### FUNCTIONAL CONNECTIVITY OF THE BRAIN IN ACTIVE PROFESSIONAL FOOTBALL (SOCCER) PLAYERS

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INTRODUCTION: Long-term consequences of heading associated repetitive head impacts (RHIs) in football (soccer) are an area of scientific debate with large clinical relevance. Functional magnetic resonance imaging (fMRI) based resting-state functional connectivity (FC) in intrinsic networks of semi-professional football players revealed increased FC within the default mode network (DMN) with large exposure to RHIs, but longitudinal fMRI investigations are still sparse. We therefore aimed to determine and evaluate potential FC changes in the DMN and the salience network (SN) in relation to heading in professional football players prospectively.
METHODS: 14 active professional male football players (20.36 ± 3.34 yrs.) were included in this exploratory, longitudinal study and were scanned twice with a 3T Philips Ingenia MRI scanner between November 2017 and May 2019. Between the scans, all trainings and matches were videotaped and all performed headers were counted. Resting-state fMRI data was analyzed with the CONN functional connectivity toolbox (v.20.b) using default preprocessing and denoising steps. Smoothing was set to 6mm. T1 weighted structural MRI sequences were included for individual anatomical reconstruction of the fMRI data. A region of interest (ROI)-to-ROI approach was applied to compare the differences between the measurements while controlling for age, focusing on ROIs of the DMN and the SN. 12 ROIs with 66 connections were analyzed with non-parametric statistics (cluster-level p-FDR <0.05). Spearman correlations between total header number and significant FC changes were calculated.
RESULTS: During the observation period of 10 to 18 months (median 17.2 months) 5822 headers in total (min.: 146, max.: 943, median: 340.5) were documented. FC increased significantly within the SN (p-FDR=0.023) specifically between the right supramarginal gyrus (SMG) and the anterior cingulate cortex (p-FDR=0.050) and between the right SMG and the left rostral prefrontal cortex (p-FDR=0.02). The numbers of total headers did not correlate with any changes in FC.

CONCLUSION: This study showed explorative FC changes within the SN, a relevant intrinsic network, suggesting functional resting-state changes in football players. However, within DMN changes with increasing impact exposure were not found. Duration of the observation period or level-of-play might have contributed to these results. A missing association between heading and SN FC changes might indicate an adaptation to playing football in general rather than a specific heading effect. To test this hypothesis larger samples and a control group are needed. Future studies should also include male and female football players of various levels-of-play and player's incidence rates as the observation period of this study varied.

**CHANGES IN THE MOTOR BEHAVIOUR DURING A FAMILIARISATION PROTOCOL TO A SOFT BACK EXOSKELETON.**

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INTRODUCTION: Back exoskeletons, defined as wearable structures that give an assistive torque to one or multiple joints, can prevent from low back disorders (LBD) during stoop lifting tasks (1). Results in the literature about benefits and disadvantages are inconsistent (2), possibly due to the lack of familiarisation to the use of exoskeletons (3). Thus, this study evaluated the effect of familiarisation to a back exoskeleton to define changes in the motor behaviour.
METHODS: Ten males (1.78±0.04 m, 69.9±5.8 kg, 22.3±2.4 years) performed 6 sessions of 1-h familiarisation to a CORFOR® soft back exoskeleton within 2 weeks. This familiarisation protocol consisted in several manual handling tasks and precision tasks involving trunk bending. Measurements were carried out at the beginning of the first session and at the end of each session, during which participants were asked to execute 10 repetitions of a lifting task in the sagittal plane using the stoop technique (8 kg; 15 cycles / minute). A timed precision task, involving the whole body to move a ring along a weaving metallic tube without touching it, was used to assess a performance score of the participant's ease with the exoskeleton. Prior to this CORFOR® familiarisation protocol, participants get used to stoop and precision tasks during 3 sessions of 20min. The level of muscle activity (RMS) was calculated from electromyographic (EMG) recordings of erector spinae (ES) and rectus abdominis (RA) muscles. Ellipse area of the centre of pressure displacements during the lifting task was calculated as a marker for postural stability. Back curvature was evaluated through 3D kinematics measurements yielding lumbar (LF) and thoracic (TF) flexions in the sagittal plane. A repeated measures ANOVA with Tuckey's HSD post-hoc tests were performed to assess the effect of the familiarisation protocol on the evolution of the motor behaviour.
RESULTS: Main effect of familiarisation was observed on performance score ($p<0.001$) and ellipse area ($p=0.01$). Post-hoc tests showed that sessions 3 to 6 were different ($p<0.05$) from the other sessions for these variables. There was no main effect of familiarisation on EMG RMS (ES: $p=0.63$; RA: $p=0.24$) or back curvature (LF: $p=0.12$; TF: $p=017$).
CONCLUSION: Changes in performance score and ellipse area suggested that the motor behaviour measured in the early stages of the participant's experience with the exoskeleton might not be representative of the long-term motor behaviour. This must be taken in consideration for the interpretation of the results of studies that investigated the effects of back exoskeleton without familiarisation. However, EMG and back curvature did not show any evolution across sessions. Accordingly, it seems that muscular and LBD possible benefits of the use of the exoskeleton do not change with practice.
REFERENCES:
1) De Looze et al., Ergonomics, 2016
2) Theurel & Desbrosses, IISE Trans Occup Ergon Hum Factors, 2019
3) Galle et al., Gait Posture, 2013

**IMPROVEMENTS IN POSTURAL STABILITY FOLLOWING AN ONLINE CORE INTERVENTION IN OLDER ADULTS.**

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INTRODUCTION: Falls are the leading cause of hospitalizations in North America in adults aged 65 years and older, the risk of falls increasing and balance decreasing with aging. Exercise of core muscles has been shown to improve balance in older adults by improving the proprioceptive system and the strengthening of muscles involved in postural stability. However, access to exercise may be challenging as some older adults face transportation issues, inclement weather, living in remote areas, and most recently, stay-at-home pandemic regulations. Thus, online exercises are essential to reducing the obstacles to exercise participation and improving postural stability in older adults. The purpose of this study, then, was to examine the effects of an 8-week online and self-led core exercise intervention on postural stability in older adults.
METHODS: Recruited through convenience and snowball sampling, 26 older adults (73.7±5.76 years; 24F:2M), participated in this pre-to-post intervention. Inclusion criteria were adults aged 65 years and older and exclusion criteria were medical conditions for which physical activity was contraindicated. Before the start of the intervention, postural stability was assessed in the mediolateral and anteroposterior planes by recording six 30-second trials of quiet standing with eyes closed: 3 trials facing the webcam and 3 trials with the left side facing the webcam. Hip and shoulder displacement were then calculated using Kinovea, a free for download sports analysis software. The core exercise intervention consisted of three 20-minute sessions per week, over 8 weeks. One session was led online, through Zoom, by a kinesiologist and the participants were then asked to complete these same exercises at 2 other times during the week, on their own time. Modifications were offered and a chair was the only equipment necessary. The same postural stability assessment was repeated post-intervention. A non-parametric Wilcoxon signed-rank test to compare displacement pre- to post-intervention with significance set to $p < 0.05$.
RESULTS: All means indicated improved postural stability, but there were no significant differences from pre- to post-intervention in mediolateral plane displacement at the hips (pre=1.99±0.92, post=1.84±1.02; $p=0.42$) or shoulders (pre=2.26±1.26, post=1.92±1.13; $p=0.44$), nor in anteroposterior plane displacement at the shoulders (pre=3.60±1.22, post=3.23±1.39; $p=0.12$). A significant difference pre- to post-intervention in anteroposterior plane displacement at the hips was observed (pre=2.79±1.13, post=2.31±0.88; $p=0.02$).
CONCLUSION: An online and self-led core exercise intervention is safe and effective at improving anteroposterior postural stability at the hips in older adults. The use of Kinovea offers a cost-efficient method to motion analysis which can be completed online. This study suggests that online and self-led interventions are feasible in the older adult population to reduce barriers to exercise access.

### NEUROMUSCULAR CO-CONTRACTION RATIOS CAN HELP UNDERSTANDING TRUNK KINEMATICS DURING PERTURBED STANCE.

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INTRODUCTION: During postural tasks, trunk motion relationship with neuromuscular activations have mainly been studied thanks to EMG latencies and amplitudes. However, it has been suggested that co-contractions could be a strategy to control trunk instability by stiffening the spine [1]. Hence, the main objective of the present study was to link trunk neuromuscular control thanks to co-contraction ratios with its kinematics during balance tasks.
METHODS: Thirty-six healthy male adults performed 6 trials of a postural perturbation task. Subjects stood on their left leg and faced a 550 ms support translation towards the right of 5.7 cm. Trunk angle in the frontal plane was recorded with IMUs together with EMG signals from the rectus abdominis, external obliquus and erector spinae muscles. Directed Co-Contraction Ratios (DCCR) [2] and Co-Contraction Indexes (CCI) [3] were computed. They respectively reflect the balance between left (agonists) and right (antagonists) muscles and the level of spine stiffness. Each variable was calculated over 100 ms windows, from 100 ms before ground translation (PRE) to 800 ms after. Moreover, maximal trunk amplitude was assessed. Repeated measures ANOVA between each time window and multiple linear regressions predicting trunk amplitude with DCCR and CCI were computed.
RESULTS: Lateral trunk angle increased significantly during the first 500 ms and reached its peak value (11.9±7.8°) at 571±183 ms. Between -100 ms and 100 ms, DCCR remained mainly negative (-0.35±0.44), then significantly switched to positive values (DCCR_200=0.59±0.28) until 300 ms and then were negative again. CCI increased significantly from -100 ms (CCI_PRE=336±168) to 200 ms (CCI_200=968±757) and then was stable around 1000.
DCCR predicted 39.1% of trunk lateral amplitude variance and CCI predicted 19.3% of this variance ($p<0.05$). Significant beta-coefficients were the PRE window for the DCCR model (B=-0.48) and the 300-400 ms window for DCCR (B=0.62) and CCI model (B=0.79). During PRE, an increased DCCR, in favour of lateral muscle activations, was linked with a decrease of trunk amplitude. Then, enhanced DCCR and CCI were related to a larger trunk amplitude.
CONCLUSION: The switch towards positive DCCR values indicated a larger weight for lateral muscles activation, probably increasing lateral lean during 100-300 ms window, whereas the later medial neuromuscular eccentric activation would limit trunk's lean. The CCI rise might reflect the need of stabilizing the trunk by stiffening the spine in the latest part of the perturbation.
Overall, early trunk lateral lean appeared to be the consequence of trunk muscles' actions, and was then limited by medial muscles and spine stiffness. Co-contraction ratios could therefore help understanding trunk kinematics.
REFERENCES:
1) Preuss & Fung, J Electromyogr Kinesiol, 2008
2) Donnelly et al., J Sci Med Sport, 2015
3) Rudolph et al., Knee Surg Sports Traumatol Arthrosc, 2000

### AN ANALYSIS OF LOWER EXTREMITY KINEMATICS IN RESPONSE TO PERTURBATIONS DURING RUNNING USING STATISTICAL PARAMETRIC MAPPING

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INTRODUCTION: Investigation of human balance control strategies might help to avoid fall incidents, prevent injuries, and may characterise movement impairments, such as in neurological diseases or musculoskeletal pain conditions. However, little is known about balance strategies during running. Kinematic assessment of perturbed running continuously throughout a gait cycle can map out balance control strategies, which might be correlated with injury risk or onset. Therefore, lower extremity kinematics were analysed in response to decelerative perturbations during running using statistical parametric mapping (SPM).
METHODS: A sample of 13 asymptomatic individuals (8 females & 5 males, 28±3 years, 171±9 cm, 68±10 kg) completed an 8-minute running protocol with 30 one-sided perturbations (15 on each side) to generate decelerative disturbances. A 3D-motion capture system including 13 cameras (500Hz) was employed to record kinematic data. Joint angles of the ankle, knee, and hip in addition to stride duration, stride length and step width were calculated for leading and trailing strides for regular (RR) and perturbed running (PR). Results were analysed descriptively, followed by one-dimensional SPM of multiple paired t-tests to compare RR versus PR joint angles (MATLAB®). Spatiotemporal parameters of stride duration, stride length and step width were compared between RR and PR with paired t-tests (SPSS statistics 22) ($P<0.025$).
RESULTS: Reactively (after perturbation), perturbations caused decreased hip adduction and stride duration of the leading leg. The trailing leg reacted with reduced ankle inversion, knee and hip flexion, hip adduction, as well as an increase in stride duration and step width ($P<0.025$). In preparation for perturbations, the leading stride did not change ($P>0.025$) however, the trailing leg reduced ankle dorsiflexion, knee flexion, and hip flexion and adduction ($P<0.025$).
CONCLUSION: In summary, applied perturbations produced substantial reactive (feedback) and predictive (feedforward) responses in the lower limbs, most apparent in the trailing leg. Observed adjustments suggest an attempt of the body to keep the foot close to the ground and widen its base of support, indicated by less hip adduction and step width, to avoid a fall.

### FIELD-BASED ASSESSMENT OF LOWER AND UPPER-LIMB VISUOMOTOR REACTION TIME IN FEMALE FOOTBALL GOALKEEPERS: A PILOT STUDY

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INTRODUCTION: The ability to execute rapid motor responses to visual stimuli is a key demand for football goalkeepers (GK). While most of previous training studies focus on improving pure motor functions, interventions that address visuomotor performance of the upper and lower extremity are still scarce (Otte et al., 2020). The aims of the pilot study were to validate a self-developed field-based visuomotor reaction time test and to investigate how the test performance relates to an GK's qualities.
METHODS: Six female football GKs (21,5□4,3, national level), 5 female football forwards (24,6□4,3, national) from the two teams (domestic league), and 6 female controls (age:21□1,9) were included. Simple and choice reaction time (RT) of the upper and lower limb were assessed

with the FitLight Trainer™ system. During the visuomotor test, participants needed to respond as fast as possible to 4 sensors light stimuli in standing position. Two sensors were positioned on eye level (one arm length) and two sensors were placed on ankle height in front of the participants (each upper and lower sensor placed left and right of participants midline). For the simple RT task, the participants were responding to a single sensor at each position (n=10). For the choice RT task, a random sequence (n=12 each) was used. To test for criterion validity, visuomotor RTs were correlated with perceptual-cognitive (cognitive flexibility, working memory; Trail-Making-Test) and motor performance (agility T-Test; MTT). For GKs only, we analysed how visuomotor RTs related to the assessed GKs qualities (rated by each team coach) using an adapted questionnaire (GKs abilities and characteristics; GKAC score). To analyze potential relationships between each limb RT, Pearson correlation coefficients were calculated.
RESULTS: A strong correlation was found between a higher overall GKAC score and faster SRT of left hand (r = 0,872;p = 0,023) and the right leg (r = 0,904;p = 0,013). No significant relationship was found between RTs and standard perceptual-cognitive and motor performance (p>0.05).
CONCLUSION: Our results provide initial evidence for a potential relationship between higher playing abilities rating scores (GKAC) and faster visuomotor speed of the lower and upper limb in GKs, indicating the ecological validity of the developed RT test. Future studies with larger sample sizes are warranted to confirm our intriguing findings and to elucidate further how this or similar visuomotor tests relate to in-game performance scores, which may open up new avenues to improve performance screening and training of football GKs.
Otte, F. W., Millar, S. K., & Klatt, S. (2020). How does the modern football goalkeeper train?–An exploration of expert goalkeeper coaches' skill training approaches. Journal of Sports Sciences, 38(11–12), 1465–1473. https://doi.org/10.1080/02640414.2019.1643202

### HOW DO EXPLICIT CONTEXTUAL CUES IN VIRTUAL-REALITY AFFECT SENSORIMOTOR CONTROL IN AUTISTIC ADULTS?

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INTRODUCTION: Most autistic people have difficulties with controlling their bodily movements and processing sensory cues. These difficulties can limit a person's ability to perform key practical skills, while affecting how independent they are and how much physical activity they do. Recent research suggests that movement-related issues in autism could be reduced by providing individuals with explicit information about their surrounding environment. Therefore, we examined how explicit contextual cues in immersive virtual-reality affect autistic sensorimotor control.
METHODS: 22 autistic and 22 non-autistic participants completed a virtual racquetball task, in which they were required to hit normal and unexpectedly-bouncy balls using a handheld virtual-reality controller. The probability of facing each type of ball was varied unpredictably over time, in order to create volatile environmental conditions. During a cued block of trials participants received explicit visual information about the likelihood of facing each ball outcome. Conversely, non-cued trials did not contain any prior cues about likely ball bounciness.
RESULTS: When compared to a non-autistic control group, autistic individuals displayed poorer task performance, atypical gaze profiles, and more restricted swing kinematics. Although these participants showed intact predictive sensorimotor control abilities, their visuomotor control was not significantly affected by prior contextual cues in virtual-reality.
CONCLUSION: Results indicate that autistic people exhibit underlying differences in how prior information and environmental uncertainty are dynamically modulated by the brain. Our findings support the development of evidence-based programmes that make the world more stable and/or predictable for autistic people.

### PLAYING WITH A TABLE TENNIS RACKET SHORTENS YOUR PERCEIVED ARM LENGTHS

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INTRODUCTION: Many sports activities require the use of specific implements like rackets, bats and clubs. Thus, an argument can be made that tool-use is a defining characteristic in many sports. Evidence from studies in cognitive psychology suggests that specific cognitive processes support tool-use in humans including for example changes in body representations (1). Thus, these processes may affect task execution in sports as well which has important implications for training regimes and performance. Therefore, the present study seeks to explore whether bouncing with a table tennis racket triggers changes in body representation. We expected that arm lengths would increase due to the embedding of the racket into the arm body representation.
METHODS: 23 participants participated in the study in a pre-post-design. Following previous studies (2), during testing participants placed one arm inside an apparatus and subsequently indicated the perceived positions of the elbow, the wrist, and the middle finger tip using the index finger of the opposite arm whilst being blindfolded. Both arms were tested such that the non-dominant arm served as a control. After pre-testing participants bounced a ball using a table tennis racket for ten minutes with their dominant hand. Segment lengths of the forearm, the hand, and deviations from actual lengths were modelled using a linear mixed-effects model ($\alpha = 0.05$).
RESULTS: Total arm lengths decreased from pre- to post ($p < 0.01$, $d = 0.29$). Analyzing arm and forearm separately, indicated no statistical significant effects for hand but statistical significant effects for the forearm ($p < 0.05$, $d = 0.32$). No interaction effects were found indicating that effects occurred in both arms. Deviations from actual total arm length suggested that participants underestimated lengths. No differences were found between the arms but deviations increased during post testing ($p < 0.05$, $d = 0.21$). Thus, changes in body representation were found were the forearm was perceived shorter after treatment and this effect transferred from the manipulated dominant arm to the non-dominant control arm.
CONCLUSION: The results showed that using a table tennis racket alters the body representation after only ten minutes of activity. However, the changes were in the opposite direction to what was expected. The results further showed that even in the non-dominant control arm the body representation was altered which is indicative of a transfer effect. Taken together, the results suggest that changes in body representation found in other tasks involving tool-use also occur in sports. At present, it is unclear to what extent these changes are linked to performance although evidence from blind cane users suggests a correlation. Thus, further research seems warranted investigating tool-use in sports.
1) Martel et al. (2016). Cogn Neuropsychol, 33(1-2), 82-101.
2) Cardinali et al. (2009). Curr Biol, 19(12), R478-479.
3) Serino et al. (2007). Psychol Sci, 18(7), 642-648.

## Conventional Print Poster

### CP-MH03 Exercise and training in patient populations

#### DIFFERENCES IN AEROBIC EXERCISE TRAINING-INDUCED FSTL1 EXPRESSION CHANGES IN DIFFERENT TISSUES IN OBESITY

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INTRODUCTION: Follistatin-like 1 (FSTL1) constitutively expresses and secretes in various tissues, mainly muscles, myocardial and adipose tissues, and is involved in cardioprotection, glucose uptake, adipose thermogenesis and anti-inflammation (1-4). Therefore, it is an essential hormone for the prevention and improvement of obesity, diabetes, cardiovascular disease and aging. However, a change in secretion from several tissues in response to exercise training remains unclear. This study aimed to examine the changes in FSTL1 protein expression in response to exercise training in various tissues, such as muscles, myocardial and adipose tissues in obesity.
METHODS: Male 20-week-old obese (OLETF) rats were divided into sedentary control (OLETF-CON: N=8) and 8-week aerobic exercise training (OLETF-AT: treadmill running for 60min at 25m/min, 5days/week: N=8) groups. In addition, age-matched male LETO rats were used as a healthy sedentary control group (N=8). After the 8-week experiment, slow-twitch fiber-rich soleus muscle, fast-twitch fiber rich tibialis anterior muscle, left ventricular and epididymal fat were isolated after collection of blood. Serum, muscles, myocardium and adipose FSTL1 protein expression levels were measured by Western Blot. Soleus citrate synthase (CS) were measured as a marker of aerobic exercise training adaptation.
RESULTS: In the OLETF-CON group, serum FSTL1 levels and soleus CS activity were significantly lower than those in the LETO group ($p<0.05$). Compared with the OLETF-CON group, serum and soleus FSTL1 levels, and soleus CS activity were significantly greater in the OLETF-AT group ($p<0.05$). However, there were no significant differences in tibialis anterior muscle, myocardium and adipose FSTL1 levels among three groups. Serum FSTL1 levels were positively correlated with soleus FSTL1 levels ($p<0.05$, $r=0.462$), but not tibialis anterior muscle, myocardium and adipose FSTL1 levels.
CONCLUSION: Since the treadmill running exercise used in this study promoted the CS activity of the soleus muscle, it is considered that the slow muscle fibers are mainly recruited by the aerobic exercise training. These findings suggest that the increased FSTL1 expression of soleus muscle, which is a slow-twitch fiber-rich, may be involved in aerobic exercise training-induced increases in blood FSTL1 secretion in obesity.
Reference:
1. Raschke S & Eckel J, Mediators Inflamm, 2013
2. Lee HJ et al, Cell Signal, 2017
3. Fang D et al, Metabolism, 2019
4. Peters MMC et al, Mini Rev Med Chem, 2019

#### HIGH-INTENSITY INTERVAL TRAINING IN PATIENTS WITH COPD: A FIDELITY AND TOLERABILITY STUDY

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INTRODUCTION: Chronic obstructive pulmonary disease (COPD) is the third leading course of death [1]. Optimizing the recommendations for physical activity (PA) in COPD is a major target, since increased PA levels is associated with increased quality of life, reduced risk of hospitalizations and death [2]. High intensity interval training (HIIT) is time efficient and has the benefits of allowing COPD patients to complete a relative high workload sufficient to induce adaptations. Even though HIIT is widely used in pulmonary rehabilitation (PR), an optimal HIIT protocol remains as a focus of interest. This study was designed to compare long and short intervals in terms fidelity and tolerability in COPD.
METHODS: The study was a randomized cross-over trial. Ten patients diagnosed with moderate to severe COPD (58.5 ± 13.5 FEV1 %) completed the study. We compared 4x4 minutes (heart rate (HR) > 85 % of HRmax in min 3:50min) and 10 x 1 minutes (intensity at 100% of watt max) performed one week apart. To evaluate and compare the two HIIT protocols we used a predesigned model of fidelity and tolerability. The model was designed to evaluate each session in a red-amber-green system. Fidelity was accessed as adherence to training duration and training intensity measured as minutes with a HR > 85 % of HRmax for the 4 x 4 protocol and number of intervals with watt adjustment for the 10 x 1 protocol. The tolerability was assessed by a 10-point Likert scale. The lowest of the three parameters determined the overall rank of the session.
RESULTS: All participants completed the 4 x 4 protocol with a HR > 85 % in more than 3:50 minutes. One training session was reported as red and three as amber due to a low Likert scale. In the 10x1 protocol three training sessions were reported red and one amber due to both low Likert scales and adjustments to the training intensity. There was no statistical difference between protocols for either time spent with a HR>85% of HRmax or Likert scale.
CONCLUSION: Our results indicate that the 4 x 4 is more favorable in terms of fidelity in COPD. Both intervals of long and short duration are feasible in moderate to severe COPD. To find the optimal HIIT protocol in COPD the heterogeneous aspect of the disease and co-morbidities should be considered.
1. Sandelowsky, H., Weinreich, U. M., Aarli, B. B., Sundh, J., Høines, K., Stratelis, G., Løkke, A.,
Janson, C., Jensen, C., & Larsson, K. (2021). COPD – do the right thing. BMC Family Practice, 22(1), 1–17.
2. Pimenta, S., Silva, C. G., Flora, S., Hipólito, N., Burtin, C., Oliveira, A., Morais, N., Brites-pereira, M., Carreira, B. P., Januário, F., Andrade, L., Martins, V., Rodrigues, F., Brooks, D., Marques, A., & Cruz, J. (2021). What motivates patients with COPD to be physically active? A cross-sectional study. Journal of Clinical Medicine, 10(23), 1–14.

**EFFECTS OF SUPERVISED AEROBIC-STRENGTH TRAINING AND DIETARY INTERVENTION ON COGNITIVE PERFORMANCE IN SEDENTARY ADULTS WITH OBESITY**

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INTRODUCTION: The incidence of obesity in adults is increasing markedly. Numerous studies have demonstrated that higher levels of obesity are associated with accelerated decline in cognitive performance (learning and memory). Regular physical exercise can support body weight maintenance. induce favourable changes in body composition as well as boost cognitive functions in adults. This study was aimed at examining the effects of exercise training intervention on cognitive performance in healthy adults with obesity.
METHODS: Thirteen adults underwent 3-month (age 38.6±6.2yrs; BMI 33.9±3.1 kg/m2; M7/F6) supervised aerobic-strength exercise training (two 1h strength and one 1h aerobic training sessions per week). Dietary intervention consisted of caloric restriction, food intake monitoring (caloric tables) and individualized dietary counselling once per week. The strength training targeted the major muscle groups, the initial workload was based on 15RM and 5% increase was introduced at each mesocycle. Aerobic training consisted of interval training using indoor cycling and rowing, boxing and step climbing (stepping), with a progressive increase of the interval from 5 up to 15 minutes/session. Rays auditory verbal learning test (AVLT) was performed before and after the intervention to assess cognitive performance. The learning score (learning ability), the score for delayed recall (short-term working memory) and the percentage of retention were calculated.
RESULTS: Three-month intervention induced an average weight loss of 9 kg (range 3.6 kg -14.9 kg) and increased aerobic physical fitness on average by 3.9 ml/kg/min (VO2max from 25.2±7.2 to 29.1±7.0 ml/kg/min) in adults with obesity. The cognitive performance improved in working memory (learning score 53.77±7.02 vs. 60.60±6.61; p=0.02), the delayed recall (12.00±2.38 vs. 13.83±1.03; p=0.02), but not in the percentage of retention (93.03±10.91 vs. 100.22±8.37; p=0.08) in adults with obesity. The percentage of retention was high and its variability in this population could be explained by the negative association with body weight (r=0.40; p=0.05).
CONCLUSION: Regular supervised aerobic-strength training positively affected body weight, physical fitness, and auditory learning performance in healthy adults with obesity. Here we provide evidence that regular exercise in combination with nutritional modification and caloric restriction should be recommended for individuals with obesity to boost cognitive performance.

**THE HYPOGLYCEMIC EFFECT OF EXERCISE COMBINED WITH SPIRULINA IN DIABETIC RATS: A SYSTEMATIC REVIEW AND META-ANALYSIS**

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INTRODUCTION: Diabetes mellitus (DM) is the most common chronic disease, which is predicted to affect approximately 643 million adults worldwide by 2030. Exercise has been endorsed as a key component in the management of DM, and is effective in improving glycaemic control. In addition to exercise, the functional food spirulina has been developed for DM because of excellent efficacy and no toxic side effects. Many researchers have confirmed that the hypoglycemic effect of the combination of exercise and spirulina in diabetic rats was significantly more effective than the single treatment, but some researchers have found that there is no difference. Therefore, it was still controversial in the hypoglycemic effect of exercise combined with spirulina in diabetic rats. We attempted to explore the effect and mechanism of exercise combined with spirulina in the treatment of diabetes, providing the reference for human clinical trial research and clinical treatment of diabetes.
METHODS: This study combined and analyzed the blood glucose (BG) in the combined treatment and the single treatment by systematic review and meta-analysis. The systematic review report was carried out based on the PRISMA. We conducted a literature search of PubMed, Embase, Scopus, Web of Science, Cochrane Library, Medline and CNKI for randomized controlled trials from their inception through April 2022. Two investigators independently performed literature screening, data extraction and quality evaluation., and the third researcher reviewed in case of disagreement. The quality appraisal was implemented by the SYRCLE tool. Meta-analysis was performed by Stata 16.0 software, and the outcome BG was calculated by combining the standard mean difference (SMD). Publication bias analysis was performed for BG by Egger test.
RESULTS: Four studies about exercise combined with spirulina in diabetic rats were included. A total of 156 experimental rats were included, and 52 diabetic rats were treated by exercise combined with spirulina. The included studies had a risk of bias of 8 points and low heterogeneity, as high quality literature. There was a highly significant difference in BG between combined therapy and spirulina supplementation (SMD=-0.88; 95% CI:-1.38~-0.42; P<0.01), and exercise therapy (SMD=-0.91; 95% CI:-1.37~-0.44; P<0.01), indicating that the hypoglycemic effect of exercise combined with spirulina in diabetic rats was significantly more effective than the single treatment. The Egger test indicated no publication bias between the spirulina treatment and combined treatment(t=-1.88, P>|t|=0.2013>0.05), and the exercise treatment (t=-1.90, P>|t|=0.1972>0.05).
CONCLUSION: Evidence indicated that the hypoglycemic effect of exercise combined with spirulina was more effective than either exercise or spirulina supplement. Based on the above evidence, we believed that exercise combined with spirulina improved the BG by synergistic effect of the protein expression independently.

**CIRCULATING SESTRINS AND FORCE VELOCITY PROFILING IN OLDER ADULTS WITH TYPE 2 DIABETES**

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INTRODUCTION: Type 2 diabetes mellitus (T2DM) has an impact on skeletal muscle, exacerbating the negative effects of aging, such as loss of muscle mass, strength, and physical function. Stress-inducible proteins named sestrins are potential novel biomarkers of muscle function due to their ability to suppress oxidative stress and prevent muscle degeneration. Our aim was to determine the association between different force-velocity (F-V) deficit profiles with physical performance (PP), body composition (BC), and circulating sestrins in Spanish older adults with T2DM to define sestrins potential utility as biomarkers of physical functionality.
METHODS: Fifty-nine participants were classified into 3 groups according to their F-V profile based on the leg press exercise: nondeficit (NDEF=40.7%), force deficit (FDEF=28.8%), and velocity deficit (VDEF=30.5%). BC was determined by bioimpedance; physical function was evaluated through the short PP battery test (SPPB), and sestrin 1 (Sesn1) and 2 (Sesn2) were analyzed by Western Blotting. Statistical

analysis was carried out using ANOVA tests, and receiver operator characteristic (ROC) curves were plotted using the program GraphPad Prism v6.0.
RESULTS: Our findings revealed that older adults with T2DM and FDEF had a significantly lower concentration in serum Sens2 (0.60 ±0.06 a.u.) compared to NDEF (0.8±0.1 a.u.) or VDEF participants (0.77±0.07 a.u.) ($p < 0.01$). Maximal dynamic strength, arms, and legs fat-free mass were also reduced in FDEF compared to NDEF group ($p<0.05$), whereas Sens1, glycated hemoglobin (HbA1c), and fasting glucose levels were similar among all groups. ROC analysis additionally showed differences between F-V deficit groups according to Sesn2 concentrations, with a better cut-off point of 0.63 (a.u.).
CONCLUSION: These results suggest that reduced levels of sestrin 2 are associated with a progressive decrease in skeletal muscle mass, and therefore a decrease in strength and functionality.
Older adults with T2DM show different F-V profiles related to low levels of Sesn2, impaired BC and PP. Basal serum sestrin 2 levels are potential biomarkers to characterize F-V profiles and it should be taken into consideration to target exercise training in this specific population.
Funding: This study was funded by Sociedad Española de Diabetes, Grant/Award Number: SE1911600154.
Alcazar J, Rodriguez-Lopez C, Ara I, et al. Force-velocity profiling in older adults: An adequate tool for the management of functional trajectories with aging. Exp Gerontol. 2018;108(January):1-6. doi:10.1016/j.exger.2018.03.015
Rajan SP, Anwar M, Jain B, Khan MA, Dey S, Dey AB. Serum sestrins: potential predictive molecule in human sarcopenia. Aging Clin Exp Res. 2020;(0123456789). doi:10.1007/s40520-020-01642-9

### THE EFFECTIVENESS OF A DIGITAL-ASSISTED GROUP REHABILITATION AFTER TOTAL HIP AND KNEE ARTHROPLASTY: A PILOT CLINICAL TRIAL

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INTRODUCTION: The rising prevalence of osteoarthritis and the increasing number of total hip and knee arthroplasties [1] as well as the decreasing availability of physiotherapists [2] require new approaches for an effective postoperative rehabilitation. Digital-assisted group exercise programs can provide patients with individual rehabilitation while one therapist is able to supervise multiple patients at the same time. Therefore, the effectiveness of a novel digital-assisted individualized group therapy on functional outcomes and quality of life was evaluated in a randomized controlled pilot study. We hypothesized that the novel rehabilitation concept is more time efficient for the therapist and allows more therapy sessions for each patient resulting in better clinical outcome.
METHODS: Before total knee or hip arthroplasty surgery, 21 patients were randomly assigned to an intervention group (IG: novel digital-assisted group therapy twice a week for 30 min carried out over 6 months) or a control group (CG: postoperative standard individual therapy currently executed in Germany). Patients outcome was assessed preoperatively as well as 6 months after surgery. Quality of life (EQ-5D) as well as functional outcomes (30 Second sit to stand Test (STS), Timed up and go Test (TUG)), and gait velocity (GV) were quantified and analyzed using an analysis of covariance with baseline adjustment (ANCOVA, A1). Furthermore, additional ANCOVAs taking the number of therapy sessions into account were conducted (A2). Significance was set at $p<0.05$.
RESULTS: The IG received significantly more therapy sessions (39.09±8.10) than the CG (21.20±11.59, $p=0.001$). The ANCOVAs with baseline adjustment (A1) revealed no significant mean group differences for STS (1.03, $p=0.716$, $\eta2=0.011$), TUG (-1.83s, $p=0.262$ $\eta2=0.096$), GV (0.09m/s, $p=0.422$, $\eta2=0.050$), EQ-5D Index (19.09, $p=0.137$, $\eta2=0.162$) and EQ-5D VAS (7.70, $p=0.181$, $\eta2=0.133$). However, small to large effect sizes for the therapy-induced changes were found, indicating a tendency for greater improvements in the IG 6 months post-surgery. This tendency was also observed for the EQ-5D Index (19.39, $p=0.278$, $\eta2=0.097$) as well as the EQ-5D VAS (14.24, $p=0.093$, $\eta2=0.217$) after accounting for the different number of therapy sessions (A2).
CONCLUSION: The novel digital-assisted group rehabilitation concept allowed more therapy sessions for each individual. Effect sizes indicated that the higher training volume had positive effects on medium-term clinical outcome and quality of life after total hip and knee arthroplasty. The results point out that it is worth to conduct a larger randomized controlled trial.
[1] Wengler et al. Hip and Knee Replacement in Germany and the USA: Analysis of Individual Inpatient Data From German and US Hospitals for the Years 2005 to 2011. Dtsch Arztebl Int. 2014;111(23–24):407-16.
[2] Neldner et al. Entwicklung der Angebotsstruktur, der Beschäftigung sowie des Fachkräftebedarfs im nichtärztlichen Bereich der Gesundheitswirtschaft. BMWi. 2017.

### EFFICACY OF A MULTICOMPONENT CHAIR-BASED EXERCISE PROGRAM WITH COGNITIVE-MOTOR EXERCISES TO PROMOTE INDEPENDENCE IN ACTIVITIES OF DAILY LIVING FOR NURSING HOME RESIDENTS WITH MOBILITY RESTRICTIONS

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INTRODUCTION: Nursing home residents are often characterized by dependency in activities of daily living (ADL) and severe mobility restrictions (1). Chair-based exercise (CBE) interventions may enable older people with restricted mobility to engage in physical exercise and thus promote motor and cognitive resources for ADL. So far, the type of exercises across different CBE programs differs greatly. Multicomponent exercise (e.g., a combination of strength, endurance, coordination, and task-specific training on ADL) combined with cognitive-motor exercises have shown promising results and might be advantageous compared to programs that use only one physical conditioning-component (2). However, most multicomponent exercise studies investigated independent older adults. Less is known about the efficacy of multicomponent CBE programs for those who are dependent in ADL. The aim of this study was to examine the efficacy of a multicomponent CBE program with cognitive-motor exercises to promote motor and cognitive resources for ADL for nursing home residents with severe mobility restrictions.
METHODS: A two-arm single-blinded randomized controlled trial integrated N=52 nursing home residents (81 ±11 years, 63% female) with severe restricted mobility assigned to a training or a wait list control group. Training duration was 16 weeks (twice a week; 60 minutes). Type of exercise was a multicomponent CBE program with cognitive-motor exercises. Primary outcomes to assess independence in ADL were the Barthel index and working memory (counting backwards). Statistics was performed using ANOVA for repeated measures.

RESULTS: Interaction effects of the ANOVA showed significant improvement of the intervention group over the control group in the Barthel index (F(1, 21) = 10.229, p = .003, ŋ_p^2 = .192) and working memory (F(1, 10) = 19.542, p = .001, ŋ_p^2 = .459) of the participants. The control group showed a decrease in both parameters after 16 weeks.
CONCLUSION: The multicomponent CBE program including cognitive-motor exercises is beneficial for improving independence in ADL for nursing home residents with severe restricted mobility. The results support the hypothesis that despite their high level of dependency nursing home residents can improve motor and cognitive resources to perform ADL.
REFERENCES:
1. Scheidt-Nave, C., Richter, S., Fuchs, J., & Kuhlmey, A. (2010). Herausforderungen an die Gesundheitsforschung für eine alternde Gesellschaft am Beispiel "Multimorbidität". Bundesgesundheitsblatt, Gesundheitsforschung, Gesundheitsschutz, 53(5), 441–450.
2. de Souto Barreto, P., Morley, J. E., Chodzko-Zajko, W., H. Pitkala, K., Weening-Djiksterhuis, E., Rodriguez-Mañas, L., Barbagallo, M., Rosendahl, E., Sinclair, A., Landi, F., Izquierdo, M., Vellas, B. & Rolland, Y. (2016). Recommendations on Physical Activity and Exercise for Older Adults Living in Long-Term Care Facilities: A Taskforce Report. J Am Med Dir Assoc, 17(5), 381–392.

**LONG-TERM EFFECTS OF HYBRID INTRADIALYTIC EXERCISE ON LEFT-VENTRICULAR FUNCTION**

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INTRODUCTION: Cardiovascular disease is the most common cause of death in hemodialysis (HD) patients (1). It is well known that intradialytic aerobic exercise can improve cardiovascular risk factors and reduce mortality in HD patients (2,3). The impact of other forms of exercise, such as hybrid exercise (aerobic exercise followed by resistance exercise), is not clear. The present study examined whether hybrid intradialytic exercise has a long-term benefit on left ventricular structure and function in HD patients.
METHODS: Twelve stable HD patients (10M/2F, 56±19yrs) participated in a nine-month-long hybrid intradialytic training program. Supine cycle exercise was performed three times weekly for 60 minutes each time during the first 2 hours of a HD session, using an adapted bicycle ergometer, at an intensity of 50-60% of the patient's maximal exercise capacity. Resistance exercises were performed using resistance bands and portable ankle weights and dumbbells. Echocardiographic assessment of left-ventricular structure and function was performed before, during and after the HD session at baseline and after the nine-month intervention. Left ventricular dimensions were determined from 2-dimensional guided M-Mode images, whilst left ventricular diastolic function was assessed from an apical 4-chamber view using conventional Doppler and Tissue Doppler Imaging techniques. Ejection fraction was calculated using the biplane Simpson's method.
RESULTS: All twelve HD patients completed the nine-month intervention program without any adverse effects. Ejection fraction (EF) improved significantly after nine months of hybrid exercise training compared to the baseline value (48.7±11.1 vs 58.8±6.5, p=0.046). EF measured at the end of the HD session increased from pre-HD assessment (50.0±13.4 vs 56.1±3.4, p= 0.054).
CONCLUSION: A nine-month hybrid intradialytic exercise training program resulted to a significant improvement in ejection fraction. Intradialytic hybrid exercise training was a safe and effective non-pharmacological approach to improve cardiac function in HD patients.
References
1. Cozzolino, M., et al., Cardiovascular disease in dialysis patients. Nephrol Dial Transplant, 2018. 33(suppl_3): p. iii28-iii34.
2. Deligiannis, A., et al., Cardiac effects of exercise rehabilitation in hemodialysis patients. Int J Cardiol, 1999. 70(3): p. 253-66
3. Graham-Brown, M.P.M., et al., A randomized controlled trial to investigate the effects of intra-dialytic cycling on left ventricular mass. Kidney Int, 2021. 99(6): p. 1478-1486.

## Conventional Print Poster

### CP-PN03 Nutrition

**UPTAKE AND UTILIZATION OF 15N-LABELLED DIETARY NITRATE BY SKELETAL MUSCLE**

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INTRODUCTION: The nitrate (NO3-) and nitrite (NO2-) stored in skeletal muscle may be important in the maintenance of systemic nitric oxide (NO) bioavailability, especially when NO requirements are elevated such as during exercise. At any given time, skeletal muscle NO3- concentration ([NO3-]) reflects the balance between metabolism of NO3- into other nitrogen-containing species, oxidation of NO produced via nitric oxide synthases (NOS), and NO3- uptake consequent to dietary NO3- ingestion. The purpose of this study was to use a stable isotope tracer (15N-labelled NO3-) to investigate the metabolic fate of ingested NO3- through the determination of changes in NO3- concentration in skeletal muscle alongside other tissues at rest and following exercise.
METHODS: 10 healthy adults volunteered to participate in this double-blind, randomised, placebo-controlled study. Participants completed two experimental visits in which they consumed a beverage containing 12.8 mmol 15N-labelled potassium nitrate (K15NO3) or a potassium chloride placebo. Skeletal muscle (m. vastus lateralis) samples were collected at baseline, for 3 h post-supplement ingestion, and immediately following the completion of 60 maximal, unilateral contractions of the knee extensors over 5 min. All biological samples were analysed using ozone-based chemiluminescence to quantify total [NO3-] and [NO2-], and by mass spectrometry to determine the endogenous vs. exogenous origin of NO3- and NO2- (i.e., by determining the recovery of 15NO3- and 15NO2- in these tissues following the ingestion of K15NO3).
RESULTS: Neither muscle [NO3-] nor [NO2-] were altered following placebo ingestion compared to baseline. Following K15NO3 ingestion, muscle [NO3-] was elevated above baseline at both 1 h and 3 h (baseline, 35 ± 9 nmol.g-1; 1 h, 147 ± 71 nmol.g-1; 3 h, 105 ± 41 nmol.g-1; P<0.001). The majority of the increase in NO3- in muscle at 1 h was 15N-labelled (baseline: 0.9 ± 0.4 nmol.g-1; 1 h: 100 ± 63 nmol.g-1; 3 h: 50 ± 25 nmol.g-1; P<0.001). However, at 3 h, there was also an increase in skeletal muscle [NO3-] that was not 15N-labelled (baseline: 34 ± 9 nmol.g-1 vs. 3 h: 55 ± 21 nmol.g-1; P<0.05). Although there was no change in total skeletal muscle [NO2-] following the ingestion of the K15NO3 bolus, there was an increase in the contribution of 15N- labelled [NO2-] in skeletal muscle at 1 h (baseline: 0.02 ± 0.01 nmol.g-1 vs. 1 h: 0.12 ± 0.14 nmol.g-1; P<0.05), but not at 3 h, following NO3- ingestion. Exercise did not induce significant changes in total skeletal

muscle [NO3-] or [NO2-]; however there was a reduction in 15N-labelled skeletal muscle [NO3-] from pre- to post-exercise (50 ± 25 vs. 28 ± 21 nmol.g-1; P<0.05).
CONCLUSION: This study shows for the first time that skeletal muscle rapidly and robustly takes up 15N-labelled dietary NO3-. This 15N-labelled NO3- appears to be utilized to support skeletal muscle metabolic processes, such as conversion to NO2- and NO, during maximal contractions.

**ERGOGENIC EFFECT OF CAFFEINE ON 100-M SPRINT PERFORMANCE IN ATHLETICS: A FIELD TEST**

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INTRODUCTION: Pre-exercise caffeine supplementation acutely enhances performance in various sports, both aerobic and anaerobic [Grgic et al. 2020]. To focus on athletics, the International Association of Athletics Federations (currently called World Athletics) proclaimed the effect of caffeine as an ergogenic aid to enhance sprint running performance in the consensus statement of the nutrition strategy for athletics [Burke et al. 2019; Slater et al. 2019]. However, no study has assessed the acute effect of caffeine supplementation on 100-m sprint running in athletics, and caffeine's net ergogenicity on 100-m sprint running remains unclear. We investigated the acute effects of caffeine supplementation on 100-m sprint running performance in a field test with a hypothesis that caffeine supplementation would shorten 100-m sprint time by increasing the running performance in the first 60 m.
METHODS: Thirteen male collegiate sprinters (Age: 20.6 ± 1.0 yrs; personal best 100-m sprint time: 11.18 ± 0.38 sec) were subjected to 100-m sprint running time trials (TTs) after ingestion of 6 mg･kg-1 body weight caffeine or placebo supplementation in a double-blind, counterbalanced, randomized, and crossover design. Sprint velocity was measured with a laser system, and sprint time was calculated from the data in which the effects of environmental factors that would act as confounding factors on sprint time during TTs were eliminated [Mureika, 2001; 2006]. Comparisons of the corrected 100-m sprint time were performed using a paired Student's t test. Comparisons of the corrected 60-m sprint time were performed using the Wilcoxon signed-rank test. Planned a priori comparisons between two conditions for the mean sprint velocity every 10 m were tested by a paired Student's t test. The statistical significance level was set at $P < 0.05$.
RESULTS: The corrected 100-m sprint time was significantly shortened by 0.14 sec with caffeine supplementation compared with placebo (placebo: 11.40 ± 0.39 sec, caffeine: 11.26 ± 0.33 sec, P = 0.007, d = -0.35 [-0.63 to -0.07]). The corrected sprint time up to 60 m during TTs was also significantly shorter with caffeine supplementation than with placebo (median of placebo: 7.21 sec [7.04-7.25], caffeine: 7.07 sec [6.90-7.13], P = 0.006). Furthermore, the mean sprint velocity for 0-10 and 10-20 m splits was significantly increased by caffeine supplementation (all $P < 0.05$).
CONCLUSION: Acute caffeine supplementation enhanced the corrected 100-m sprint time by improving the sprint performance in the first 60 m following more explosive acceleration in the early stage of the acceleration phase. Thus, for the first time, we directly demonstrated caffeine's ergogenicity on sprint performance in athletics.

**THE EFFECTS OF SODIUM BICARBONATE SUPPLEMENTATION ON SPRINT INTERVAL SWIMMING PERFORMANCE IN TRAINED COMPETITIVE SWIMMERS**

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INTRODUCTION: The use of sodium bicarbonate (NaHCO3) supplementation to improve repeated high intensity performance is recommended, however most swimming performance studies examine time trial efforts rather than repeated swims indicative of training sessions. The aim of this study therefore was to investigate the effects of sodium bicarbonate supplementation on sprint interval swimming reflective of a typical training session.
METHODS: Fourteen trained competitive swimmers (body mass: 73±8 kg) volunteered for this double blind, randomised, crossover designed study. Each participant was asked to swim 50 m (front crawl), from a competitive diving block, at their maximum effort and repeat this 8 times (Interspersed with a 50 m active recovery swim). Each exercise bout was run off a 5 min base, which left the participants with approximately 3 min passive recovery. After one familiarisation trial, this was repeated on two separate occasions whereby participants ingested either 0.3 g.kg-1 BM NaHCO3 or 0.05 g.kg-1 BM sodium chloride (placebo) 60 minutes prior to exercise. Time to complete each 50 m interval was recorded, along with blood measures for pH and bicarbonate (HCO3-) using a Radiometer (ABL9, Copenhagen, Denmark) and lactate (Lactate Pro 2, Arkray, Japan) at rest, at 60 min (post-supplementation), and post-exercise. Aggregated gastrointestinal (GI) discomfort was measured using Visual Analogue Scales (VAS) within a range of symptoms throughout each trial. Two-way repeated measures ANOVA were used to assess performance and blood measures and were conducted using a statistical software package (SPSS V28, IBM, Chicago, IL, USA). Hedges' g effect size (ES) was also calculated for pairwise comparisons between treatments and interpreted using Cohens D thresholds.
RESULTS: Performance was improved by NaHCO3 ingestion prior to the interval swimming (p=0.005, $P\eta 2$=0.301). Whilst there were no differences between sprints 1 to 4 (p>0.05), improvements were observed in sprint 5 (p=0.011; ES=0.26), 6 (p=0.014; ES=0.39), 7 (p=0.005; ES=0.6), and 8 (p=0.004; ES=0.79). Following NaHCO3 supplementation, pH was greater at 60 min (p<0.001; ES=3.23), whilst for HCO3- it was greater at 60 min (p<0.001; ES=3.23) and post-exercise (p=0.016; ES=0.53) compared to placebo. Lactate was greater following NaHCO3 supplementation post-exercise compared to placebo (17.6±4.9 vs. 14.7±3.8 mmol.l-1; p < 0.001; ES = 0.64). Aggregated GI discomfort was higher for NaHCO3 compared to placebo (21±12 vs. 3±1; p=0.021; ES=2.05).
CONCLUSION: These findings suggest NaHCO3 supplementation can improve the latter stages of sprint interval swimming performance, which is likely due to the augmentation of pH and HCO3- prior to exercise and the subsequent increase in buffering capacity. Performance improvements may be beneficial during high intensity training blocks in improving adaptation (via increasing exercise intensity training volume), however further research is warranted to investigate NaHCO3 and training responses.

**DOES ACUTE CAFFEINE INTAKE INCREASE TRAINING VOLUME DURING A RESISTANCE EXERCISE SESSION AMONG RESISTANCE-TRAINED MEN HABITUATED TO CAFFEINE?**

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INTRODUCTION: There is wide evidence showing the ergogenic effect of acute caffeine intake on maximal strength and power output during several forms of resistance-based exercise. Evidence also demonstrates that caffeine's ergogenicity is reduced in athletes chronically ingesting caffeine. However, there is no information about the potential effect of caffeine to enhance training volume during a resistance exercise session. The aim of this study was to explore the effect of acute caffeine intake on training volume during a session of full-body resistance exercise in individuals habituated to caffeine.
METHODS: Twelve resistance-trained men (24 ± 6 years, 83.2 ± 8.3 kg) habituated to caffeine (2.1 mg/kg/day) participated in a randomized, counterbalanced, crossover and double-blind experiment. Each participant performed two identical experimental sessions after the intake of 3 mg/kg of caffeine (CAF) or a placebo (PLAC). After 60 min for substance absorption, participants performed a resistance exercise session consisting of seven exercises: a) leg press, b) sitting leg extension, c) lying leg curls, d) lat pull-down, e) chest supported row, f) bench press g) machine overhead press. In each exercise, participants performed three sets at 70% of their one-repetition maximum (1RM) until momentary muscular failure using 4/0/x/0 tempo. Time under tension and the number of repetitions were obtained through video recording. Immediately after exercise, participants reported their rating of perceived exertion (RPE; range 6 – 20 arbitrary units (a.u.)) and muscle soreness and fatigue (on the Overall Fatigue Scale, Overall Soreness Scale, and a Soreness on Palpation Scale; range 0 – 10 a.u.) were measured before, immediately after and for the 5 days after testing.
RESULTS: There were no differences in the total number of repetitions between PLAC and CAF trials (180 ± 13 vs 184 ± 14 repetitions; $p = 0.407$) nor in the total time under tension (761 ± 70 vs 760 ± 52 s; $p = 0.971$) and RPE (13.8 ± 2.4 vs 14.6 ± 2.6 a.u.; $p = 0.289$). CAF did not modify the number of repetitions nor the total time under tension in any exercise ($p > 0.05$ for all). No significant differences were observed on the Overall Fatigue, Overall Soreness, and Soreness on Palpation before, immediately after and for the five days after testing ($p > 0.05$ for all).
CONCLUSION: These results indicate that 3 mg/kg of caffeine is not an effective dose to improve training volume during a resistance-based workout in men habituated to caffeine.

**12G OF CITRULLINE MALATE 60 MINUTES PRIOR TO EXERCISE DOSE NOT ACUTELY IMPROVE HIGH OR LOW LOAD BENCH PRESS PERFORMANCE IN EITHER MEN OR WOMEN**

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INTRODUCTION: The body of research investigating the effects of citrulline malate (CM) on strength and power performance has increased substantially in recent years. After absorption, citrulline is converted arginine and then to nitric oxide (NO) promoting vasodilation and increased in blood flow to the skeletal muscle (1). This mechanism is potentially ergogenic, as it may reduce blood pressure, increase substrate and O2 delivery while facilitating clearance of metabolic by products through the urea cycle that may attenuate muscular fatigue (2). However, outcomes remain equivocal. Most RE studies have used male participants and moderate training loads, with no study to date examining the impact of load choice during resistance exercise (RE) after CM supplementation. Additionally, there is clear underrepresentation of female participants, despite data suggesting females display higher plasma nitrite levels at baseline (3) and differential physiological responses to NO promoters (4). This research aims to examine the effects of CM supplementation on resistance exercise performance at both high and low loads, and to compare these responses between the sexes.
METHODS: Nineteen resistance trained participants (n = 19; 10 male, 9 female) completed the study in a double-blind crossover design. After familiarisation, participants reported to the laboratory on two occasions separated by one week. On each occasion they consumed a taste matched beverage in a randomised order, either a 12g Citrulline Malate (CM) Solution or Placebo. Sixty minutes after consumption participants completed as many repetitions as possible at 85% and 40% one repetition maximum (1RM) respectively on the barbell bench press. Number of reps completed and peak bar velocity m.s¬-1 (Push band 2.0, Push Inc., Toronto, ON) were recorded. Two way repeated measures ANOVA were used to detect the effect of Supplementation, Sex, and Sex x Supplementation interaction on all measures at both loads. Significance was accepted at $p < 0.05$, and data are mean ± SD.
RESULTS: There were no significant effects of supplementation on repetitions completed at 85% 1RM ($F1 = 0.688$, $p = 0.419$) or 40% 1RM ($F1 = 1.267$, $p = 0.277$), nor was there a significant supplement x sex interaction at either load ($p = 0.241$; $p = 0.928$). Similarly, supplementation with 12g of CM had no significant effect on peak bar velocity during at either 85% or 40% of 1RM ($F1 = 0.688$, $p = 0.419$; $F1 = 0.685$, $p = 0.419$). However, there was a trend for PV to be lower in the female group by 0.08 ± 0.1 m.s¬-1 after CM supplementation at 85% ($F1 = 4.32$, $p = 0.054$) compared to males.
CONCLUSION: A high dose of CM does not improve upper body RE performance on sets taken to momentary muscular failure in recreational trainees. This effect appears to be regardless of light or heavy loads, with a uniform response between the sexes. The data on CM and resistance exercise performance remain mixed, and individual variability may be of larger influence than dose, sex, or load selected.

**EFFECTS OF BETA-ALANINE INGESTION ON PHYSICAL PERFORMANCE IN WELL-TRAINED TENNIS PLAYERS**

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INTRODUCTION: Nutritional interventions (e.g., beta-alanine ingestion) can be capable of increasing muscle-buffering capacity and attenuating the increase in acidosis during high-intensity intermittent exercise and might increase performance in intermittent sports (e.g., soccer, tennis) (1). However, although different studies present evidence of the efficacy of beta-alanine supplementation in high-intensity efforts, the effects of beta-alanine in racket sports is barely studied. Thus, the aim of this study was to study the effects of beta-alanine supplementation (28-days) on physical tennis performance.
METHODS: Fourteen well-trained tennis players (23.28 ± 3.68 years) were randomly assigned to receive either beta-alanine (4.8 g day−1, Crown Nutrition, Spain) or placebo (fructose, 4.8 g day−1 Crown Nutrition, Spain) during 28-days in a double-blind design. Before and after the supplementation period tennis performed a neuromuscular test battery in a tennis court consisted in different test such as, counter-

movement jump, isometric handgrip strength, 10-m sprint, modified 5-0-5 agility test and repeated sprint ability. After 48 h of the realization of neuromuscular test battery, tennis players performed VO2max consumption test (i.e., treadmill).
RESULTS: Significantly greater training improvements were observed in the beta-alanine condition versus placebo group in repeated sprint ability test (p=0.042; np2 =0.12). However, no significant improvements were observed in the others physical performance parameters analysed such as countermovement jump, isometric handgrip strength, 10-m sprint, modified 5-0-5 agility test and VO2max consumption test. (p=0.246-1.000; np2 =0.00-0.04).
CONCLUSION: Beta-alanine supplementation (4.8 g day−1) during 28-days training block may improve repeated sprint ability capacity in well-trained tennis players, while no differences were reported in countermovement jump, isometric handgrip strength, 10-m sprint, modified 5-0-5 agility test and VO2max consumption test.

## COLLAGEN AND WHEY PROTEIN INGESTION DO NOT INCREASE MUSCLE CONNECTIVE TISSUE PROTEIN SYNTHESIS RATES DURING RECOVERY FROM EXERCISE IN MALE AND FEMALE RECREATIONAL ATHLETES

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INTRODUCTION: Resistance exercise stimulates myofibrillar and muscle connective tissue protein synthesis rates. Whey protein ingestion during post-exercise recovery further augments myofibrillar protein synthesis rates, but does not stimulate muscle connective tissue protein synthesis rates. It has been suggested that collagen protein, due to its high glycine and proline contents, may be more effective in stimulating muscle connective tissue protein synthesis rates during recovery from exercise. The objective of this study was to assess the impact of both whey and collagen protein ingestion on post-exercise myofibrillar and muscle connective tissue protein synthesis rates in male and female recreational athletes.
METHODS: In a randomized, double-blind, parallel design, 45 young male and female recreational athletes (age: 25±4 y; BMI: 24.1±2.0 kg/m2) were selected to receive primed continuous intravenous infusions with L-[ring-13C6]-phenylalanine and L-[3,5-2H2]-tyrosine. Following a single session of resistance type exercise (6 sets of the barbell squat exercise), subjects were randomly allocated to one of three groups ingesting either 30 g whey protein (WHEY, n=15), 30 g collagen protein (COLL, n=15) or a non-caloric placebo (PLA, n=15). Blood and muscle biopsy samples were collected over a subsequent 5-hour recovery period to assess myofibrillar and muscle connective tissue protein synthesis rates. Time-dependent variables were analyzed by a two-factor repeated-measures ANOVA. Non-time-dependent variables were compared between treatment groups using a one-way ANOVA. A statistical level of P<0.05 was accepted. All data are expressed as mean±SD.
RESULTS: Whey and collagen protein ingestion strongly increased circulating plasma amino acid concentrations when compared to the PLA group (P<0.05). The post-prandial rise in plasma leucine and total essential amino acid concentrations was greater in the WHEY compared with COLL group (P<0.05). In contrast, post-prandial plasma glycine, proline, and hydroxyproline concentrations increased to a greater extend in the COLL compared with WHEY group (P<0.05). Myofibrillar protein synthesis rates averaged 0.041±0.010, 0.036±0.010 and 0.032±0.007 %/h following whey, collagen, or placebo ingestion (P<0.05), respectively, with WHEY resulting in significant greater rates when compared with the PLA group (P<0.05). Muscle connective tissue protein synthesis rates did not differ between groups (WHEY: 0.072±0.019, COLL: 0.068±0.017, PLA: 0.058±0.018 %/h; P=0.09).
CONCLUSION: Ingestion of whey protein during recovery from exercise increases myofibrillar protein synthesis rates. Post-exercise collagen protein ingestion does not increase myofibrillar protein synthesis rates. Neither whey or collagen protein ingestion increase muscle connective tissue protein synthesis rates during the early stages of post-exercise recovery in male and female recreational athletes.

## LEUCINE SUPPLEMENTATION DOES NOT ATTENUATE THE DECLINE IN MUSCLE PROTEIN SYNTHESIS RATES OR PRESERVE LEG MUSCLE MASS DURING SHORT-TERM IMMOBILIZATION IN YOUNG OR OLDER ADULTS

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INTRODUCTION: Muscle disuse leads to a loss of muscle mass and strength. The loss of muscle mass during disuse has been attributed to a decline in basal and post-prandial muscle protein synthesis (MPS) rates. Leucine supplementation has been suggested to stimulate post-prandial MPS rates and, as such, may represent an effective strategy to attenuate muscle disuse atrophy. The present study assessed the capacity of leucine supplementation to attenuate the loss of muscle mass and the decline in daily MPS rates during 3 days of unilateral knee immobilization in both young and older adults.
METHODS: 24 young (23±4 y) and 24 older (69±4 y) adults (male/female: 1/1) underwent 3 days of unilateral knee immobilization by means of a full leg cast with leucine (LEU) or maltodextrin (PLA) supplementation (5 g, three times daily). Prior to and directly after immobilization, quadriceps muscle cross-sectional area (CSA) was assessed by Computed Tomography and a biopsy from the m. vastus lateralis was obtained. Daily MPS rates over the 3-day immobilization period were determined by applying deuterated water. Data were analyzed with a 2-way repeated measures ANOVA, and paired and independent samples t-tests. Data are expressed as means +/- standard deviation.
RESULTS: In young adults, quadriceps muscle CSA decreased by ~1.2 % in the immobilized leg (P<0.01), with no differences between the LEU and PLA group (from 6993±1174 to 6910±1185 mm^2, and from 7330±1147 to 7241±1095 mm^2, respectively; time*treatment: P=0.92). A similar ~1.0 % decrease in quadriceps CSA was observed in the immobilized leg in older adults (P=0.02), with no differences between the LEU and PLA group (from 5753±1086 to 5679±1073 mm^2 and from 5864±1146 to 5823±1161 mm^2, respectively; time*treatment: P=0.50). In the young individuals, the decline in CSA was accompanied by a ~15 % lower MPS rate in the immobilized compared to the non-immobilized leg assessed over the 3-day intervention period (1.28±0.29 vs 1.50±0.26 %/d, respectively). The MPS rates in the immobilized leg did not differ between the LEU and PLA groups (1.29±0.24 vs 1.26±0.34 %/d, respectively; P=0.83). In the older individuals, MPS rates over the 3-day intervention period were ~23 % lower in the immobilized compared with the non-immobilized leg (1.10±0.16 vs 1.47±0.28 %/d). The MPS rates in the immobilized leg did not differ between the LEU and PLA groups (1.10±0.14 vs 1.10±0.19 %/d, respectively; P=0.90).
CONCLUSION: Free leucine supplementation (5 g, three times daily) does not attenuate the decline in MPS rates or preserve leg muscle mass during short-term immobilization in young or older individuals.

## EFFECTS OF 16/8 TIME-RESTRICTED FEEDING ON ENDURANCE EXERCISE PERFORMANCE, BODY COMPOSITION AND MARKERS OF METABOLIC HEALTH: A RANDOMIZED AND COUNTERBALANCED CROSSOVER STUDY IN HEALTHY MEN

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INTRODUCTION: To explore the effects of 4 weeks of time-restricted feeding (TRF) vs. regular diet on physiological indices of endurance running performance, body composition and markers of metabolic health in well-trained young men.
METHODS: Fifteen healthy males were included (age: 24.4±3.3 years, height: 175.0±0.1 cm, body mass: 75.2±11.0 kg, body mass index: 24.5±2.9 kg/m2, total cholesterol: 156.6±26.3 mg/dL, high-density lipoprotein: 53.7±8.5 mg/dL, low-density lipoprotein: 75.2±26.6 mg/dL, glycaemia: 90.1±6.9 mg/dL, peak oxygen uptake: 74.3±5.7 mL.kg fat-free mass−1.min−1). Inclusion was limited to participants with > 3 years of practice in endurance running. The order of dieting was randomized and counterbalanced, and all participants served as their own controls. Two weeks of washout separated both conditions (no specific diet or structured exercise). TRF was limited to an 8-h eating window. The non-TRF involved a customary meal pattern without any timing restrictions. Participants completed graded exercise tests and body composition scans (using dual-energy X-ray absorptiometry) at baseline and post-four weeks of each dietary intervention. Before testing, all participants were asked to fill out 4-day dietary record. Fasted blood samples were analysed for glycaemia and blood lipids. The participants were asked to follow a specific training routine in combination with each dietary intervention (3 outdoor runs x 10 km/week within the heavy domain + 3 running bouts x 1000 m within the severe domain, after each 10 km run). Two- way repeated measures ANOVAs, adjusted for baseline values as covariates, were used.
RESULTS: Energy intake was similar at baseline in both conditions (before TRF: 2311.1 ± 681.0 kcal vs. before non-TRF: 2284.9 ± 659.3 kcal, p = 0.785). We obtained a significant time x condition interaction for body mass (F = 4.97, p = 0.046; ES = 0.29). While TRF was effective in decreasing body mass (pre: 75.3 ± 11.0 vs. post: 74.8 ± 10.7 kg, p < 0.05), this was not the case for non-TRF (pre: 75.0 ± 11.1 vs. post: 75.5 ± 11.4 kg, p > 0.05). Fat mass and fat-free mass remained unchanged between time points with both interventions. Significant time main effects were obtained for the ventilatory threshold (Δ with TRF and non-TRF of ~ + 6%), absolute and fat-free mass corrected peak oxygen uptake (Δ with TRF and non-TRF of ~ + 3%) as well as for peak minute ventilation (Δ with TRF and non-TRF of ~ + 2.7%) (F = 6.8, F = 6.6 and F = 6.4, respectively; p < 0.05). Low-density lipoprotein decreased by ~ 8% after 4 weeks of TRF and non-TRF (time main effect: F = 6.8, p < 0.05).
CONCLUSION: Based on our findings, 4-weeks of TRF (with an 8-h eating window), can be used in combination with regular training to elicit body mass reductions in well-trained males. Yet, in comparison with a customary meal pattern without any timing restrictions, TRF does not offer any benefit for improving submaximal or peak exercise capacity in well-trained males.

## RESPONSE TO PROTEIN-FEEDING AFTER REPEATED BOUTS OF RESISTANCE EXERCISE DIFFERS BETWEEN MEN AND WOMEN

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INTRODUCTION: Protein (PRO) ingestion following resistance exercise (RE) acutely increases the rate of muscle protein synthesis (MPS). This study investigated the impact of repeated bouts of RE and bolus PRO ingestion on cumulative MPS over 24h in RE trained men and women and identified any sex-based differences in responses.
METHODS: Healthy RE trained (3 times/week for at least 6 months) women (n=8: 25.9 ± 0.9 years, 23.6 ± 0.9 BMI) and men (n=8: 24.1 ± 1.1 years, 25.8 ± 0.9 BMI) were recruited into the study following written informed consent and screening. After a DXA scan, a venous blood sample was taken to allow measurement of baseline (BL) MPS over the next 24h, and participants then consumed 500ml of 70AP heavy water (D2O) over 5h. Twenty-four hours later, fasted saliva, venous blood and vastus lateralis muscle biopsy samples were obtained, and participants then performed 3 sets of 8 repetitions at 75% 1 repetition maximum (2min rest between sets) of latissimus dorsi pull down, single-leg press and chest press. Immediately post-exercise, participants ingested a drink containing 30g whey PRO. After 4h rest, saliva, venous blood and muscle biopsy samples were collected, and volunteers repeated the RE and PRO ingestion procedures. Further saliva, blood and muscle samples were obtained 4h later (8h) and the following day (24h). In addition to the whey PRO drinks, subjects consumed a controlled diet between 8h and 24h on the study day (55% carbohydrate, 30% fat and 15% PRO; men 2925 ± 98 kcal, 1.2 ± 0.1 g/kg BW PRO; women 2131 ± 109 kcal, 1.4 ± 0.1 g/kg BW PRO) and performed only the exercise prescribed. Body water and muscle protein D2O enrichment were measured to quantify the rate of MPS (1). Statistical analysis was performed using two-way repeated measures ANOVA with a Bonferroni post-hoc test. Values are mean ± SEM.
RESULTS: Overall, RE and PRO ingestion increased the rate of MPS from BL over time, but there was no gender x time interaction. Regarding this time effect, the rate of MPS increased above BL (0.068 ± 0.005 %/h) over 0-4h (0.140 ± 0.021 %/h, p<0.01), 0-8h (0.121 ± 0.012 %/h, p<0.01) and 0-24h (0.099 ± 0.011 %/h, p<0.05) in women. An increase in the rate of MPS above BL (0.058 ± 0.003 %/h) was observed in men from 0-8h (0.092 ± 0.009 %/h, p<0.05), but not 0-4h (0.092 ± 0.015 %/h) or 0-24h (0.077 ± 0.005 %/h).
CONCLUSION: Post-RE ingestion of 30g PRO increased MPS above BL following two successive bouts of exercise in RE trained men and women, and over 24h in women but not in men. This demonstrates that bolus ingestion of 2x30g PRO post-RE sustains a muscle anabolic response in RE trained women for up to 24h. The apparent blunted response in men may be explained by habituation of MPS to RE training reported in men (2).
REFERENCES:
1. Wilkinson DJ, et al. (2014) Am J Physiol Endocrinol Metab, 306(5):E571-9.
2. Brook MS, et al. (2015) FASEB J. 29, 4485–4496.

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### CP-MH04 Cancer-Ageing

#### RESISTANCE EXERCISE TRAINING COUNTERACTS THE ADVERSE EFFECTS OF ANDROGEN DEPRIVATION THERAPY ON BODY COMPOSITION, MUSCLE MASS, STRENGTH AND AEROBIC CAPACITY IN PROSTATE CANCER PATIENTS

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INTRODUCTION: Androgen deprivation therapy (ADT) is the cornerstone in the treatment of (locally) advanced prostate cancer. However, ADT results in numerous adverse effects, including an increase in fat mass, loss of muscle mass, a lower quality of life and more fatigue. We hypothesized that resistance exercise training counteracts these side effects and that protein supplementation further enhances the benefits of training.
METHODS: Sixty prostate cancer patients receiving ADT were randomly assigned to 20 weeks of supervised, progressive resistance exercise training (twice a week, 60 min) with supplementation of 31 g whey protein (EX+PRO, n=30) or placebo (EX+PLA, n=30), consumed immediately after exercise and every night before sleep. A separately recruited control group (CON; n=36) only received usual care. At baseline and after 20 weeks, body composition (dual-energy X-ray absorptiometry), leg muscle mass (quadriceps cross sectional area by computed tomography), leg press strength (1-repetition maximum; 1-RM), aerobic capacity (VO2peak), quality of life (EORTC QLQ-C30), fatigue (MFI) and habitual dietary intake (food diary) were assessed. Data were analyzed using repeated-measures ANOVA (time x treatment) followed by within-group (paired t-tests) and between-group (univariate general linear models (GLM)) analyses. For 1RM-data the %-differences over time within groups were calculated and compared between groups with univariate GLM.
RESULTS: For total fat and total lean mass, significant time x treatment interactions were found, with differences over time between EX+PLA and CON (fat mass: 0.4±2.2 vs 2.1±1.7 kg, respectively; P=0.002, lean mass: 0.6±2.0 vs -0.7±2.4 kg, respectively; P=0.053). Quadriceps cross-sectional area and 1-RM strength increased similarly in both exercise groups (EX+PLA: 2.0±3.0 cm2 and 12±14%, respectively; EX+PRO: 1.9±2.7 cm2 and 13±11%, respectively), and these improvements were significantly different from the declines observed in the CON group (-1.2±2.5 cm2 and -5±11%, respectively; P<0.001). VO2peak decreased in EX+PRO and CON (-1.5±2.3 and -3.0±2.7 mL·min-1·kg BW-1).This decline was attenuated in EX+PLA (-0.6±2.8 mL·min-1·kg BW-1) compared to CON (P<0.005). The EORTC QLQ-C30 only showed a significant decrease in perceived level of physical functioning over time, and fatigue significantly increased over time, with no differences between groups. Average habitual protein intake was >1.0 g·kg BW-1·day-1, with no changes over time or differences between groups.
CONCLUSION: Prolonged resistance exercise training counteracts the adverse effects of ADT on body composition, muscle mass, strength and aerobic capacity, with no additional benefits of protein supplementation in prostate cancer patients habitually consuming ample amounts of protein.

#### CHARACTERIZATION OF THE COMBINED EFFECTS OF EXERCISE AND IMMUNO CHEMOTHERAPY TREATMENTS ON TUMOUR GROWTH IN MC38 COLORECTAL CANCER MICE

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INTRODUCTION: It is well established that physical exercise triggers several health benefits and is an important component of comprehensive health-care strategies in oncology. Previous studies have hypothesized that tumor blood flow may be modulate during exercise, which could impact the tumor microenvironment. Moreover, acute exercise, i.e., a single physical exercise bout, induces transient physiological changes resulting in tumor microenvironment modifications and possible alterations in tumor development. On the other hand, recent preclinical data have shown that moderate aerobic exercise improves tumor vascular function and increases chemotherapy efficacy in mouse models. However, the potential of exercise combined with immunotherapy as a cancer therapy remains to be elucidated. The purpose of this pre-clinical study is to assess the capacity of exercise conducted immediately prior to treatments injection to improve the efficacy of immuno-chemotherapy via modification of the tumor microenvironment. Using an orthotopic preclinical model of colon cancer, we tested the hypotheses that during exercise tumors would experience 1) decreased tissue hypoxia, 2) modulate the immune cells infiltrate that could explain the link between exercise and tumour regression and thus improved survival.
METHODS: 4 weeks mice model of colorectal cancer (MC38) will perform incremental maximal speed (MS) test and be randomly separated in 4 groups (n = 20/groups): control (CTRL), immune-chemotherapy (TRT), exercise (EXE) and combined intervention (TRT-EXE). Both TRT and TRT-EXE will receive immuno-chemotherapy (anti-PD1-1 + capecitabine + oxaliplatine) treatment 5 times per week for 1 week, moreover TRT-EXE and EXE will be submitted to 50 min of treadmill exercise at 60% MS before each treatment administration (<15 minutes). All along the protocol, tumor growth will be monitored. At D7, colon hypoxia (and tumor immune microenvironment will be measured.
RESULTS: Will be available in April 2022. Preliminary results obtained by flow cytometry show a greater decrease in tumor development in the TRT-EXE group compared to the other groups. Indeed, it seems that this is due to changes in biomarkers such as a decrease in the percentage of PD-1 expression on T cells and a decrease in the percentage of Treg on CD4+ cells. We expect that exercise improves TRT efficacy in a MC38 colorectal cancer mice model thanks a decrease of intratumoral hypoxia that can caused tumor regression for mice receiving the combination of exercise plus immuno-chemotherapy compared to TRT alone.
CONCLUSION: This study may provide insights on the combined effect of pre-treatment exercise and immuno-chemotherapy in colorectal cancer and will provide valuable information to design a randomised controlled trial with sufficient power to assess efficacy on clinically important endpoints (e.g. progression-free survival) in cancer patients eligible for immuno-chemotherapy.

**MITOCHONDRIAL RESPIRATION IN ADIPOSE AND MUSCLE TISSUE FROM PATIENTS UNDERGOING PANCREATIC SURGERY**

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INTRODUCTION: Cancer cachexia affects 80% of all pancreatic cancer patients, accounts for up to 20% of all pancreatic cancer related deaths and is associated with impaired physical performance. Increased energy expenditure and altered metabolism are hallmarks of cancer cachexia, yet the molecular mechanisms underlying these hallmarks are poorly understood. We aimed to investigate mitochondrial respiration of adipose and muscle tissue from patients undergoing pancreatic surgery as a potential early marker of cancer cachexia.
METHODS: Patients scheduled for pancreatic surgery for cancer or benign disease at Rigshospitalet, Denmark, were eligible. The patients with benign disease served as a cancer free reference group. Subcutaneous adipose tissue (SAT), visceral adipose tissue (VAT) together with muscle tissue (m. vastus lateralis) were collected during the initial part of the surgery. Mitochondrial respiration was measured by high resolution mitochondrial respirometry (Oxygraph 2k, Oroboros Instruments) performed using SUIT-protocol (Adipose tissue: leak, oxidative phosphorylation (OX), and uncoupling (UC). Muscle: Fat oxidation (FO), ATP productive (ATP), OX and UC). Prior to surgery, body composition was assessed by DXA-scan while usual gait speed and handgrip strength were used to evaluate physical performance. Differences in body composition and physical performance were analyzed using t-tests. Mitochondrial respiration was modelled using linear mixed models on log-transformed data to improve model compliance. All results are back-transformed and presented as ratios with 95% confidence intervals.
RESULTS: In total, 54 patients with pancreatic cancer (age 66±10 years, weight 77.7±16.2 kg, BMI 26.8±11.0, men 70.4%) patients and 18 patients with benign disease (age 67.7±7.7 years, weight 71.7±16.2 kg, BMI 24.7±4.7, men 38.9%) was included. Patients with pancreatic cancer had similar appendicular lean mass (+0.45kg/m2; P=0.19), fat mass (+1.58kg; P=0.59), usual gait speed (-0.3 m/s; P=0.67) and hand grip strength (+2.7 kg; P=0.30) compared to patients with benign disease. In adipose tissue we found no differences between patients with cancer and benign disease in mitochondrial respiration during leak (0.79; CI 0.51 – 1.23; P=0.30 and 0.92; CI 0.59 – 1.42; P=0.69), OX(0.76; CI 0.49–1.18; P=0.22 and 0.85; CI 0.55 – 1.33; P =0.47) or UC(0.84; CI 0.54 – 1.29; P=0.42 and 0.82; CI 0.53 – 1.27; P=0.37) for SAT and VAT, respectively. Similarly, patients with pancreatic cancer did not have increased mitochondrial respiration in muscle tissue FO (1.08; CI 0.88 – 1.33; P=0.46), ATP(1.02; CI 0.83 – 1.25; P=0.88), OX(1.05; CI 0.86–1.29; P=0.63), UC(1.07; CI 0.88–1.32; P=0.49).
CONCLUSION: The pancreatic cancer patients did not show any clinical signs of cancer cachexia at the time of the surgery compared to patients with benign pancreatic disease and there were no subclinical signs in terms of increased mitochondrial respiration in neither SAT, VAT, nor muscle tissue.

**ABSOLUTE AND RELATIVE HANDGRIP STRENGTH AS INDICATORS OF SELF-REPORTED PHYSICAL FUNCTION AND QUALITY OF LIFE IN BREAST CANCER SURVIVORS: THE EFICAN STUDY**

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INTRODUCTION: Breast cancer (BC) is the most prevalent type of cancer in the world, with more than 2.2 million new diagnoses in 2020. BC is also the type of cancer with the highest survival rate (86% of patients surviving after 5-years). This implies that many people live long after the treatments and have to deal with their side effects. The physical function (PF) and health-related quality of life (HRQoL) of BC survivors decreases significantly, which makes important to identify markers that may be associated with a better health status and prognosis. Previous studies suggest that handgrip strength (HGS) and HGS relative to the body mass index (rHGS) are good indicators of PF and HRQoL in different populations. However, it is unknown whether this applies to BC survivors. The objective of the present study was to evaluate the association of HGS and rHGS with different PF and HRQoL variables in this population.
METHODS: Sixty female BC survivors (52.3±9.0 years) participated. Handgrip strength was assessed with a digital dynamometer, arm volume was estimated using the truncated cone formula and upper limb impairments, as well as cancer-related fatigue, depression, life satisfaction and HRQoL, were assessed using standardized questionnaires.
RESULTS: Higher levels of HGS and rHGS were associated with higher levels of HRQoL, lower cancer-related fatigue, and fewer shoulder-arm disabilities of the affected arm. However, no association of HGS or rHGS with arm volume difference, depressive symptoms or life satisfaction was found.
CONCLUSION: These results suggest that HGS and, especially, HGS relative to body mass index may be good indicators of self-reported PF and HRQoL in female BC survivors.

**EFFECT OF AN INNOVATIVE TECHNOLOGICAL SOLUTION FOR HOME-BASED RESISTANCE TRAINING ON WALKING PARAMETERS: A PRELIMINARY REPORT**

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INTRODUCTION: Space-time walking gait parameters are related to health, risk of falls, independence and quality of life. These aspects are influenced by the muscle strength and power of the lower limbs. Aging affects negatively these variables, but can be counteracted by resistance training. Unfortunately, older adults have some difficulties to participate in gym program activities, that were exacerbated by the COVID-19 pandemic. Therefore, the purpose of this study was to evaluate the effects of a home-based resistance training intervention, performed using an innovative technological solution, on the main space-time parameters of walking in older adults.
METHODS: 69 healthy old subjects (35 females; 34 men, 67.1 ± 6.0 yrs) were selected and randomly divided into 2 groups: intervention (IG) (45 - F: 23; M: 22) and control (CG) (24 - F: 12; M: 12). IG received the training system (Kari®, Euleria), consisting of an inertial sensor and a tablet with dedicated software on board, for practicing exercises at home. The 3-months training program involved 12 exercises for the whole body (2-4 sets for 8-12 repetitions) performed 3 to 5 times per week. CG continued life as usual. Both groups visited the laboratory before (T0) and after 3 months (T3). In these occasions, they performed 2 trials of linear 10 m walk at self-selected speed. We used optical detection and photocell systems (Optogait® and Witty Gate®, Microgate) to collect data and speed on 4 m, cadence, stride length and double support. Compliance to the training intervention was recorded through the Kari® device and a high compliance (IGh, ≥ 3 sessions per week, # 21) and low compliance (IGl, <3 sessions per week, # 19) subgroup were created. A mixed 2-way ANOVA was used to compare results across groups (CG, IGh, IGl) and time (T0, T3).

RESULTS: While speed and double support were unaffected, there was a positive main effect of Time on stride length (increased, p<0.001) and cadence (decreased, p=0.012). The post-hoc analysis showed a significant difference between T0 and T3 in IGh (p<0.05) and CG (p<0.05) groups. Yet, there was no main effect of Group on all variables (for all variables p>0.05) and no interaction of time and group (for all variables p>0.05).
CONCLUSION: During the observation period, cadence and stride length parameters of walking gate improved in our group of healthy older adults. However, the improvement observed in the IGh was no larger than that of the CG suggesting a possible effect from an external factor. Indeed, the beginning of this study coincided with the end of the national lock down and the possibility to be engaged in spontaneous physical activities. This could have confounded the effect of the intervention protocol of our still ongoing study. A second cohort of individuals, recruited outside of the transition period that followed the epidemic, will help to isolate the effect of the training intervention from that of the return to near-normality.

### SYSTEMATIC BALANCE EXERCISE AFFECTS THE LEVEL OF SIRT1 AND SIRT3 IN OLDER ADULTS

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INTRODUCTION: Sirtuins have regulatory functions but their activity decreases with age. In young people, aerobic training have been shown to cause up-regulation of sirtuins expression. The aim of our study was to assess the impact of various forms of balance exercise (BE) on the blood concentration of selected sirtuins in older adults
METHODS: Volunteers were randomly divided into 3 groups: classic BE (CBE, n=22, age 66.64±0.63 years; body height 166.20±1.80 cm; body mass 78.55±3.07kg), virtual BE (VBE, n=16, age 65.31±0.86 years; body height 167.36±2.00 cm; body mass 79.62±2.83 kg) and control group (CON, n=22, age 66.27±0.74 years; body height 168.11±1.94 cm; body mass 78.49±3.21 kg). Classic or virtual reality BE (using Nintendo Wii) consisted of 60 min sessions, mainly of moderate intensity, performed three times per week. Venous blood samples were taken before and at the end of twelve weeks of BE. All data are expressed as mean ± SEM.
RESULTS: At baseline the level of sirtuins were similar in compared groups. In the CBE group after 12 weeks of BE the concentration of Sirt1 and Sirt3 were significantly higher than before (respectively: 2.67±0.18 ng/mL vs. 3.89±0.35 ng/mL, p < 0.001; 1.38±0.23 ng/mL vs. 2.25±0.32ng/mL, p = 0.002). Sirt1 and Sirt3 levels did not differ significantly after completion of the 12-week BE in VBT group. In the CON group, the level of sirtuins was comparable in the analyzed period of time. After 12 weeks, the level of Sirt1 was significantly higher in the CBT group than in the CON group (3.89±0.35 ng/mL vs. 2.73±0.20 ng/mL respectively, p = 0.037).
CONCLUSION: Balance exercise with moderate intensity increase blood levels of Sirt1 and Sirt3 in older adults, but the effect is dependent on form of applied exercise.
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Keywords: elder people, sirtuins, balance training

### ASSOCIATION BETWEEN BARTHEL INDEX AND GRIP STRENGTH AT ADMISSION AND PROGNOSIS IN COMMUNITY-ACQUIRED PNEUMONIA: A PROSPECTIVE COHORT STUDY

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INTRODUCTION: Functional status is a risk factor for hospitalization in patients with community-acquired pneumonia (CAP). The aim was to determine the influence of functional status on severe outcomes, including length of stay (LOS), admission to the intensive care unit (ICU), readmission, and mortality in patients with CAP.
METHODS: A prospective cohort study of 355 patients hospitalized with CAP. Functional status was assessed with the Barthel index and grip strength. The association between functional status and LOS was assessed using linear regression. The association between functional status and severe outcomes (admission to ICU, readmission, and mortality) was assessed by logistic regression.
RESULTS: Overall, 18% had a low Barthel index (<80), and 45% had a low grip strength (males <27 kg and females <16 kg). Patients with a low Barthel index had a higher risk for admission to the ICU (OR 3.6, 95% CI 1.2–10.9) and 27.9% (95% CI 2.3%–59.7%) longer LOS. Further, a low Barthel Index was associated with risk for readmission within 30, 90, and 180 days (OR 2.1-2.4, p<0.05) and mortality within 90 and 180 days (OR 4.2-5.0, p<0.05). Low grip strength was associated with an increased risk for 90 days of readmission (OR 1.6, 95% CI 1.0–2.6) and risk for mortality within 30, 90, and 180 days (OR 2.6-3.2, p<0.05).
CONCLUSION: Functional status at admission was associated with a longer LOS and increased risk for ICU admission, readmission, and mortality in patients hospitalized with CAP. Therefore, functional status should be included in the severity score of patients with CAP to identify individuals with excess risk of a poor prognosis.

### STEPS/DAY AND PEAK CADENCE MODERATE THE ASSOCIATION OF SEDENTARY TIME AND CARDIOMETABOLIC RISK IN OLDER ADULTS

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INTRODUCTION: Sedentary time (ST) is a risk factor for cardiometabolic diseases. There is an inverse relationship between the volume (steps/day) and intensity (peak cadence) of the ambulatory behavior and cardiometabolic disease risk in older adults. However, it is unknown whether the steps/day and peak cadence moderate the association of ST and cardiometabolic disease risk in this population. Therefore, this study investigated the moderating effect of steps/day and peak cadence in the relationship of ST and cardiometabolic disease risk in older adults.
METHODS: This cross-sectional study included 241 community-dwelling older adults (65.9 ± 4.9 years of age; 78% females). Sedentary time, steps/day and peak cadence were measured by accelerometry during seven days. Peak cadence was defined as the average of steps/min of the highest 30 min (not necessarily consecutive) for all valid days. Cardiometabolic disease risk was defined using a sex-specific continuous metabolic syndrome score (cMetS). Sedentary time was used as an explanatory variable for cMetS and steps/day and peak cadence as moderators (multiple linear regression). The Johnson-Neyman technique was used to specify the value of moderate variables at which the significant relationship between ST and cMetS disappears.

RESULTS: Both steps per day (β = -0.030, 95% CI -0.049 – -0.011; P = 0.001) and peak cadence (β = -0.004, 95% CI -0.006 – -0.001; P = 0.002) had a moderating effect in the relationship between ST and cMetS. The association of ST with cMetS disappears (p < 0.05) when step count was higher than 6,753 steps/day or peak cadence was faster than 63 steps/min.
CONCLUSION: In summary, both steps/day and peak cadence moderate the association between ST with cardiometabolic disease risk in community-dwelling older adults. A threshold of 6,753 steps/day or a peak cadence of 63 steps/min seem to offset the deleterious associations of ST with cardiometabolic risk in this population.

## Conventional Print Poster

### CP-AP01 Energy expenditure / Cycling

#### THE VALIDATION AND CALIBRATION OF RATING OF PERCEIVED EXERTION (RPE) FOR MONITORING HIGH-INTENSITY INTERVAL TRAINING (HIIT) IN ADOLESCENTS

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INTRODUCTION: HIIT has emerged as a feasible and effective strategy to deliver vigorous intensity physical activity which is important in promoting health-related fitness in children and adolescents. However, its implementation may be hampered by the incompliance of prescribed intensity. Rating of perceived exertion (RPE) is a simple and versatile alternative to the time-consuming and expensive measurement of heart rate (HR) in quantifying HIIT intensity. No study has validated and calibrated RPE for the purpose of quantifying HIIT intensity in youth. This study aimed to validate and calibrate RPE in monitoring HIIT intensity in adolescents.
METHODS: A total of 45 healthy adolescents (16 girls, 13.0 ± 0.9 years) from previous cross-over studies were extracted retrospectively. Three groups of participants, two cycling based interval training groups (C-HIIT, 16 girls and 16 boys) and one running based interval training group (R-HIIT, 13 boys), performed 8 work intervals and 7 rest intervals (work-to-rest ratio = 75: 60s) under different intensities. Sessions were conducted on separate days and in a counterbalanced manner. RPE, HR and maximal oxygen uptake (V O2) were taken at 16 time-points (20s before each end of work and rest intervals and immediately post exercises). Within subject correlation (r) combined with Fisher's z transformation scores established the criterion validity of RPE on both HR and V O2 across the intensities and modalities. Receiver Operator Characteristic (ROC) curve analysis was performed to determine RPE cut-points across a wide range of HIIT intensity threshold: 80%, 85%, 90%, 95% and 100% HRmax and 70%, 75%, 80%, 85% and 90% V O2max.
RESULTS: Across C-HIIT and R-HIIT, RPE was significantly correlated with both HR (r = .68, p < .01) and V O2 (r = .52, p < .01). For C-HIIT, RPE and HR were largely correlated across intensities (r = .56 to .79, p < .01), while there were moderate to large correlations between RPE and V O2 (r = .47 to .63, p < .01). For R-HIIT, RPE was both largely correlated with HR and V O2 across intensities (r = .52 to .76, p < .01). The findings also showed that these correlation coefficients increased as the intensity augmented, irrespective of modality. ROC analysis indicated that the RPE cut-points could be identified for predicting HRmax (4 for 80% and 85% HRmax, 5 for 90% and 95% HRmax, and 6 for100% HRmax), while not for the V O2max threshold.
CONCLUSION: This is the first study attempting to validate and calibrate RPE as a tool to predict HRmax and( V)̇ O2max. Criterion validity has demonstrated that RPE is a valid method of quantifying intensity for HIIT interventions in adolescents and it is significantly correlated with HIIT intensity. RPE could be adopted to identify adolescents' HRmax with specific cut-points during HIIT rather than( V)̇ O2max. Future studies could use RPE as a valid and feasible tool for monitoring HRmax in order to inform more scaling up HIIT studies.

#### ESTIMATION OF ENERGY EXPENDITURE IN PROFESSIONAL CYCLISTS USING POWER DATA: VALIDATION AGAINST DOUBLY-LABELLED WATER

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INTRODUCTION: Accurate determination of total daily energy expenditure (TDEE) in professional cyclists is important to inform on appropriate energy intake, which in turn is required for optimal performance and injury prevention [1]. Current approaches of determining TDEE are however insufficiently accurate as they typically use basal metabolic rate (BMR) prediction equations that are developed for non-elite athletes in combination with a generic physical activity level (PAL) value to determine non-exercise energy expenditure (EE). This is combined with exercise energy expenditure (EEE) estimated from power data to determine TDEE. Knowledge about the non-exercise PAL-value and BMR equations for professional cyclists would improve the accuracy of this approach, but are currently unavailable. We therefore aimed to 1) determine the non-exercise PAL-value during training and competition based on power data in combination with a measured BMR and doubly-labelled water (DLW), and 2) compare outcomes between a multi-day cycling competition (Vuelta a España) and single-day races (Ardennes classics).
METHODS: Twenty-one male professional cyclists participated. The following parameters were measured: 1) BMR, 2) the relation between power output and EE during an incremental cycling test, 3) TDEE using DLW. The relation between power output and EE was used to determine EE during exercise (EEE). A non-exercise PAL value was obtained by subtracting BMR and EEE from TDEE. We compared the measured BMR to BMR predicted with popular equations and compared TDEE estimated with a generic approach to our approach.
RESULTS: Measured BMR was 7.9 ± 0.8 MJ/day, which was significantly higher than predicted by the Oxford equations (6.95 ± 0.5 MJ/day), but not different from the Ten Haaf [2] equation (7.87 ± 0.46 MJ/day). Mean TDEE was 31.8 ± 2.6 MJ/day and 27.3 ± 2.8 MJ/day, EEE was 21.1 ± 1.9 MJ/day and 27.8 ± 3.4 MJ/day (for only the race days), and the non-exercise PAL was 1.3 and 1.8 for the Vuelta and Ardennes classics, respectively. Non-exercise EE was estimated to be 11.51 MJ/day with the ten Haaf [2] BMR equation and a generic PAL-value of 1.45 for sedentary or light activity lifestyle [3], which overestimated non-exercise EE by 0.88 MJ/day (~3%) as compared to the measured BMR and PAL-value of 1.3 for the Vuelta.
CONCLUSION: The proposed approach can be used to get more accurate estimations of TDEE than the use of a generic PAL value in combination with BMR predictive equations developed for non-elite athletes, and is also relatively easy to implement in practice. This in turn can improve nutritional strategies in professional cyclists. A secondary finding is that TDEE is higher, while EEE and the non-exercise PAL are lower in a multi-day cycling competition compared to single-day races.

REFERENCES:
[1] Stellingwerff T. et al. (2021) Sports Med; 51:2251-80.
[2] Ten Haaf T. et al. (2014) PLoS One; 9:e108460.
[3] Shety, P. (2005) Plub Heal Nutr; 8:994-1009

### HYPERCAPNIC WARM-UP IMPROVES THE PERFORMANCE OF THE CYCLING SPRINT INTERVAL TRAINING

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INTRODUCTION: Special breathing exercises performed during the warm-up with the added respiratory dead space volume mask (ARDSv) lead to hypercapnia and stimulation of the mechanisms that lead to an increase in physical performance during a single session of cycling sprint interval training (SIT)[1]. However, to date, there is a lack of information on the use of hypercapnic warm-up in the training cycle. Therefore, we determined the effect of a 6-week experiment with the hypercapnic warm-up in SIT on the development of anaerobic capacity. This will be manifested by obtaining higher peak power output (PPO) in the Wingate test, higher hydrogen ion concentration (H+) and lactate concentration ([La-]).
METHODS: Twenty physically active men participated in the experiment. During 12 sessions of cycling sprint interval training, over a 6-week period, the experimental group (EG: n=10, age=23±2.0yr, body mass=78.2±9.8kg, body height=178±7cm, VO2max=50±5.7ml·kg-1·min-1) performed the hypercapnic warm-up (pCO2~48mmHg) with a 1200ml ARDSv mask prior to SIT. The control group (CG: n=10, age=23±2.5yr, body mass=78.5±8.6kg, body height=179±7cm, VO2max=49.9±6.1ml·kg-1·min-1), performed warm-up and SIT without the ARDSv mask. Each SIT session was preceded by a 10-min warm-up at an intensity of 60% of maximal aerobic power. The main part of the SIT consisted of 2 series of 3x10-sec "all-out" efforts with a load of 10% of the participants body mass. The recovery between efforts was 30-sec and between series was 15-min with a load of 50W. PPO, time to obtain PPO, heart rate (HR), body temperature (T), H+, [La-], and rating of perceived exertion (RPE) were analyzed before and after SIT. A two-way repeated measures ANOVA was performed to detect differences in means on endpoints. All data are expressed as mean±SEM.
RESULTS: After SIT with the hypercapnic warm-up, PPO on the Wingate test increased by 8.2% ($p<0.01$). The time to obtain PPO decreased by 0.6sec ($p<0.05$). HR in both CG and EG increased by 3beats·min-1 ($p<0.05$) and 10beats·min-1 ($p<0.01$) respectively. Body T was 0.8 °C and 1.0 °C lower after the test in EG and CG groups, respectively. [La-] and H+ were statistically significantly higher ($p<0.05$) after the 6-week SIT training only in EG group by 1.6mmol·l-1 and 9.1nmol·l-1 respectively. RPE decreased statistically significantly by 6.3%, only in EG ($p<0.01$).
CONCLUSION: Results from the present investigation suggest that six weeks of cycling sprint interval training with Warm-up with added respiratory dead space volume mask increases anaerobic performance. Hypercapnic warm-up prior to cycling SIT produces an ergogenic effect by obtaining higher PPO, [La-], H+ in the Wingate test with a lower RPE.

### BEYOND THE SECOND VENTILATORY THRESHOLD: RESPIRATORY COMPENSATION POINT AND THIRD VENTILATORY THRESHOLD.

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INTRODUCTION: Ventilatory thresholds (VT) are commonly used to identify physiological boundaries. Recently, authors have suggested a third ventilatory threshold (VT3) is present in well trained, but not recreationally trained cyclists.(Ozkaya et al., 2021) However, it is unclear whether VT3 is an overestimation of a second ventilatory threshold (VT2) and subsequently comparable to respiratory compensation point (RCP), or indeed an independent threshold. The aims of this study were to investigate (1) time dependent change-points in respiratory parameters during an incremental cycle test to reveal whether VT3 is independent of RCP and (2) to assess the relationship between performance parameters and the presence of VT3.
METHODS: Thirty-nine cyclists performed a maximal incremental test on a cycle ergometer. VT2 and VT3 were identified via a second and third inflection point in breathing equivalents of oxygen (EQO2) and end tidal partial pressure of carbon dioxide (PETCO2), plus the first and second inflection point in the breathing equivalents of carbon dioxide (EQCO2). RCP was identified via the first inflection point in VE/VCO2. The inflection points were visually identified.
RESULTS: VT2 and RCP was identified in all participants, whereas VT3 was present in 25 participants (64.1%). Participants presenting a VT3 reported a higher peak power to weight ratio (4.7 ± 0.7 W/kg) compared to those without VT3 (4.2 ± 0.7 W/kg) ($P = 0.04$), however no significant difference was observed for peak power output (PPO) or VO2MAX between the two groups ($P=0.40$, $P=0.08$ respectively). Of the 25 participants displaying three breakpoints, power output (PO) was not different between VT2 and RCP (238.9 ± 52.4 W and 235.0 ± 54.2 W respectively) ($P=0.12$). However, PO at VT3 (310.9 ± 53.2 W) was significantly greater compared with VT2 and RCP ($P<0.001$, $P<0.001$ respectively).
CONCLUSION: It is demonstrated that the use of ventilatory equivalents and PETCO2 provide a method to determine time dependent change points in respiratory parameters. VT3 was evident in individuals who possess a higher power to weight ratio and therefore the presence of this could be dependent on trained status. Recreationally active individuals incur three identifiable phases, isotonic buffering phase, isocapnic buffering phase and hypercapnia alongside hyperventilation. However, in well trained athletes a delay between hypercapnia and hyperventilation can be identified, establishing a third threshold independent of VT2 and prior to exhaustion. Future research should look to investigate the reliability of identifying VT3 and its prevalence VT3 during other exercise modalities (running).
Ozkaya, O., Balci, G. A., As, H., & Yildiztepe, E. (2021). A new technique to analyse threshold-intensities based on time dependent change-points in the ratio of minute ventilation and end-tidal partial pressure of carbon-dioxide production. Respiratory Physiology & Neurobiology, 294, 103735.

### FACTORS AFFECTING PERFORMANCE IN WOMEN COMPETITIVE ROAD CYCLING: A SYSTEMATIC REVIEW

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INTRODUCTION: Women cycling has grown in popularity in the last couple of years. Since the introduction of the Women's World Tour in 2016, the quality of performances of riders and competitions has increased [1]. However, although the factors affecting women's road

cycling performance may be different from those affecting men, the number of studies carried out on this topic is still scarce. Therefore, the main purpose of this systematic review is to analyze the studies focused on factors affecting performance in women competitive road cycling.
METHODS: A systematic review following PRISMA guidelines [2] was conducted, using the terms performance AND bicycle OR bike OR cyclists OR cyclists' OR cyclist AND women OR female OR womens OR woman in five different databases (Pubmed, Medline, Sportdiscus, Scopus and Google Scholar). After the duplicates were removed, titles and abstracts were screened against the inclusion criteria (i.e., primary studies, 1990-present, written in any language that could be translated into Spanish or English, and full text available). Finally, a full-text review was carried out to verify that the study participants were a minimum of five elite competitive or competitive recreational women between the ages of 15 and 50.
RESULTS: A total of 1630 studies were retrieved from this search, resulting in 1065 studies after duplicates were removed. 277 studies remained after the title and abstract screening, and of these, 55 studies were finally selected after the full-text review. The selected studies were classified into 7 different factors affecting performance (i.e., physiology, nutrition, training, competition, biomechanics, psychology, and sociology) according to their main purposes. The majority of the studies focused on nutrition (24.6%), followed by physiology (31.6%) and training (22.8%). Six studies analyzed competition (10.5%), four focused on psychology (7%), and only one study focused on biomechanics (1.8%) and sociology (1.8%).
CONCLUSION: Despite the recent growth of women's competitive road cycling, currently only 55 studies have analyzed factors affecting performance. Specifically, a lack of studies focused on the biomechanics, sociology and psychology of female cyclists has been identified. Therefore, more studies focused on women's competitive road cycling are needed to fully understand the requirements of these competitions.

**OBJECTIVATION OF CYCLING PERFORMANCE: CLASSIFICATION AND DETECTION OF ATYPICAL ATYPICAL TRAINING**

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INTRODUCTION: Quantification of training loads in cycling have been of great interest, from modelling performance or to monitoring fatigue. Our goal here is to model the internal response of cyclists to a given external load, to then detect atypical behavior, and highlight some combination of parameters, such that sleep quality, mood or RPE for instance, that promote better or worse performance.
METHODS: A 6-month follow-up was conducted with 14 athletes to collect training and fitness data. Training data include information about individual training sessions, such as heart rate (BPM), power (Watts), elevation (meters), speed (meters per sec), air temperature (Celsius) and other environmental variables.
Three methods were implemented to handle these data :
-A model using quantile regression statistical framework, to build, for each power performed by the athlete, a classic interval of heart rate expected by the athlete,
- A regression model to predict heart rate from external load data (power, elevation, temperature etc.), taking into account the temporal aspect of a training,
-Some methods to objectively classify the different type of training sessions were tried, starting with PCA and using more complex method such that building embeddings for multivariate time series.
RESULTS: The quantile regression method notifies that when the athletes (internal) cardiac response is higher than her "expected" (model-predicted) cardiac response, the athletes fitness variables, as well as some performance parameters (self-reported performance), are also below the athletes standards (underperformance). The same conclusion can be drawn with lower than expected heart rate responses, for which the athletes self-reported variables suggest that the exercise was better than usual (overperformance).
The models for predicting heart rate as a time series achieved an average accuracy of 8.57 bpm using a 5-variable nonlinear regression model.
Comparing the classification results obtained by PCA, with the annotation of workouts by domain experts, it follows that classifying workouts by type is not unfeasible.
CONCLUSION: Our different prediction models allow us to obtain an interesting first baseline according to our objectives. However, as sport performance is complex to predict, other physiological behaviors could be taken into account in order to have results closer to reality. The use of VRAE (Variational Recurrent Auto-Encoders) type models would allow us to obtain a simplified and discriminating representation of training sessions according to their type. Variations of recurrent neural networks would also allow us to take into account certain physiological phenomena such as the appearance of fatigue.

**IS RPE A GOOD BASIS FOR EXERCISE PRESCRIPTIONS IN DIFFERENT ACTIVE COHORTS?**

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INTRODUCTION: Borg's ratings of perceived exertion (RPE) has often been used to measure and monitor exercise intensity. A study by Scherr et al (2013) reported its strong correlation with both heart rate (HR) and blood lactate concentration (La). This ratifies it is a valid tool for monitoring and prescribing exercise intensity. RPE is therefore commonly used in rehabilitation settings, e.g. cardiac rehabilitation, to assess the subjective perceived exertion during an incremental exercise test. Especially in rehabilitation settings but also in recreational sports, exercise requires a proper level of intensity as misclassification might lead to the absence of a beneficial or potential harm of exercise. To investigate the handling of RPE (6–20 scale) in different exercise settings, we analysed the interrelationships between RPE, HR, and La in recreational athletes (RA), people suffering from long-covid (LC) and active people suffering from heart disease (HD) as especially the last two groups should avoid levels of too high intensity.
METHODS: A total of 76 participants (29 females; aged 18-69 yrs; RA: n=31, HD: n=26, LC: n=19) performed a stepwise incremental exercise test until total exhaustion on an electromagnetically braked cycle ergometer, with the initial workload varying between 25–100 W according to their individually expected maximal capacity. Capillary blood samples were obtained from the earlobes to measure lactate concentration before and within the last 15 sec of each workload during exercise testing. RPE was assessed at the time of lactate measurements. HR was continuously measured using a standardised 12-lead surface ECG. For statistical analyses, data for La, HR and RPE were determined at the individual anaerobic threshold (IAT).
RESULTS: RPE at IAT was on average at 13.0, 95% CI [12.4, 13.6] for RA and with 11.7, 95% CI [10.9, 12.5] and 12.0, 95% CI [11.1, 12.8] marginally lower for HD (p=.014, d=0.67, BF10=3.61) and LC (p=.047, d=.60, BF10=1.53), respectively. Including all groups, data showed a

positive linear Pearson correlation with medium effects between RPE and HR (p=.033, r=.25, BF10=1.34) and La and HR (p=.027, r=.25, BF10=1.58). The only significant within group correlation referred to the positive relationship between RPE and HR (p=.012, r=.49, BF10=4.80) for HD. Bayesian correlations confirmed that there was no linear association (i.e. data were more likely to occur under H0) between RPE and La – both across and within groups (p>.597, r <±.13, BF10<0.33).
CONCLUSION: Our data support the use of RPE for exercise prescriptions as intensities between an RPE of 11–14 or an RPE of 12–14 are recommended by international guidelines. In contrast to other literature (e.g. Scherr et al.), there was no correlation between HR, La and RPE. The mismatch between La and RPE might most likely be the result of using different testing protocols which were adapted according to the individual fitness level.
Scherr et al. Eur J Appl Physiol. (2013)

**FATIGUE INDEX PREDICTION IN THE WINGATE TEST IN FEMALE CYCLIST**

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INTRODUCTION: The Wingate (WAnT) test consists in pedaling 30-seconds at maximal speed and against a constant force [1]. Different metrics related to performance can be obtained from this test such as peak power, mean power, and fatigue index (FI) [1]. The FI is used for evaluating performance during the WAnT in different sports (e.g. cycling, rugby, or football) and physical fitness condition (e.g. physically inactive or professional cyclists) [2]. This study aimed to assess which physiological parameters are related to FI of WAnT test in female cyclists.
METHODS: Eighteen female cyclists (25 ±8 years, 1.65 ±0.07 m, 59.8 ±7.2 kg and BMI 21.81 ±1.97 kg/m2) performed a protocol consisting of a twelve minutes warm-up and a WAnT test. The cyclists were instructed to avoid consuming any stimulant substances and perform exercise 24 hours before the tests. Power output (W.kg-1), normalized heart rate (%), lactate (mmol.L-1), rating perceived exertion (RPE; Borg Scale 6-20), and the muscle oxygen saturation (%SmO2) on the vastus lateralis (assessing the execution inclination; EI) [3], were measured. The test was performed with a constant load of 0.075 kg per body mass kg. Multi regression analysis model with a stepwise selection of variables was performed to assess the relationship between FI with demographic variables and the rest of the outcomes of the WAnT test.
RESULTS: Participants obtained the following values in the WAnT test: FI 38.9 ±13.1%, peak power output 9.2 ±0.9 W. kg-1, mean heart rate 84 ±6% of the maximum heart rate, lactate 6.0 ±3.4 mmol/L, RPE 17 ±2 points, and EI 0.93 ±0.47. Regression analysis obtained the following model: FI = -50.97 + RPE*4.3 + EI*15.8 (R2=0.69, p<0.001).
CONCLUSION: The main finding of this study was the great correlation of EI and FI found. Thus, we can suggest the measurement of muscle oxygen saturation for monitoring this kind of anaerobic efforts.
1. Bar-Or (1987)
2. Christie (2021)
3. Castillo et al. (2016)

**THE RELATIONSHIP BETWEEN TRAINING LOAD AND TIME TRIALS IMMEDIATELY FOLLOWING DIFFERENT TRAINING SESSIONS**

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INTRODUCTION: The purpose was to examine the differences in training load (TL) metrics when quantifying different training sessions, which differed in intensity and duration. Also, the relationship between these TL metrics and the acute performance decrements (APD) measured immediately after the training sessions was assessed.
METHODS: 11 male recreational cyclists performed four training sessions in a random order, immediately followed by a 3 km time trial. Before the start of the training period, participants performed the time trial twice in order to obtain a baseline performance. The difference in the average power output for the time trials following the training sessions was then expressed relatively to the best baseline performance. The training sessions were quantified using seven different TL metrics, four using heart rate as input, two using the power output and one using the rating of perceived exertion (TLRPE)
RESULTS: Training sessions were ranked differently, depending on the TL metrics used. Also within the metrics using the same input (HR, power), differences were found. TLRPE was the only metric showing a response that was consistent with the APDs found for the different training sessions. The Training Stress Score (TSS) and the individualized training impulse (iTRIMP), demonstrated similar patterns but overexpressed the intensity of the training sessions. The total work done (TWD) resulted in an overrepresentation of the duration of training.
CONCLUSION: Using different TL metrics, results in different ranking of training sessions. The way in which the intensity of training sessions is calculated, plays a key-role in the determination of the total load of a session.

**DIFFERENCES IN MUSCLE OXYGEN SATURATION AND PERCEPTUAL RESPONSES BETWEEN CYCLE, ELLIPTICAL, AND TREADMILL**

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INTRODUCTION: Muscle oxygen saturation (SmO2) is the balance between muscle oxygen supply and demand measured in a local muscle, and its response to different types of training remains unclear [1]. This study aimed to identify differences between 3 types of exercise at the same cardiovascular intensity on acute SmO2 and total hemoglobin (tHb) response of vastus lateralis (VL) and gastrocnemius medialis (GM) and perceived exertion (RPE).
METHODS: Fourteen volunteer healthy participants (age=34.9±9.1 years; height=169.4±8.6 cm; body mass=69.7±9.8 kg; GM skinfold=8.2±3.4 mm; VL skinfold=15.2±5.9 mm) completed 5 minutes of constant load at 50% of heart rate reserve (%HRR) in i) Cycle ergometer - cadence of 60 rpm, average power of 107±32 W; ii) Elliptical trainer - cadence of 120 bpm, average power of 110±44 W; iii) Treadmill walking - speed of 5.8 km/h, average grade of 5±3%. An ANOVA with repeated measures and Bonferroni correction for pairwise comparison was used for data analysis.

RESULTS: At a moderate intensity of 50% of HRR, significant differences were found between exercise types in SmO2 (F[1,19]=4.47, p=0.035, η2=0.256, and F[2,26]=24.15, p<0.001, η2=0.650, in VL and GM, respectively), the minimum value of SmO2 (SmO2min) (F[2,26]=4.74, p=0.018, η2=0.267, and F[2,26]=24.66, p<0.001, η2=0.655, in VL and GM, respectively), tHb (F[2,26]=4.72, p=0.018, η2=0.266, in GM) and RPE (F[2,26]=6.77, p=0.004, η2=0.342). The average value of SmO2 in VL was lower during cycle vs treadmill (65±21% vs 79±15%, p=0.018) and in GM was lower during treadmill vs elliptical (35.6±11.7% vs 51.3±11.3%, p=0.010) and cycle (35.6±11.7% vs 65.9±11.4%, p<0.001) and in elliptical vs cycle (51.3±11.3% vs 65.9±11.4%, p=0.005). The SmO2min in VL reached during the exercise was lower in cycle vs treadmill (50.9±25.9% vs 72.8±17.8%, p=0.043) and in GM was lower in treadmill vs elliptical (26.4±10.8% vs 42.9±12.3%, p=0.010) and cycle (26.4±10.8% vs 57.6±11.1%, p<0.001) and in elliptical vs cycle (42.9±12.3% vs 57.6±11.1%, p=0.010).
The tHb in GM was higher in the treadmill compared to cycle (12.66 ± 0.44 g/dL vs 12.53 ± 0.50 g/dL, p=0.024) and elliptical (12.66±0.44 g/dL vs 12.53±0.51 g/dL, p= 0.041).
A higher RPE was found in cycle vs elliptical (13.1±1.7 vs 11.5±1.7, p=0.026) and treadmill (13.1±1.7 vs 11.5±1.7, p=0.026).
CONCLUSION: For a moderate intensity at 50% of HRR, the cycle ergometer promotes lower values on VL in both SmO2 and SmO2min and the treadmill walking promotes lower values on GM in SmO2 and SmO2min with a higher tHb value. The cycle ergometer was related to a higher perceived exertion.
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References:
[1] Perrey, S., & Ferrari, M. (2018). Muscle Oximetry in Sports Science: A Systematic Review. Sports medicine, 48(3), 597-616.

## Conventional Print Poster

### CP-BM02 Neuromuscular Physiology / EMG / Postural stability

#### INTER-MUSCULAR COORDINATION IN ADULTS WITH DOWN SYNDROME. A NETWORK ANALYSIS

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INTRODUCTION: Down Syndrome (DS) is a chromosomal disorder affecting the neuro-muscular system among others. Some of the most common alterations include muscle hypotonia and impaired inter-muscular coordination during activities of daily living. However, the mechanisms underlying cross-frequency network communication among distinct muscle fibers across muscles in DS individuals remain unknown. Accordingly, we investigate how different muscle fiber types dynamically synchronize with each other and integrate as a network across lower limb muscles during a static standing position in adults with and without DS.
METHODS: Seven adults with DS (DS group) and 10 adults without disabilities (non-DS group) performed a static standing position for 30 seconds. Electromyographic activity of 8 muscles (soleus, tibialis anterior, gastrocnemius lateralis, gastrocnemius medialis, gluteus maximus, rectus femoris, biceps femoris and semitendinosus) from the right leg was collected during the task. We first obtained 10 time series of EMG band power $\bar{S}(f)$ for each muscle, representing the dynamics of all representative EMG frequency bands. Frequencies below 40-60 Hz can be attributed to the activity of small alpha-motoneurons and related type I muscle fibers, 60-120 Hz frequencies can be associated with medium alpha-motoneurons and related type IIa fibers, and higher frequencies 170-220 Hz can be attributed to the large alpha-motoneurons and their related type IIb fibers. To investigate cross-frequency interactions among EMG frequency bands that occur as a result of synchronous modulation of their spectral amplitudes, we calculate the bivariate equal-time Pearson's cross-correlation for each pair of EMG band power $\bar{S}(f)$ time series across all lower limb muscles.
RESULTS: We identify 4 patterns of inter-muscular network interactions in the non-DS group according to the role and topology of the selected muscles — each pattern is characterized by differentiated contribution of frequency bands leading to specific link strength profiles. In contrast to the non-DS group, inter-muscular network interactions for DS group are characterized by (i) an overall significant increase of link strength across all muscles ($p < 0.05$) and (ii) a change on the link strength profiles for all observed patterns.
CONCLUSION: Adults with Down Syndrome showed overexpressed/excessive network connectivity reflecting an unfunctional/pathological state, which pushes the neuro-muscular system toward a rigid order reducing its adaptability to environmental constraints. The reported empirical findings will break new ground in the study of inter-muscular coordination and will provide new understanding of the effects of the Down Syndrome disorder on the neuro-muscular system.

#### EFFECT OF PROLONGED CROSS-LEGGED SITTING ON BIOMECHANICAL VARIABLES

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INTRODUCTION: Previous studies have reported that maintaining a cross-legged posture more than 10 minutes lead to the creep phenomenon that temporarily delay muscle restoration due to the stretching of the gluteus muscles (1). Creep situation many have a negative effect on walking and sitting movements, which are often performed in daily life. Moreover, retaining of repetitive and continuous creep conditions can induce abnormal movement pattern such as Trendelenber signs (2 & 3). Therefore, the purpose of this study was to verify the effect of cross-legged sitting for 15 minutes on the kinematic and kinetic variables.
METHODS: Nineteen healthy male adults who had no experience of musculoskeletal injuries or surgical operations on the trunk or lower extremities within the past 6 months participated in this study (age: 28.78±4.31 yrs., height: 172.95±5.84 cm, body mass: 76.50±13.10 kg, navicular drop test; 5.8±1.7 mm). After full warm-up, each participant was asked to perform one-leg squat without loads (pre_squat) followed by the intervention (a 15 minutes cross-legged sitting). Then, the squat was asked to be performed again within 2 minutes after the intervention (post_squat). A three–dimensional motion analysis included 8 infrared camera and 2 channels EMG with sampling rate as 100Hz and 1000 Hz, respectively, was performed in this study. A paired t-test was conducted to verify the intervention effect and the statistical significance was set at $\alpha$=.05.

RESULTS: Significant increase in the maximum hip adduction(8%) and knee valgus were found in post_squat compared with those of pre_squat throughout the entire single-leg squat(p<.05). Also, significantly increased pevic height in support feet was found in post_squat compared with that of pre_squat (p< .05). Finally, post_squat revealed significantly decreased gluteus medius muscle activation compared with that of pre_squat during ascending phase of the squat (p< .05).
CONCLUSION: In this study, we found that prolonged cross-sitting may cause overuse of specific lower extremity muscles as a function of compensation movement and damage to the most vulnerable joints in the body. Therefore, it is suggested that cross-legged sitting should be avoided when sitting and light strength training for the gluteus medius or dynamic break is necessary to prevent deformation of the tissues around the pelvis and lower extremities.
REFERENCES:
1) Shin & Mirka, Clinical Biomechanics, 2007
2) Bailey et al., Physical Therapy Reviews, 2009
3) Ekegren et al., ournal of Orthopaedic & Sports Physical Therapy, 2009

**NEUROMUSCULAR TRAINING AND THE EFFECT ON LOW BACK PAIN AND POSTURAL STABILITY**

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INTRODUCTION: The complex multicausal syndrome “low back pain” (LBP) is nowadays the leading cause of disability worldwide [1]. A reduced postural control is associated with a risk factor for LBP [2]. Coordination/stabilisation exercise programs have beneficial effects in the treatment of chronic LBP [3]. The aim of the study was to investigate the effects of a neuromuscular training on LBP and postural stability.
METHODS: 112 subjects participated 12 times 1 hour in a weekly sports course for students. 54 (f: n=45/m: n=9 22±2.9 kg/m²; 26.7±7.4 yrs) conducted a standardised neuromuscular training (called RanRücken; RR), 25 (f: n=13/m: n=12; 22.1±2.5 kg/m²; 28.6±8.1 yrs) did a general strength training (ST) for LBP prevention and 33 (f: n=26/m: n=7; 22.4±3.1 kg/m²; 24.7±6.3 yrs) participated on college courses without specific neuromuscular or LBP related training (Control Group; CG). Pre- and post-measurements (MiSpEx-Protocol [4]) include isokinetic trunk force (IsoMed 2000), countermovement jumps (CMJ) and posturography (Center of Pressure; COP left/right), both measured with Wii Boards (Nintendo, CSMi modified). In addition, the von Korff-Questionnaire was assessed (Characteristic Pain Intensity (CPI), Disability Score (DS)). Data were normal distributed. Depended t-tests and mixed ANOVA were performed. Cohens d was used to estimate the effect size.
RESULTS: Trunk force did not change for RR (n=39; Flex: p=.030, d=.07; Ext: p=.133, d=.16). Back strength did not change for CG (n=29; Ext: p=.567, d=-.04). Trunk Force improvements could be detected for CG (n=29; Flex: p=.003, d=.15) and ST (n=25; Flex: p=.012, d=.23; Ext: p=.013, d=.14). CMJ performance did not differ for all groups (RR: n=53, p=.309, d=.07; ST: n=24, p=.024, d=.19; CG: n=32, p=.414, d=-.07). There were no differences in postural stability for ST (n=25; COP l.: p=.980, d=.01; COP r.: p=.806, d=.08) and CG (n=32; COP l.: p=.165, d=.33; COP r.: p=.284, d=.30). RR improved the right leg stand stability (n=54; COP l.: p=.023, d=.25; COP r.: p=.014, d=.33). Pain intensity and pain related disability did not differ for ST (n=25; DS: p=.018, d=.40; CPI: p=.286, d=.15) and CG (n=32; DS: p=.328, d=-.47; CPI: p=.422, d=-.25). RR showed less pain and pain related disability (n=54; DS: p<.001, d=.51; CPI: p<.001, d=.45). Group comparisons revealed differences in CPI and DS for RR and ST compared to CG, but not between RR and ST.
CONCLUSION: ST has small beneficial effects on the trunk force, whereas the neuromuscular training caused low improvements in postural stability. Both interventions focused on LBP reduction and prevention, but only RR could show medium effects in LBP reduction and less pain related disability.
References
[1] Hartvigsen J et al. (2018). The Lancet 391(10137): 2356–2367
[2] Borghuis J et al. (2008). Sports Med 38 (11): 893–916
[3] Searle A et al. (2015). Clin Rehabil 29 (12): 1155–1167
[4] Niederer D et al. (2016). Trials 17 (1): 507
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**WHY DECELERATION OCCUR IN THE 100-M DASH? : TIMING OF THIGH MUSCLE ACTIVITY IS A FACTOR LIMITING PERFORMANCE.**

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INTRODUCTION: The 100-m dash can be divided into three phases (acceleration phase, maximal speed [Max] phase, and deceleration [Dec] phase) (Ae at al. 1992). The running speed (RS) reaches maximum in the Max phase. Interestingly, the maximum RS cannot be maintained, and RS gradually decreases towards the finish (the Dec phase). What happens in the Dec phase to cause the observed decrease in RS? Previous studies demonstrated a decrease in RS in the Dec phase is inevitable even in world class sprinters, due to a decrease in step frequency (SF). Hence, to lessen the inevitable decrease in RS in the Dec phase, sprinters should maintain the SF as high as possible. In addition, we have recently demonstrated that timing of rectus femoris (RF) and biceps femoris (BF) activities influences the SF at the maximal RS (30-50 m section) (Kakehata et al. 2021). Therefore, the purpose of this study was to analyze the changes in the timing of electromyography (EMG) activity of the RF and BF in both legs, together with spatiotemporal variables (RS, SF, and step length: SL) in the Max and the Dec phases of the 100-m dash.
METHODS: Nine male track & field athletes performed the 100-m dash with maximal effort. A portable wireless data logger was attached to the subjects lower back to record EMGs. We defined the Max phase as the 50-70 m section and the Dec phase as the 80-100 m section. We calculated spatiotemporal variables (RS, SF, SL). Moreover, we also calculated onset/offset timing (%) of RF and BF in both legs using a Teager-Kaiser Energy Operator filter (e.g., ipsilateral leg RF onset is “iRF-onset”, contralateral leg BF onset is “cBF-onset”). A paired-sampled t-test was used to determine the difference between the two phases (Max vs Dec). Moreover, to analyze which muscle activity timing affects the SF decrease in the Dec phase, we examined the Pearson’s product–moment correlation between the changes in SF (Δ SF) and EMG variables (Δ EMG) from Max phase to Dec phase.
RESULTS: The decreased RS in the Dec phase ($P < 0.001$) was due to a decreased SF ($P < 0.001$). Moreover, iRF-onset ($P = 0.002$), iRF-offset ($P = 0.008$), iBF-offset ($P = 0.049$), and cBF-offset ($P = 0.017$) in the Dec phase shifted to later in the running cycle as compared with the Max

phase. Furthermore, the time difference between the swing leg RF activity (iRF-onset) and the contact leg BF activity (cBF-onset) ("Scissors1") became bigger in the Dec phase (P = 0.041). Significant negative correlations were found between ΔiRF-onset and ΔSF (P = 0.045), and between ΔiBF-offset and ΔSF (P = 0.036).
CONCLUSION: The decreased RS and SF in the Dec phase of the 100-m dash would be the delayed timing of the RF and BF activities in the same leg as well as the disturbed inter-leg muscular coordination. Moreover, a greater change in EMGs have a greater change in SF. We concluded that the timings of thigh muscle activity is a factor limiting performance in the deceleration phase of the 100-m dash.

**DOES DUAL-TASKING AFFECT THE ABILITY TO GENERATE ANTICIPATORY POSTURAL ADJUSTMENTS IN YOUNG ADULTS?**

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INTRODUCTION: To date, little is known about the impact of additional cognitive tasks on perturbed balance and whether different types of cognitive tasks elicit different balance response mechanisms. The aim of this study was to investigate how two additional cognitive tasks (Stroop test and counting backwards task) would influence young adults' ability to generate appropriate postural responses.
METHODS: Twenty young adults (25.95 ± 2.97 years) stood eyes open, bare feet shoulder-width apart on a moving platform which was translated in the anterior-posterior direction at three different frequencies (0.1, 0.25, 0.5 Hz) and performed either a counting backwards task, a Stroop task, or no additional cognitive task. Muscle tonic activity and muscle onset latencies of the Rectus Femoris, Bicep Femoris, Tibialis Anterior, and Gastrocnemius Medialis were measured through surface electromyography (1000 Hz). The number of steps taken and cognitive errors made were also recorded.
RESULTS: Results showed no significant differences in muscle onset latencies and tonic activity between dual tasking and single tasking conditions, nor between the two dual tasking conditions. Cognitive errors were made in the counting backwards task (238 total cognitive errors across all frequencies) but not the Stroop task. A frequency effect was identified with participants showing greater tonic activity in the Rectus Femoris ($p= 0.012$), the Gastrocnemius Medialis ($p= 0.016$), and the Bicep Femoris ($p= 0.043$) at 0.5 Hz, as well as earlier muscle activation in the Tibialis Anterior, ($p< 0.001$), the Gastrocnemius Medialis, ($p< 0.001$) and the Bicep Femoris ($p< 0.001$) at 0.5 Hz compared to the other frequencies. Transition and steady state muscle onset latencies were only significantly different for the Gastrocnemius Medialis at 0.25 Hz ($p= 0.001$), possibly because the 0.1 Hz frequency was too easy to require adaptation and the 0.5 Hz frequency was large enough to trigger earlier muscle activation from transition state which was then carried to steady state.
CONCLUSION: Dual tasking did not seem to influence anticipatory postural adjustments in young adults, however perturbation intensities did. It is assumed that due to the 'threatening' nature of the 0.5 Hz perturbation, a stiffer position was adopted as seen by the increased tonic activity, and anticipatory mechanisms were triggered sooner than the other frequencies, as seen by earlier muscle activation. Since posture was unchanged between single and dual tasking, it is, suggesting suggested that participants' postural control was automated and the cognitive errors in the two mental tasks could reflect their difficulty level. Future research should explore body kinematics and centre of pressure to identify the balance strategies adopted, as well as take into account cognitive task the reaction times of the cognitive task to better understand participants' allocation of attention during perturbed balance dual tasking.

**WHOLE BODY VIBRATION PRODUCES A POSTURAL DESTABILISING EFFECT DURING A HALF-SQUAT**

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INTRODUCTION: Scientific evidence has shown that introducing instability into strength training is beneficial for improving sport performance and injury recovery (1). However, there is limited research on the effects of whole body vibration (WBV) acting as a destabilising stimulus.
METHODS: Therefore, the aim of this study was to determine whether WBV produces postural destabilising effect during a half squat with different ballasts and rhythms measuring the movement variability through entropy. A total of 12 male athletes (age: 21.24 +- 2.35 years, height: 176.83 +- 5.80 cm, body mass: 70.63 +- 8.58 kg) performed a half-squat with weighted vest, dumbbells and a bar with the weights suspended with elastic bands, with and without WBV at 40 bpm and 60 bpm. Subjects performed one set of twelve repetitions of each situation, composed by the combination of the three factors. The movement variability was analysed by calculating the sample entropy (SampEn) of the acceleration signal recorded at the waist using an accelerometer.
RESULTS: With WBV, significant differences were found between dumbbells and weighted vest ($p<0.001$; ES: 2.87 at 40 bpm; $p<0.001$; ES: 3.17 at 60 bpm) and between the bar and weighted vest at both rhythms ($p<0.001$; ES: 3.12 at 40 bpm; $p<0.001$; ES: 2.93 at 60 bpm) and a higher SampEn was obtained at 40 bpm with all ballasts ($p<0.001$; ES of WV: 1.22; ES of D: 4.49; ES of B: 4.03). No significant differences were found without WBV.
CONCLUSION: These findings reveal that the WBV produces a destabilising effect performing half-squat with different ballasts and rhythms. In addition, a higher movement variability is achieved when the ballast is placed on the upper limbs and when performed at a slow rhythm. Our results show that the WBV can be used in combination with the appropriate ballast and rhythm for the athlete's characteristics, to progress and avoid the loss of training potential of the strength exercises or to improve muscle feedforward, which can prepare the athlete for challenging situations in sport.
REFERENCES
1) Behm DG, Muehlbauer T, Kibele A, et al. Effects of strength training using unstable surfaces on strength, power and balance performance across the lifespan: a systematic review and meta-analysis. Sports Med 2015; 45: 1645–1669. doi:10.1007/s40279-015-0384-x

**STABILITY IN PARA-SHOOTING: A MULTIMODAL APPROACH.**

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INTRODUCTION: Although the questions of postural control and stability are widely studied in competitive shooting in the able-bodied, no study has quantified these aspects on Paralympic athletes [1]. While the goal of postural stability may seem similar, the approach is quite different. Indeed, in the context of para-shooting, the handicap of each athlete requires an individualized and multimodal response. We have selected 2 cases of athletes to illustrate this multimodal approach.

METHODS: For each of the athletes, we have quantified the impact of spasticity on the posture by a comparative biomechanical analysis (100hz, Motive, Optitrack) of the movement in a match situation: the performance of 10 shots at 10m (Scatt MX02) before and after intramuscular infiltration of anesthetic.
Athlete 1, international SH1 level, hemiplegic, is a specialist in pistol shooting at 10m. In his practice but also in his professional life, the athlete is disabled by an almost continuous contraction of the elevator muscles of the shoulder. This hyperactivity becomes painful in stressful situations such as important competitions. We have specifically quantified the shoulders angle in relation to the horizontal axis.
Athlete 2, international SH2 level, hemiplegic, is a specialist in 10 and 50 meters rifle shooting. As part of his practice, the athlete is disabled by dystonia of the finger flexors of the hand which allows the rifle to be held on the gallows. This dystonia presents at random during the pre-shot aiming, making the athlete apprehensive with each shot. We specifically quantified the range of the area of the polygon formed by the fingers of the hand.
RESULTS: Regarding athlete 1, we observe an increase in the angle of the shoulders (13 ° vs 18 °) which is explained by the lowering of the shoulder by 4cm (133 vs 129cm from the ground). At the shooting performance, we see an improvement: 88 points versus 82, 38 versus 34.6 mm for the stability of aiming.
Regarding athlete 2, we observe a decrease in the opening of the hand (6.1% versus 1.4%). In terms of shooting performance, we do not observe any changes in the 104 score versus 102 points, but a decrease in the stability of aiming 15.5 versus 9.2 mm. This decrease is explained by a less unstable trace due to the barrel movement suppression by the involuntary contraction of the fingers.
CONCLUSION: These two multimodal analyses (ie. the combination of anesthetic block, movement analysis, Scatt analysis and performance results) highlight the relevance of a common reflection involving the technical staff, the athlete, and the medical staff. The management of disability-related underperformance factors requires that the medical staff appropriates the performance criteria of each sport in regard to its regulatory constraints.
[1] Spancken S, Steingrebe H, Stein T. Factors that influence performance in Olympic air-rifle and small-bore shooting: A systematic review. PLoS One. 2021 Mar 31;16(3):e0247353.

### PATIENTS WITH LOWER-LIMB COMPLEX REGIONAL PAIN SYNDROME RELY LESS ON PROPRIOCEPTIVE INFORMATION TO CONTROL UPRIGHT STANDING COMPARED WITH HEALTHY ADULTS

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INTRODUCTION: Previous work reported proprioceptive impairment for patients with unilateral Complex Regional Pain Syndrome (CRPS) affecting the lower limb (1). A decrease in leg proprioception can lead to decrease the contribution of proprioception on balance control, and therefore alter postural control (2). The objective of the present study was to determine whether lower-limb CRPS decreases the reliance on proprioceptive information to control balance in upright standing.
METHODS: The displacement of the centre of pressure (CoP) was measured from a force platform during 40-s epochs in 10 patients suffering from lower-limb CRPS (49±13 yr), and 10 age- and sex-matched healthy individuals (controls). Participants maintained upright standing with eyes open (EO) and closed (EC) before and after 30 min of bilateral Achilles tendon vibration (1-mm amplitude, 80Hz frequency) in a seated position. To probe the efficacy of the vibration to alter the proprioceptive pathway (3), the maximal amplitude of the Hoffmann H-reflex (Hmax) and M wave (Mmax) were recorded in in the soleus muscle in a seated position. A maximal voluntary isometric contraction (MVC) of the ankle plantar flexor muscles of the injured leg for the CRPS group and the left one for control group was recorded with the participants seated in an ergometer.
RESULTS: The MVC torque in ankle plantar flexor was lower in the CRPS patients than in controls (72 Nm vs.114 Nm, -37%, p=0.035) and unchanged after vibration. Before vibration, CRPS patients exhibited greater CoP path length than controls in EC only (360 mm vs. 233 mm, p=0.047). CoP path length did not change after vibration in patients (360mm to 342mm, -5%, p=0.922) but increased for controls in EC condition only (233mm to 280mm, +20.5%, p=0.037). The vibration-related decrease in Hmax/Mmax ratio was similar in both groups.
CONCLUSION: The lesser postural effect of vibration in CRPS patients on balance control suggest a decreased reliance on proprioception to control balance in patients (3). In addition to the decrease in the strength of the plantar flexors, this may contribute to alter postural control in patients, especially in the absence of visual information.
References
1. Mouraux et al. 2021. Disability and Rehabilitation 43(7): 967-975.
2. Henry & Baudry. 2019. Journal of Neurophysiology 122(2): 525-538.
3. Baudry & Duchateau. 2020. Experimental Gerontology 131: 110822.

## Conventional Print Poster

## CP-AP08 Strength I

### QUADRICEPS AND HAMSTRING STRENGTH PREDICTORS OF REACTIVE BOUNDING COEFFICIENT IN SPRINTERS

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INTRODUCTION: Reactive strength involves exerting force in minimal time and is often referred to as plyometrics (e.g., drop jump and bounding exercises), which is inherent in sprinting development. Recently, reactive bounding coefficient (RBC) was utilised as a measure of horizontal reactive strength to evaluate stretch-shortening cycle performance in sprinters (Washif and Kok, 2020). The relation between maximum strength (prerequisite in many sport skills) and horizontal reactive strength has not been examined. Therefore, this study investigated the relationship between maximum strength and RBC10 (10 bounds). Additionally, the relationship between RBC10 and sprint performance was computed.
METHODS: Fifteen sprinters (9 men, 6 women; 21±4 years; World Athletics score: 1009±78 points) participated in the study at the beginning of their preparation training period. One repetition-maximum (1RM) was assessed during power clean and back squat exercises (day 1), while peak force was recorded during bilateral isometric prone (0°) hamstring and Nordic (eccentric) hamstring curl exercises (day 2).

The greatest force measure (average of left and right legs) of three maximal repetitions was used for analysis. Relative measure of each exercise was determined by dividing the highest weight lifted or peak force recorded with own body mass. Sprint performance was assessed in the 60m sprint from a block start, with split times at 10m and 30m, and 20-30m and 30-60m segments were recorded (day 3). All athletes were healthy, and familiarised with testing protocols as part of their previous tests and training. Pearson's product-moment correlation (r) was used to determine the relationships between variables, and interpreted as follows: small (0.10-0.29), moderate (0.30-0.49), large (0.50-0.69), very large (0.70-0.89), nearly perfect (0.90-0.99), and perfect (1.00).
RESULTS: Very large correlation was observed between relative 1RM power clean and RBC10 (r=0.71, p=0.003). Relative 1RM back squats also appear to be largely correlated with RBC10 (r=0.60, p=0.019). Absolute values for 1RM power clean (r=0.49, p=0.06) and back squat (r=0.46, p=0.089) showed moderate correlations with RBC10. Large correlation was observed between RBC10 and the absolute (r=0.58, p=0.023) and relative (r=0.66, p=0.008) values of Nordic hamstring curls. On the other hand, 'weaker' correlations were observed in absolute (r=0.50, p=0.06) and relative (r=0.36, p=0.188) values of isometric prone hamstring exercise with RBC10. Correlations coefficient between RBC10 and sprint performance ranged from -0.62 (large) to -0.72 (very large), p<0.05.
CONCLUSION: The outcomes of the study support the importance of developing maximal strength of the knee extensor and flexor muscles to enhance speed-bounding performance. Coaches and strength and conditioning professionals are advised to appropriately (e.g., eccentric exercise for hamstrings) and sufficiently integrate maximal strength training in the annual plan in order to improve horizontal 'specific-strength' quality (i.e., speed-bounding) to subsequently enhance sprint performance.
Reference: Washif JA, Kok LY. The reactive bounding coefficient as a measure of horizontal reactive strength to evaluate stretch-shortening cycle performance in sprinters. J Hum Kinet. 2020;73:45-55

**RESISTANCE TRAINING VERSUS PLYOMETRIC TRAINING FOR IMPROVING RUNNING ECONOMY AND RUNNING TIME TRIAL PERFORMANCE: A SYSTEMATIC REVIEW AND META-ANALYSES**

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INTRODUCTION: Running economy has a critical role in long-distance running performance. Mounting studies have adopted resistance training and plyometric training as an adjunct to endurance running training to improve running economy and running time trial performance. For long distance runners, however, it is unclear which of the two training modalities is more effective in improving running economy and the performance of run-time trials. Therefore, the present systematic review and meta-analysis aimed 1) to determine if there are different effects of resistance training vs. plyometric training as an adjunct to distance running training on running economy and running time trial performance in long-distance runners; and 2) to elucidate the effective training variables to improve these outcomes.
METHODS: Electronic databases were searched on the PubMed, Web of Science, and SPORTDiscus databases with a variety of key words relating to strength training, running economy, and long-distance running performance. Twenty-two studies fully satisfied the inclusion and exclusion criteria. Data on running economy and running time trial performance were extracted for the meta-analyses. Subgroup analyses were performed using a random-effects model with the following potential moderators: 1) based on maximal oxygen uptake; 2) age; and 3) intervention period. In addition, the studies conducting resistance training were categorized with 4) training modality (isometric or dynamic); and 5) training intensity.
RESULTS: Resistance training had a beneficial effect on running economy, and the magnitude of beneficial effect of resistance training were greater than that of plyometric training (Hedges' g = -0.29, 95% CIs [-0.45, -0.13] and g = -0.12 [-0.52, 0.27], respectively). The effect on running time trial performance was also larger in resistance training (g = -0.28 [-0.74, 0.19]) than in plyometric training (g = -0.15 [-0.43, 0.13]). Subgroup analyses indicated that resistance training over a longer duration of more than 10 weeks enhanced the magnitude of the effect size (g = -0.50 [-0.81, -0.18]). Additionally, heavy-loads (≧ 90% 1RM or ≦ 4RM) resistance training improved running economy regardless of the runners' age and training duration.
CONCLUSION: The major findings obtained from the current review were that resistance training exhibited greater improvement in running economy and running time trial performance compared with plyometric training. Subgroup analysis indicated that resistance training over 10 weeks or longer had a moderately beneficial effect on running economy, and that with heavy loads produced greater improvement in running economy regardless of the age of the runner and training duration. These results suggest that as an adjunct to endurance running training, resistance training over 10 weeks or longer and with heavy load will be more effective in improvomg running economy and running time trial performance as compared to plyometric training.

**WHEN YOU BELIEVE YOU ARE IN THE INTERVENTION GROUP, YOU WILL GET BETTER TRAINING RESULTS. A RANDOMIZED CONTROLLED PLACEBO STUDY.**

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INTRODUCTION: Over the last two decades, research in sport and exercise science has shown that placebo effects can have a major impact on athletic performance. Most of these studies, however, have concentrated on the benefits of ergogenic aids. Currently, we know very little about the potential placebo effect when investigating different training configurations (e.g., exercise selection, loading, volume, frequency). Hence, we aimed to investigate whether a placebo effect is present when participants are told they get "optimal training", compared to being told they get generic "control training".
METHODS: A total of 40 athletes (male: n=31, female: n=9) completed a 10-week training intervention (age: 22±4 years, height: 183±10 cm, and body mass: 84±15 kg). Measurements included countermovement jump (CMJ), 20-meter sprint, one-repetition maximum (1RM) back-squat, a leg-press test, ultrasonography of muscle-thickness, and a questionnaire regarding expectations of the training intervention. The subjects were randomized to different training programs, with slight variation in exercises and loading schemes. To administer the placebo treatment, the participants were either told that the training program they got was individualized based on their force-velocity profile, or that they were in the control group. Meaning, on average, both groups consisted of subjects doing the same workouts, but half of them believed they did optimal individualized training (Placebo), and the other half believed they were the control group with non-optimal training (Control).
RESULTS: Placebo increased 1RM squat more than Control (Effect size [ES]: 0.88±0.76, Bayes Factor: 5.1 [BF10], p<0.05). Additionally, Placebo increased muscle-thickness compared to baseline (ES: 0.73±72, BF10: 3.0, p=0.06), whereas there were no change from baseline in

Control (ES: -0.04, BF10: 0.3, p=0.89). Placebo had slightly higher adherence (placebo: 82±18% control: 72±13%, difference: BF10: 2.0, p=0.08). Importantly, the group difference in 1RM squat was still significant after controlling for the differences in adherence (p<0.05). On average, both groups reported similar levels of expectations towards the interventions (Placebo: 5.6±0.7 Control: 5.9±1.1 [Median & quartiles]), However, the expectations were not normally distributed in Control, where the subjects in the lower quartile of Control had lower expectations towards the training intervention compared to Placebo (r=0.72 [rank-biserial coefficient of correlation], p<0.05). No significant differences between groups were observed in CMJ, 20-m sprints, or leg press power.
CONCLUSION: To the author's knowledge, this is the first training study investigating the placebo effect in response to subjects believing they get optimal training configurations vs a generic training program. The results suggest that the placebo effect may explain meaningful outcome variances in sports and exercise training interventions. More research is needed to understand the potential mediators and moderators.

**THE EFFECTS OF ACUTE SLEEP DEPRIVATION ON H-REFLEX AND V-WAVE**

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INTRODUCTION: The impact of sleep deprivation on muscular strength and power remains poorly understood. In healthy individuals, it has been suggested that the negative impact of sleep deprivation on muscle strength is aetiologically linked to disturbed neural function (1). A reduction in voluntary activation was in fact observed for knee extension exercise (using the interpolated twitch technique, ITT) following ~30 (2) and 24 hr of sleep deprivation (3). Nonetheless, the ITT cannot differentiate between supraspinal and spinal adaptations and this is an importante limitation because muscle activation depends both on the excitability of descending supraspinal pathways and spinal motoneurons (MN) (4). The mechanisms underlying neural changes to specific experimental interventions can be investigated by measuring reflex responses, namely the H-reflex and V-wave (5). The H-reflex is more sensitive to changes in presynaptic inhibition and/or motoneuron excitability and the V-wave is more sensitive to modifications in supraspinal input to the MN pool. We aimed to determine the acute effects of 24 hr of sleep deprivation on H-reflex and V-wave excitability.
METHODS: Fourteen healthy young adults (eight men, six women) were included. Participants visited the laboratory on two different occasions, without and with 24 hr of sleep deprivation. In each session, participants were tested for maximal voluntary contraction (MVC) of the plantar flexors and dorsiflexors, soleus H- and M-recruitment curves (6), and evoked V wave (7), as well as tibialis anterior/ soleus electromyographic co-activation.
RESULTS: Twenty-four hours of sleep deprivation did not affect either plantarflexion MVC or soleus electromyographic normalized amplitude ($p > .05$). Moreover, H-reflex and V-wave peak-to-peak normalized amplitude did not change with sleep deprivation ($p > .05$). Conversely, we obtained a significant increase in antagonist/agonist level of co-activation during MVC post-sleep deprivation ($6.2 \pm 5.2\%$, $p < .01$).
CONCLUSION: In conclusion, we found that H-reflex and V-wave responses are well preserved after 24 hr of sleep deprivation, revealing that descending neural drive and/or modulation in Ia afferent input remains largely unaffected under these circumstances. Yet, sleep deprivation affects motor control by exacerbating the magnitude of antagonist/agonist co-activation during forceful muscle contractions and this is novel.
References:
(1) Knowles et al., JSciMedSport, 2018
(2) Skein et al., MedSciSports Exerc, 2011
(3) Arnal et al., MedSciSportsExerc, 2016
(4) Behrens et al., (2015). JSciMedSport, 2015
(5) Burke, ClinNeurophysiolPract, 2016
(6) Vila-Chã et al., JApplPhysiol, 2012
(7) Mendonca et al., JClinNeurophysiol, 2019

**ACUTE EFFECTS OF BODY-WEIGHT SQUATS VARIATIONS ON HEART RATE, ACCELERATIONS, AND PERCEPTUAL RESPONSES**

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INTRODUCTION: The variations in organismic and task constraints related to performing the squat exercise promote different kinematic, cardiovascular, and perceived exertions (RPE). This exploratory study aimed to compare the body acceleration, heart rate (HR), and RPE responses to performing six squat variations.
METHODS: Eight healthy adults (age 26.9±2.8 yr, body mass 74.7±7.8 kg, height 174.9±0.1 cm) were submitted to a familiarisation session, and all completed in a random order six squats for 90 sec interspersed to 5-min rest (cadence: 40-60 bpm). The squat variations were deep (shoulder wide/ dynamic/ 110º), jump (shoulder width/ 90º/ dynamic), wall-sit (shoulder width/ 90º/ isometric), uneven (shoulder wide/ 90º/ dynamic), single-leg (shoulder width/ 110º/ dynamic) and unstable (shoulder width/ 90º/ dynamic in terra-core platform). An inertial measurement unit (Blue Trident sensor, Vicon, NZ) was attached to the lumbar region [1] to capture body acceleration data generated in the anterior-posterior, medio-lateral, and vertical directions, and further used to determine the root mean squares [2]. The HR was measured using a Garmin HRM3-SS (USA) monitor strapped on mid-sternum and RPE using the Borg scale (6-20). Data were analysed using a repeated-measures ANOVA
RESULTS: Jump squat exhibited highest values of HRmean and HRlast 30 sec (143.3±19.0 bpm and 159.7±19.8 bpm, respectively), with differences been identified between jump and others, except for single-leg (HRmean = $F [5,35] = 2.904$, $p=0.027$, $\eta 2 = 0.293$, and HRlast 30 sec = $F [5,30] = 3.834$, $p=0.008$, $\eta 2=0.390$). These differences were also identified for the RPE ($0.001 \leq p \leq 0.032$). The values of mean resultant acceleration ranged from 9.78 to 10.75 m. s-2 (wall-sit CONCLUSION: Jump squat recorded higher mean values for all variables analysed. HR values as a cardiovascular variable, from lower to higher, match the general RPE (except for isometric squat) suggesting a relationship between these variables. Our current findings help to reinforce evidence-based decisions regarding the complex process of exercise prescription, by understanding better the organic responses to different constraints.
Funding:
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References:
[1] Bonnet et al., IEEE Trans Biomed Eng 2013, 60(7):1920-1926
[2] Moe-Nilssen. R. Clin Biomech 1998, 13(4):320-327

**PRESCRIBING INTENSITY IN RESISTANCE TRAINING USING RATING OF PERCEIVED EFFORT: A RANDOMIZED CONTROLLED TRIAL**

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INTRODUCTION: Rating of perceived effort (RPE) scales are used to prescribe intensity in resistance training (RT) in several ways. For instance, trainees can reach a specific RPE value by modifying the number of repetitions, lifted loads, or other training variables. Given the multiple approaches of prescribing intensity using RPE and its growing popularity, we sought to compare the effects of two RPE prescription approaches on adherence rates, body composition, performance and psychological outcomes, in an online RT intervention.
METHODS: We randomly assigned 57 healthy participants without RT experience (60% females, age range: 18-45) to one of two groups that received two weekly RT sessions using a resistance-band for eight weeks. In the fixed-repetition group, participants adjusted the band resistance with the goal of completing 10 repetitions and reaching a 7-RPE on a 0-10 scale by the 10th repetition. In the open-repetition group, participants selected their preferred band resistance and completed repetitions until reaching a 7-RPE by the final repetition. We measured body composition, performance tests, and program satisfaction rates.
RESULTS: We assessed 46 participants at post-test, 24 from the fixed-repetition and 22 from the open-repetition groups. We observed non-significant and trivial differences between groups in all outcomes ($p>.05$). We then combined the pre-post change scores of the two groups. We found that adherence rates began at 89% and gradually decreased to 42%. On average, participants increased their fat-free mass [0.3 kg (95% CI: 0.1-0.6)], isometric mid-thigh pull [5.5 kg (95% CI: 0.8-10.4)], isometric knee-extension [2.2 kg (95% CI: 0.8-3.7)], and push-ups [6.3 repetitions (95% CI: 4.5-8.2)]. We observed non-significant and trivial changes in bodyweight, grip-force, and countermovement jump. Participants reported high satisfaction rates with all components of the program.
CONCLUSION: Participants in both groups improved their body composition and physical capacity to a similar extent, and reported comparable satisfaction rates with the programs they followed. Accordingly, either prescription approach can be used to deliver online RT sessions based on personal preferences and logistical constraints. However, since adherences rates declined over the course of the study, future research should test additional strategies aiming to maintain adherence rates.

**FAMILIARIZATION AND LEARNING EFFECT IN ISOKINETIC STRENGTH ASSESSMENT OF KNEE MUSCLE ACTION AMONG MALE CIRCUMPUBERTAL ADOLESCENTS**

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INTRODUCTION: Assessment of muscle strength has a large spectrum of applications in sport science. Isokinetic dynamometry is considered a valid protocol to assess knee muscle strength. When multiple repetitions are completed at a short interval, participants may evidence improvements in strength performance. This phenomenon is known as learning effect. Indeed, the number of repetitions to obtain peak torque values is not consistent in the literature. Taking into account the preceding, the current study was aimed to examine the learning effect during a 5-repetition isokinetic strength protocol composed of reciprocal actions of knee extensors (KE) and knee flexors (KF) separately for concentric (cc) and eccentric (ecc) contractions among male adolescent swimmers aged 11-12 years.
METHODS: The study was approved by the Ethics Committee (CE/FCDEF-UC/00182016). The sample was composed of 38 male swimmers aged 10.06-13.26 years. Isokinetic strength of the preferred lower limb was done using Biodex System 3 (Shirley, NY, USA) adopting an angular velocity of 60 °.s-1. The protocol started with three reciprocal concentric contractions of KE and KF for familiarization. After a 60-s interval, 5 reciprocal maximal concentric (cc) contractions were performed. Then, participants rested for 60 s and the sequence was repeated for the eccentric (ecc) contractions. Each participant completed 20 isokinetic curves for analysis (KEcc: 5, KFcc: 5, KFecc:5, KEecc:5) using Acknowledge (version 4.1, Biopac Systems, Inc.). the previous allowed the extraction of peak torque (PT).
RESULTS: The gradient for PT values was, on average, KEecc (91.0 N.m) > KEcc (67.8N.m) > KFecc (61.2 N.m) > KFcc (41.7 N.m). Intraclass correlation coefficients (ICC) tended to be smaller than 80%: KEcc (ICC=0.754), KEecc (ICC=0.724), KFcc (ICC=0.580), KFecc (0.716). The percentages of participants attaining their best score in the earliest two repetitions were less than half for the concentric contractions (KEcc: 44.7%; KFcc: 44.7%). The fifth isokinetic curve retained for analysis as the best score was as follows: KEcc (n=7), KEecc (n=1), KFcc (n=9), KFecc (n=3).
CONCLUSION: A 5-repetition protocol to assess isokinetic knee muscle actions at the angular velocity of 600.s-1 is characterized by a substantial intra-individual variation in circumpubertal swimmers. As expected, the highest PT value was not obtained in the first repetition suggesting a learning effect. In fact, the best performance was distributed over the five repetitions for both KE and KF independently of the contractions. The preceding claims for refinements in the warm-up protocol, number of repetitions for familiarization and probably an additional number of repetitions in the assessment per se (from five to six). Future study needs to examine technical error of measurement, %CV and ICC and intra-individual mean differences from PT obtained in two time-moments one week apart.

**SPORT ROCK CLIMBERS PRESENT GREATER FORCE VALUES AND SIMILAR FATIGUE DYNAMICS THAN NON-CLIMBERS IN AN ALL-OUT CRITICAL FORCE TEST**

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INTRODUCTION: Rock climbing requires repeated fatiguing actions from the finger flexors when progressing through a sport route. All-out critical force (CF) testing has been successfully used to assess climbers resistance to fatigue [1]. Previous evidence explored the CF and energy store component (W') parameters as indicators of the aerobic isometric work threshold and anaerobic isometric work capacity, and positively related them to climbing performance [1]. The aim of our study was to explore the force fatigue dynamics of the finger flexors during an all-out CF test while comparing climbers and non-climbers.

METHODS: Twnety advanced-to-elite climbers [2] and 16 non-climbers were recruited. A flat wooden climbing hold (20 mm deep) attached to a force gauge was used to test finger flexors all-out CF using a half-crimp grip. The all-out CF test comprised 30 maximum contractions with a work:rest ratio of 7:3 s. The filtered data (Butterworth low-pass filter, 4th order, 10 Hz cut-off frequency) from the 5 central seconds of each contraction were used to compute the contraction mean value. The mean force values were fitted with an exponential regression model and then, a bi-segmental lineal regression model was used to characterize a fast fatigue phase and a slow fatigue phase. The following variables were computed: (1) maximum mean isometric force value (MIF ); (2) the CF level as the mean of the last 6 contractions; (3) the W' as the integral above CF; (4) slopes of the fast (slope1) and (5) the slow (slope2) fatigue phases defined by the two regression lines ; and (6) the x-coordinate (repetition number, Xint) and (7) y-coordinate (Fint) of the intersection between the two regression lines. All variables except Xint were expressed as % of body weight (BW) . T-tests or U-Mann Whitney were used to test differences between climbers and non-climbers. Level of significance was set at alpha = 0.05
RESULTS: Although climbers showed significant slight differences in BW% force decrements during slope1 (2.0%) and slope2 (0.6%) than non-climbers (1.4% and 0.2%), it seems that dynamic of force-fatigue followed similar trends . On the other hand, climbers presented significant greater BW % MIF, CF, W', and Fint than non-climbers. At the same time, climbers showed a slightly latter Xint than non-climbers.
CONCLUSION: These results evidenced that sport-related adaptations allow climbers to exert greater maximum isometric forces and maintain greater forces under fatiguing conditions. The greater initial force found and the similar fatigue trend between groups causes climbers to present greater force at the end of the test (CF), larger anaerobic work capacity (W'), and a greater force value when the force depletion slows down (Fint). Characterizing slope1, slope2, and Fint along with the CF value and W', could provide further insight in climbing training-related adaptations.
REFERENCES:
1. D. Giles et al., Int. J. Sports Physiol. Perform. (2020).
2. N. Draper et al., Sport. Technol. 8, 88–94 (2015)

## EFFECTS OF BODY-WEIGHT SQUATS VARIATIONS (ANGLES, STANCE, SURFACE, AND TYPE OF CONTRACTION) ON MUSCLE SATURATIONS AND LOCAL PERCEIVED EFFORT

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INTRODUCTION: Assessment of muscle oxygen saturation (SmO2) during exercise provides information related to local blood flow and muscular oxygenation [1]. The effects of organismic and task constraints related to body-weight squat exercise on SmO2 are still unknown. This study aimed to compare the SmO2 of the vastus lateralis (VL) and soleus (SL) muscles and local perceived exertion (RPE) during six squat variations.
METHODS: Eight healthy adults participated in this study (age 26.9±2.8 yr; body mass 74.7±7.8 kg; height 174±7 cm; BMI: 24.8±3.1 kg/m2; VL skinfold=14.2±4.8 mm; SL skinfold=12.7±3.3 mm). After a familiarisation session, participants completed in a random order 6 six squats for 90 sec interspersed to 5-min rest (cadence ranged between 40-60 bpm). The squat variations were Deep (shoulder width/ dynamic/ 110º), Jump (shoulder width/ 90º/ jump), Wall-Sit (shoulder width/ 90º/ isometric), Uneven (shoulder wide/ 90º/ dynamic), Pistol (shoulder width/ 110º/ dynamic) and Unstable (shoulder width/ 90º/ dynamic in terra-core platform). The SmO2 was measured in percentage (%) using four MOXY monitors (Fortiori Design, Hutchinson, USA) in VL and SL of both legs. Local RPE (Borg 6-20) was collected immediately after each variation [2].
RESULTS: Repeated measures ANOVA revealed differences in local RPE between exercise variations ($p<0.05$). A higher local RPE was reported during Jump and Wall squats (18.6±0.9 and 16.8±3.2, respectively). No changes in mean SmO2 were identified on right VL ($F[5.30]=1.572$, $p=0.198$, $\eta2=0.208$), neither on left VL ($F[5.35]=1.778$, $p=0.143$, $\eta2=0.203$,). Differences in right SL mean SmO2 ($F[5.30]=2.548$, $p=0.049$, $\eta2=0.298$) were seen in Deep vs Pistol. Left SL ($F[5.30]=5.026$, $p=0.002$, $\eta2=0.456$) showed significant differences ($p<0.05$) in Jump (42.77%) vs Deep (65,59%), Jump vs Uneven (67.24%) and Jump vs Pistol (65.59%); Unstable (54.54%) vs Uneven, Unstable vs Wall (65.11%); Unstable vs Pistol and Unstable vs Deep; Deep vs Pistol. No differences were identified in Uneven vs Deep, Wall vs Pistol; Jump vs Unstable. In the last 30 sec of exercise, no differences were found in right SL ($F[5.25]=2.388$, $p=0.067$, $\eta2=0.323$). In turn, in the left SL ($F[5.25]=5.411$, $p=0.002$, $\eta2=0.520$) SmO2 was lower in Unstable (49.87%) compared to Deep (60.97%), to Uneven (67.38%) and to Wall (58.22%) as in Jump (30.61%) compared to Uneven and Wall; Wall was lower than Deep.
CONCLUSION: Lower SmO2 both in VL and SL, during Jump as well higher RPE, shows higher physiological stress during this body-weight squat variation. Further studies are needed to better understand the variation effects on specific muscles.
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References:
[1] Miranda-Fuentes et al. Int J Environ Res 2021; 18(8): 4293
[2] Gómez-Carmona, Carlos D. et al. J. Strength Cond. Res. 2020; 34(5):1227-1236

## MUSCLE PROPERTIES DURING RAPID WEIGHT LOSING IN A PROFESSIONAL BOXER: A CASE STUDY

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INTRODUCTION: It is important for combat athletes to understand effects of rapid changes of body weight on muscular functions. The purpose of this case study was to investigate time-course changes in muscle strength, muscle size and neural input during rapid weight losing in a professional boxer.
METHODS: One professional men boxer (26 years old) participated in two matches during measurements, welter weight (66.6kg; WW) and super welter weight (69.85kg; SWW). He needed to lose weight substantially for WW and slightly for SWW. The measurement was performed at 6 week (baseline), 3 week (Pre3wk), 2 week (Pre2wk), 1 week (Pre1wk) and 0 week (Pre0wk) before and 1 week (Post1wk) after the matches. Body composition was measured using a bioelectrical impedance spectroscopy. Maximal voluntary isometric knee extension torque was measured using a dynamometer. Cross sectional area of vastus lateralis muscle (mCSA) were evaluated using an ultrasonography. High density surface electromyography on vastus lateralis was also recorded during submaximal isometric contraction based on the

maximal strength at baseline (MVC-base) and individual motor units were identified. Motor units discharge rate was evaluated at 60-70% MVC-base during 70% MVC-base ramp-up task.
RESULTS: His baseline body weights were 70.80 kg and 71.42 kg for matches of WW and SWW, respectively. At Pre0wk, his body weight decreased to 68.75 and 71.36 kg at WW and SWW, respectively. For WW match, skeletal muscle mass and mCSA were decreased a lot from baseline to the match (36.1 to 35.8 kg and 21.1 to 20.3 cm2, respectively). On the other hand, for SWW match, skeletal muscle mass and muscle cross sectional did not decrease a lot (36.4 to 36.5 kg and 23.2 to 22.7 cm2, respectively). The number of detected motor units was 15.7±5.2 at each section. As for recruitment threshold of motor units, two-way ANOVA revealed no interaction. As for motor unit discharge rate, two-way ANOVA revealed a significant interaction between condition (WW vs SWW) and time. Post-hoc tests indicated that discharge rate in WW was significantly greater at Pre0wk (16.2±2.7 pps) than at baseline (13.5±1.6 pps), Pre3wk (12.6±2.0 pps), Pre2wk (13.3±2.1 pps) and Post1wk (13.8±2.9 pps), but not change in SWW. A correlation coefficient between motor unit discharge rate and body weight at 6 time points in WW was -0.951.
CONCLUSION: Skeletal muscle mass decreased but motor units discharge rate increased as body weight losing. It is suggested that an excitability as neural input to muscle is activated as body weight losing and muscle mass decrease to maintain the muscle strength. When considering the effects of rapid body weight losing, we should keep in mind that not only body compositions but also neural factor is adapted.

## Conventional Print Poster

### CP-SH04 Learning and teaching in sports

#### BASIC PSYCHOLOGICAL NEED FRUSTRATION IN GRASSROOTS YOUTH SOCCER: A MIXED-METHODS STUDY OF INTRA- AND INTERPERSONAL FACTORS

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INTRODUCTION: Previous research has emphasized that if we are to understand the behavior of adolescents in sports, we must look at both factors in- and outside the sport context, as this can affect how young people behave toward each other in the socialization process. Additionally, studies have shown that the unique socialization processes offered by sport participation might influence adolescents' mental health negatively, thereby triggering basic psychological needs frustration. Thus, the purpose of this mixed-methods study was to investigate psychosocial factors assumed to have an influence on basic needs frustration in grassroots youth soccer.
METHODS: Young players (n=588, M.age=15.7 years; SD= ±1.4) between 14-19 years of age playing for teams in Agder county were recruited to this study. The participants completed a questionnaire including intra- and interpersonal factors. Classification and Regression Tree (CRT) analyses were used to analyze the quantitative data. CRT is referred to as the most appropriate method for analyzing complex data sets. Moreover, as part of this study, 15 girls and 11 boys participated in focus group interviews (n=6). The participants were interviewed with regards to social interactions in their teams. Thematic analysis was used to analyze the qualitative data.
RESULTS: We performed four CRT analyses (i.e., an analysis for each basic need as well as an overall analysis of the three basic needs). The results from analysis 1-2 showed that psychosomatic symptoms were strongly related to autonomy and competence frustration. The group who reported higher levels of symptoms (20% of the participants >20,000; n=120) reported a higher level of autonomy and competence frustration. In analysis 1, the results showed that those reporting high levels of psychosomatic symptoms (>20,000) reported a higher level (>1,400) of being ignored (53% of the participants; n=64). In analysis 3, perceiving to be ignored was the main explanatory variable of relatedness frustration (47% of the participants; n=282). Looking at the overall basic need frustration, analysis 4 showed that perceiving to be ignored was the main explanatory variable. Other important factors in the CRT analysis were giving autonomy support to teammates and participants' emotional stability. The qualitative findings confirmed the quantitative findings with respect to social interactions, and indicated that conflicts, inequalities, and social thriving were key factors in explaining social interactions between teammates. The qualitative findings also showed that some adolescents chose to quit playing soccer due to relatedness frustration, in connection to passive exclusionary behavior.
CONCLUSION: Our findings indicated that there were positive associations between psychosocial factors and young soccer players' basic psychological needs frustration. Indeed, frustration of the three psychological needs were mainly related to psychosomatic symptoms and perceiving to be ignored.

#### CHARACTERISTICS OF THE TEAM TEACHING SYSTEM IN PHYSICAL EDUCATION CLASSES IN JUNIOR HIGH SCHOOL SPECIAL SUPPORT CLASSES: FROM VISUALIZATION DATA OF TEACHERS AND STUDENTS' VERBAL RELATIONSHIPS

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INTRODUCTION: In special needs education in Japan, it is important to give the most accurate guidance to students who have individual educational needs. Therefore, as a mechanism for providing diverse and flexible guidance, team teaching has been introduced. Even in previous research, individualized guidance is important for team teaching in special education, and for that purpose, the ability of teachers to be involved in individual student's tasks is necessary even in group activities. Especially in physical education classes conducted in special support education, coaching by team teaching is common. However, how the team teaching in the special support education so far is done, each teachers it is not clear how they interact with students. The purpose of this study is to clarify the current situation of team teaching for physical education classes in the special support class of junior high school using visualization data of the state of cooperation between the primary teachers and sub teachers, the state between the teachers and students.
METHODS: 19 junior high school students (14 boys, 5 girls) belonging to a junior high school special support class, 2 primary teachers (PT) and 5 sub teachers (ST), a total of 7 people were targeted. The survey period covers a total of 5 hours of physical education classes conducted from early July to mid-August 2021. All the target classes were conducted by team teaching.

As a state index of the team teaching, the state of cooperation between PT and ST, the state between teachers and students were collected with a business microscope of Hitachi, Ltd, and the state of communication was analyzed at. business microscope can measure verbal communications by body movements. In addition, the contents of the teachers utterances were collected by a voice recorder and analyzed by text mining.
Results and Discussion:
As a result of the state of communication, PT and ST or ST and ST, in all the target lessons, communicated with different groups and individuals. Furthermore, there was a state of one-on-one communication. The result was the same in a class in which multiple STs participated. The result of the teachers utterances revealed that the PTs and the STs commonly used the word "Kun"(in Japanese, the honorific title that is mainly used for a man) for the students.
In team teaching in physical education classes in junior high school special support classes, the PTs and the STs each communicated with different students, suggesting that they had division of roles. In addition, the fact that they had many verbal relationships with individuals suggests that the teachers were aware of each students needs and provided individualized support and guidance during group activities in physical education classes.

**INCLUSIVE PHYSICAL EDUCATION ACCORDING TO ECOLOGICAL DYNAMICS APPROACH: THE SAT MODEL**

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Improving the quality of teaching-learning process is a key aspect for the implementation of effective learning environments able to respond to multiple educational needs.
This study aims to highlights the principles of the Systemic Approach to Teaching in Physical Education, a model to educational planning according to inclusive perspective. The theoretical model and design criteria of SATinPE is at definition stage; in the next three years a longitudinal training-research will be carry out to test the theoretical model and to define the tools.
The perspective from which this model is born, shifts the focus from the technical-performance results to processes oriented to knowledge, skills and competences. According to this perspective, in the awareness that any behavior or action directed towards a goal is the product of self-organization emerging from an interaction between constraints, at the center of the model there is individual-task-environment triad. In an integrated and at the same time systemic vision, in the class group, every individual and, therefore, every individual triad, interconnects with other individualities many complex adaptive systems interact with each other, inducing in adaptations and behavioral readjustments. For this reason, the conceptual framework of SATinPE, to complete the triad, reports a double extension of the elements to be taken into consideration in the design. A first circle highlights the principles of Chows non-linear pedagogy: representative learning design, information- perception couplings, manipulation of constraints, functional variability, external focus of attention; a second circle, from an inclusive perspective highlights the seven key points of inclusive education adapted to physical education: peer learning, adaptation of tasks, extension of proposals / exploration and discovery, emotional-motivation aspects, cognitive processes, metacognition, feedback and results.
The above design variables have been the subject of study and analysis; however, as highlighted, the variables influence each other, sometimes resulting in unpredictable and unexpected educational repercussions. The systemic approach arises from this awareness with the aim of understanding how to exploit the educational effectiveness of these complex and dynamic interconnections in a functional way.
References
Chow, J. Y., & Atencio, M. (2012). Complex and nonlinear pedagogy and the implications for physical education. In Sport, Education and Society, pp.1-21.
Chow, J., Davids, K., Button, C. & Renshaw, I. (2015). Nonlinear Pedagogy in Skill Acquisition: An Introduction. New York, NY: Routledge.
Newell, K.M. (1986). Constraints on the development of coordination. In MG Wade & HTA Whiting (Eds.) Motor development in children. Aspects of coordination ad control, pp.341-360. Dordrecht, Netherlands: Martinus Nijhoff.
Zambotti, F. (2015). SEN at school. The 7 key points of inclusive education. Trento: Erickson.

**COMMUNICATION ANALYSIS WITH WEARABLE ACCELERATION SENSOR CONTRIBUTED TO FOR PHYSICAL EDUCATION IN JAPAN.**

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[Introduction]
Currently, analysis is being conducted using science and technology in the field of education. Among them, there are contents that must be evaluated and fed back to daily educational activities. It is physical education. Physical education is closely related to future sports activities. The role of sports is important for extending a healthy lifespan. [1] In addition, it makes sense to reduce the risk of injury during exercise to support a healthy life. [2] It is even more important to objectively evaluate these contents and make them understood by the teachers and students. In this study, we focused on communication in physical education. This is because communication skills are also an even more important aspect of future education.
[Methods]
Teacher and children attached the acceleration sensors of the 100Hz sampling to their chest and the momentum in physical education and skill training was estimated. The measurements with wearable acceleration sensor were performed for five weeks. We examined from the collected data, physical activity level of class (teacher and children) and communication level.
[Results]
In two groups divided according to the high or low of physical activity and communication level, there was a significant difference in the feature quantity (change in communications) in the volley ball motion obtained from the two types of training and playing data during the class ($p<0.05$). As a result of further detailed analysis, we were able to classify communication into two typical types. And we could derive the features on the receiving side and the talking side in the discussion activity. In this way, it became possible to analyze the level of communication and the amount and content of conversation, and it was possible to suggest the possibility of using it in classes.
[Discussion & Conclusion]
We succeeded in performance analysis of children and class statement in the game and skill trainings. Although the individual's movement had been focused on until now, the analysis of the group movement must become important because using communication would be demanded recent years. Regarding this point, it is useful that the present system for analyzing the communication level in real time can

connect a model of the future's education. In addition, it may lead to improved lessons. It also objectively shows what kind of physical activity is appropriate. Controlling the thoughts and movements of children and teachers by quantifying performance and communication using the developed method contributes to the development of education.
[References]
[1] UN Inter-Agency Task Force on Sport for Development & Peace, 2003
[2] Timpka T., Lifetime history of sexual and physical abuse among competitive athletics (track and field) athletes: cross sectional study of associations with sports and non-sports injury. Br J Sports Med. 2019 Nov;53(22):1412-1417.

## EFFECTS OF THE PUPILS CONSCIOUSNESS ABOUT THEIR CLASSROOM ON PHYSICAL ACTIVITY OF PHYSICAL EDUCATION CLASS IN ELEMENTARY SCHOOL

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Effects of The Pupils Consciousness about Their Classroom on Physical Activity of Physical Education Class in Elementary School
Introduction
In physical education classes in Japan, pupils often learn as a group by interacting with others, and therefore, the pupils consciousness about their classroom has been considered important. For this reason, the relationship between the pupils consciousness about their classroom and physical education class has been examined in many studies. However, until now, there has been no study of the pupils consciousness about their classroom based on specific data of pupils in physical education classes. The purpose of this study is to clarify the effects of the pupils consciousness about their classroom on physical activity of physical education class in elementary school.
Methods
The subjects of the study were 61 pupils (31 boys and 30 girls), enrolled in two schools in Sapporo. The target classes were tag rugby (a minimal contact version of Rugby), volleyball, high jump, and basketball. We measured the amount of pupils physical activity with physical activity meters (OMRON HJA-750C Active style Pro). We also measured pupils consciousness about their classroom using the scale of consciousness about classroom consisting of 16 questions. The results of the analysis were categorized into two groups: high consciousness group and low consciousness group, based on the median values of group consciousness. The amount of physical activity was analyzed using two-way ANOVA.
Results
In tag rugby, the high consciousness group was significantly more active than the low consciousness group in the first period. In volleyball, the high consciousness group tended to be significantly more active than the low consciousness group in the first and fourth periods. In high jump and basketball, there were no significant differences between the high consciousness group and the low consciousness group at any time.
Discussion
The significant differences in the first period of tag rugby and volleyball may be related to the pupils attitudes toward physical education classes. Based on previous studies, the higher the pupils consciousness about their classroom, the more positive the attitude toward exercise. Therefore, it can be inferred that the high consciousness group was more active than the low consciousness group in the first period of the unit in which the trial game was set. The results for high jump and basketball may be due to the content of the learning activities. For example, in high jump, the number of times the pupils engaged was standardized, which may explain why there were no significant differences between the high consciousness group and the low consciousness group.
In summary, this study suggests that the pupils consciousness about their classroom influences the amount of physical activity during the beginning of a unit in physical education classes.

## HOW DO TEACHERS ASSESS LEARNING PREREQUISITES FOR AQUATIC EDUCATION IN LEARN-TO-SWIM PROCESSES?

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INTRODUCTION
In order to select appropriate methods for swimming lessons, the swim-specific (motor) prerequisites of the learners must be diagnosed at a teaching series' beginning of swimming lessons. This implies a high level of diagnostic competence of teachers [1]. While the majority of studies assess diagnostic competence on the basis of the accuracy of teachers judgements [2], there's little research on how teachers compose their diagnostics. Therefore, this research addresses the question of how teachers proceed in the diagnostic process and which diagnostic tools are used to get to an assessment in swimming lessons. This study forms the basis for the implementation and evaluation of a diagnostic tool to determine swim-specific prerequisites of children in primary and secondary schools.
METHODS
(1) Qualitative, structured interviews were conducted with German teachers from different backgrounds (n=10; 80% female; aged 45.7 ±18,6%; years of professional experience 16.25 ±56,9%). The interviews were transcribed, double-coded and categorically analysed. (2) The hypotheses derived were then tested in a larger-scale quantitative online study (n=596).
RESULTS
(1) It was found that the teachers diagnostic approach is highly individualised. Different diagnostic occasions and survey instruments are chosen, which differ from each other in terms of quality criteria and usability. The predominant method used is movement observation, which is mostly carried out without or on the basis of self-assembled criteria and is only partially recorded in writing. Some teachers state that they rely mainly on their "gut instinct" when dividing the group into non-swimmers and swimmers, for example. Interviewees also state that no standardised procedure is used among their colleges. (2) The evaluation of the quantitative examination of these statements has not yet been completed at this stage.
CONCLUSION
Although the teachers surveyed in the first part of the study consider themselves to be in a position to assess the learning prerequisites of their learners with the procedures they have chosen, the majority of them expresses the need for a scientifically sound procedure for diagnostics in swimming. The findings of the subsequent quantitative online survey are hypothesised to support these identified needs. Furthermore, factors influencing the diagnostic approach, e.g. professional experience and qualification level, are to be examined in a more in-depth analysis.

REFERENCES
1. Moreno-Murcia, J.A., de Paula Borges, L., Huescar Hernandez, E., Design and Validation of the Scale to Measure Aquatic Competence in Children (SMACC). Int J Environ Res Public Health, 2020. 17(17).
2. Karst, K., Förster, N., Ansätze zur Modellierung diagnostischer Kompetenz [Approaches for modelling diagnostic competence], in Diagnostische Kompetenz von Lehrkräften. Theoretische und methodische Weiterentwicklungen., A. Südkamp and A.-K. Praetorius, Editors. 2017, Waxmann: Münster. p. 19-20.

## AN ANALYSIS OF THE REPRESENTATION OF A LEARN-TO-SWIM PROCESS IN CHILDREN'S BOOKS: A TRANSFER OF KNOWLEDGE TO SOCIETY?

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INTRODUCTION: Learn-to-swim is a present theme in childhood that many children's books address as milestone. With this, the genre of children's books may be seen as a transfer of knowledge to society [1]. However, the focus of learn-to-swim skills mediated may differ within books, forming the rationale of evaluating to what extent water competencies [2] are addressed in children's books. Thus, this study investigates which essential water competencies are most frequently and which are least addressed in children's books themed learn-to-swim. The aim is to investigate to what extent children's books can provide a realistic representation about the process of learn-to-swim.
METHODS: To systematically search for respective children's books, elements of the PRISMA statement [3] were used. The books were found via databases and websites (e.g. The British Library, Simon & Schuster) by means of a keyword search (including e.g. swim, learn-to-swim) and selected according to predefined inclusion criteria (e.g. British, last 20 years). After screening a total number of 625 books, 11 books were identified eligible for the analysis in this study.
RESULTS: Swimming on front, back or side was most addressed in the books (91%), followed by breath control competence (82%). The safe entry and coping with risk competence both were displayed in 64% of the books. The least addressed competencies were swimming with clothes, knowing one's own ability as well as recognizing and assisting a drowning person, each addressed in one book only (9%). Three of the overall 15 water competencies were not addressed at all (i.e. orientation competence, use of personal flotation device and knowledge of local hazards competence).
CONCLUSION: In general, the sample of books analysed does not adequately address all the essential competencies, although they are equally important in terms of a learn-to-swim process with respect to water safety [2]. The missing or least addressed competencies are as if less significant and, thus, create a distorted representation of their importance. That swimming on front, back and side was most addressed, emphasizes that swimming mostly is associated with propulsion. However, research has shown that safe behaviour in, on and around the water also requires cognitive and affective skills, such as saving others or assessing one's own ability [2], which are not covered at all. Further studies in need may add a focus regarding parent's expectations on what should be taught and learned for swimming.
References
1. Weinkauff, G. and G. Von Glasenapp, Kinder- und Jugendliteratur [Children's and Young Adult Literature]. 2014, Paderborn: Ferdinand Schöningh.
2. Stallman, R.K., et al., From swimming skill to water competence: Towards a more inclusive drowning prevention future. International Journal of Aquatic Research and Education, 2017. 10(2): p. 3.
3. Moher, D., et al., Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Medicine, 2009. 6(7): p. 1-6.

## MANUAL GUIDANCE IN GYMNASTICS: APPROACHING DETERMINANTS FOR THE APPLICATION BY PHYSICAL EDUCATION TEACHERS

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INTRODUCTION: In gymnastics, the manual guidance of movements is of utter importance to ensure safety within motor learning processes. Physical Education (PE) teachers are required to master this technical expertise to assist movement execution and, moreover, enable students to perform this complex task mutually. Considering the associated responsibility PE teachers take in gymnastics, the question occurs to what extend teachers are able to meet this challenge. Thus, the present study aims to reveal determinants for the application of manual guidance taking theoretical expertise and practical experience into account, hypothesising both aspects to be related to problems regarding an application in gymnastics.
METHODS: A questionnaire-based design served to address PE teachers from different school types in North Rhine-Westphalia (i.e., primary and secondary schools). Literature- and interview-based category coding identified the variables theoretical expertise and practical experience, serving a predefinition of items and creation of rating-scale tasks. Subsequent to a pre-test including qualified and trainee teachers (N=3) of different experience and expertise levels (e.g., great and low gymnastics-related affinity) in order to validate the items' suitability, the optimised questionnaire was used for data collection over three weeks (soscisurvey.de). A total of 80 qualified PE teachers and trainee teachers (female: n=39; male: n=41) completed or participated at least in parts in the questionnaire. Data processing including descriptive statistics, correlations and regression analyses was performed using SPSS (version 27.0).
RESULTS: Descriptive statistics revealed an assessed score of 4.54±0.88 for theoretical expertise (ranging from 1=layperson to 6=expert). Further, theoretical expertise and problems with manual guidance correlated ($r[64]=.57$, $p<.01$; $R2 =.33$, $p<.01$). In addition, descriptive statistics revealed an assessed score of 2.28±0.70 for practical experience within the last year (ranging from 1=never to 6=daily). Further, practical experience and problems with manual guidance correlated ($r[65] =.55$, $p<.01$; $R2 =.30$, $p<.01$).
DISCUSSION:
In line with the initial hypotheses, the present study's findings confirm reasoning that problems regarding an application of manual guidance in gymnastics may be related to theoretical expertise and practical experience. In noticing linking problems, detailed analyses considering beneficial effects of coach-related compared to sport active-related experiences suggest this to reflect possible deficits of PE teacher studies at universities (i.e., the ratio of experiences in the students' vs. the prospective teachers' role) as well as lacking continuing education for PE teachers in schools. Taking pandemic-related impacts into account, however, the findings give rise to consequently research-driven teaching concepts in order to counteract PE teachers' reservations when teaching gymnastics in school.

## PRESCHOOLERS, PARENTS AND PONIES – MILITARY TRADITIONS CHALLENGES BY PEDAGOGICAL PLAY AT SWEDISH AND NORWEGIAN RIDING SCHOOLS

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Introduction
Participation in sports has grown stronger among younger children (preschoolers). Even in riding school activities, the age limit has dropped and the previously usual seven-year limit to start riding has disappeared (Thorell et al 2016). Riding lessons have been criticized for being outdated as they are still characterized by military traditions and culture (Lundesjö Kvart, 2020). Pedagogy has now been given more space in riding school education, but there is a lack of knowledge about how this has been adapted for younger children (Rosén et al, 2021).
Aim and theoretical framework
The aim of this study is to analyze riding teachers' perceptions and experience of teaching preschool children at riding schools from a sociocultural perspective. Learning at riding schools can be characterized as a process that involves preschool children and their parents being included in a culture. Through a sociocultural perspective, the riding teachers' shape the learning environment based on the culture and the prerequisites that exist at the riding school.
Methods
In-depth interviews with 11 professional riding teachers' from Sweden and Norway have been conducted. Qualitative content analysis was used.
Results
The riding school activities for preschool children focus on basics in riding and horse knowledge. Parents are also expected to learn and participate actively as assistants. The teaching is based on the traditional education system for riding school activities, but the riding teachers' feel it is difficult to apply due to the younger childrens physical and social development. Therefore, they instead create new methods with more focus on play pedagogy and balance exercises. There are also several challenging factors to deal with. Parents expectations and different levels of knowledge, as well as safety in relation to the ponies, are common challenges based on the riding teachers experiences.
Discussion and Conclusion
From the riding teachers perspective, the learning environment emerges as an interplay between them and the preschoolers - parents - ponies and through interaction and communication, experience and knowledge are formed. It can be seen as central to the learning process and to the learning environment created within the framework of the institutional community of practice. The traditional riding lessons are challenged as teaching preschool children at riding schools requires a different form of pedagogy. Being adaptable, flexible and creative is a prerequisite for creating a developing and safe learning environment for preschool children. Skills that the riding teachers' feel they have developed through experience and not primarily acquired through previous education.

## TOWARDS RACISM-CRITICAL TEACHING COMPETENCE IN PHYSICAL EDUCATION: A CONCEPTUAL APPROACH AND PRELIMINARY RESULTS

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Introduction
Racism is an expression of social power relations and discrimination patterns based on them [1]. These patterns exist in all areas of our society, including school-based Physical Education (PE). Therefore, the aim of this conceptual approach is to contribute to a development of teaching competences with respect to mediating racism-critical PE.
According to the initial stages of this project, findings from the first of four consecutive project phases, including participatory-reflexive evaluations, will be highlighted.
Methodology
Based on 1) a systematic literature review (i.e., elements of the PRISMA statement) aiming to categorize the contexts of racism-critical PE, 2) a qualitative and 3) a quantitative survey aiming to illuminate e.g. experiences and requirements of pupils, students, and teachers in the contexts of racism-critical PE will be conducted prior to 4) aiming to develop knowledge-based professional qualification programs for PE teachers in schools and PE teacher studies at universities.
Results
Within the systematic literature review promising international qualitative and quantitative surveys as well as theoretical reflections were found. Subsequent to exclusion (e.g. English or German language; peer-reviewed publication; PE or PE study-related), this review included a total of 64 racism-critical publications. 97% of the publications were international, while 3% had a national (German) focus. Within the 64 publications 34% had a conceptual, theoretical approach, 56% were using qualitative methods, 3% were quantitative papers and 5% used a mixed-methods approach. Furthermore, considerable differences in the approach and quality of the papers were identified. Perspectives of teachers from schools and universities, students and PE studies from various age groups were found.
Discussion
In general, it appears that there are few large-scale quantitative surveys devoted to the topic of racism-critical PE, whereas there are promising quantitative and theoretical approaches. Despite the historical responsibility of Germany to act racism-critically, publications are rather lacking. Although there is an established empirically supported German discourse on intercultural education in sports, this field only includes the racism dimension of culture. Other racism dimensions such as religion or biological characteristics have not yet been considered. Thus, the findings of this systematic literature review legitimise the urgent need to follow the project phases two to four.
All in all, the overall project wishes to make a (small) contribution to a racism-free society, which is no longer characterized by the structural discrimination of minorities. We are confident that a transparent presentation of this conceptual approach will lead to a constructive critical discourse.
[1] Essed, P. (2008). Everyday Racism. In D. T. Goldberg & J. Solomos (Eds.), A Companion to Racial and Ethnic Studies (pp. 202–216). Blackwell Publishers Ltd

## Conventional Print Poster

### CP-PN10 Supplementation and metabolism

#### LACTATE INGESTION PROMOTES BRAIN NEUROGENESIS IN MICE, AS LIKE EXERCISE TRAINING

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INTRODUCTION: Adult hippocampal neurogenesis plays an important role in learning and memory. Therefore, promoting of the AHN is required to prevent or ameliorate the cognitive deficits. Lactate, known as just byproduct of glycolysis and primary factor of fatigue when exercise, is highlighting as a promising signaling molecule that regulates the exercise-induced adult hippocampal neurogenesis. Therefore, we hypothesized that exercise with lactate intake can augment the exercise-induced adult hippocampal neurogenesis.
METHODS: Six-week-old male ICR mice were randomly divided into four group (n = 8 per group): sedentary vehicle (VEH), sedentary with lactate intake (LAC), exercise vehicle (EXE+VEH), and exercise with lactate intake (EXE+LAC). Lactate intake groups were orally administrated 3g/kg of sodium lactate and mild-intensity exercise was conducted 5 times per week for 5 weeks. At the last week of experiment, cognitive function (spatial working memory) was evaluated by Y-maze spontaneous alternation test. After the experiment ended, neurogenesis (Ki67, neural stem cell proliferation marker; DCX, marker of differentiation to immature neurons) and the relevant factors (FNDC5, BDNF, PGC1α VEGFA, HCAR1, and MCT1/2) were evaluated respectively by immunohistochemistry (IHC) and by Western blot (WB) on hippocampus.
RESULTS: The number of Ki67+ cells of LAC tended to increase compared to that of VEH and the number of DCX+ cells of LAC significantly increased compared to VEH. However, there was no difference between EXE+VEH and EXE+LAC in the number of Ki67+ and DCX+ cells. Therefore, these results indicate that the mild exercise with lactate intake did not augment exercise-induced AHN although the mild exercise and lactate promoted the adult hippocampal neurogenesis respectively. The number of arms entered did not differ among all groups. Nevertheless, the alternation of EXE+LAC was significantly higher than that of EXE+VEH and LAC. There was no difference between VEH and LAC or EXE+VEH. As a result, the performance of spontaneous alternation behavior was solely promoted by the exercise with lactate intake. Notably, the hippocampal FNDC5 protein expression of EXE+LAC was significantly enhanced compared to that of EXE+VEH and the hippocampal BDNF, PGC1α, and MCT2 protein expression of EXE+LAC was higher than that of EXE+VEH by 20, 9, and 19 % respectively. Therefore, these results indicate that the mild exercise with lactate is likely to be more beneficial on promoting the relevant proteins to the exercise-induced AHN.
CONCLUSION: The study revealed the potential that the mild exercise with oral intake of lactate can be noteworthy strategy for augmenting the beneficial effects of exercise on
hippocampus.

#### GLUCOSE INGESTION BEFORE AND AFTER RESISTANCE TRAINING DOES NOT AUGMENT RIBOSOME BIOGENESIS IN YOUNG MODERATELY TRAINED ADULTS

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INTRODUCTION: Responses to resistance training (RT) are not uniform across the population, and individuals responding poorly to RT show a blunted ability to produce novel ribosomes. Recent research further strengthens the relationship between increased rates of total RNA, a proxy marker of ribosome biogenesis, and the magnitude of RT-induced adaptations, with ribosome abundance being associated with UBF protein levels. As a response to RT, total RNA increases robustly following 8 sessions of RT, then reaches a plateau. However, 10-15% of individuals undertaking a period of RT have previously shown considerable impaired growth, with blunted accumulation of total RNA coinciding with poor adaptations to RT. Despite RT volume being a potent tool to increase beneficial RT-induced adaptations, tweaking RT modalities alone do not convert such low-responders to high-responders. Thus, other means than RT _per se_ is necessary to circumvent this discrepancy. High glucose treatment has been observed to augment rDNA transcription _in vitro_, however, its effect on RT-induced adaptations in humans remains quite unexplored.
METHODS: Sixteen healthy moderately trained participants were included and randomized to having one leg perform unilateral resistance training with glucose supplement (16) and the other with placebo (16), alternating training every other day. Participants remained overnight fasted, only receiving glucose/placebo and protein until after completion of the daily intervention. Resistance training consisted of 3 sets of 10 repetitions maximum unilateral leg press and knee extension. Micro biopsies were sampled pre (T1/T2) and post (T3/T4) the intervention, and maximal unilateral isometric and isokinetic knee extension force and torque were measured pre (T0), during (days 4, 5, 8, 9) and post (T3/T4, day 13) intervention.
RESULTS: Despite robust increases in total RNA accumulation in glucose and placebo (26 and 22%, respectively), there were no differences between supplements ($p = 0.499$). This was also evident in the expression of mature rRNA in both glucose and placebo (34-43 and 33-41%, respectively, $p > 0.05$). Further, there were no differences between supplements in maximal unilateral isometric knee extension force and isokinetic peak torque during the intervention ($p > 0.05$) and following the last session ($p > 0.05$), apart from the 60 d/s test before last RT session ($p < 0.05$).
CONCLUSION: There were no differences in glucose- compared to placebo supplement ingestion before and after five RT sessions in muscle biology markers measured as total RNA and rRNA, or markers of muscle functionality such as muscle recovery, total session volume, and training intensity in moderately trained young adults. Based on these findings, glucose supplement before and after RT does not augment RT-induced ribosome biogenesis compared to placebo supplement, nor does it affect peak torque during a five-session RT intervention, or enhance muscular recovery following a single session of RT.

## EFFECT OF LEUCINE-ENRICHED AMINO ACID SUPPLEMENTATION ON FAT METABOLISM FOLLOWING A SINGLE BOUT OF ENDURANCE EXERCISE

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INTRODUCTION: Amino acid supplementations are widely accepted as a nutritional supplement among athletes and people involved in moderate physical activities (1). Branched-chain amino acid supplementations (BCAAs), which consist of leucine, isoleucine, and valine, are oxidized and used for energy production during exercise. BCAAs delay exercise-induced fatigue and enhance fat oxidation during exercise in glycogen-depleted subjects (2). Fat metabolism can be evaluated using blood variables (e.g., plasma free fatty acid, serum total ketone body and glycerol concentrations). Additionally, attention to the breath acetone level is growing to evaluate exercise-induced fat oxidation (3). However, little has been reported on the time-course changes in serum ketone body and breath acetone after endurance exercise following short-term amino acid supplementation. Therefore, the present study aimed to investigate the effects of leucine-enriched essential amino acid (LEAA) supplementation on post-exercise fat metabolism.
METHODS: Six active healthy males (22.3 ± 1.9 years, 173.7 ± 3.4 cm, 65.8 ± 12.6 kg) completed both LEAA trial and placebo trial on different days, with a randomized, double-blind, crossover design. Participants received either LEAA supplements (AA; 4.0g/time) or placebo (PLA; maltodextrin 4.0g/time), 3 times a day (every morning, at 3 pm, before bedtime) for 5 consecutive days (days 1-5), separated by at least 21-day washout period. During the days 3-5 of supplementation period, standard meals were provided. On day 6, they performed 60 min of treadmill running at 70% of maximal oxygen consumption (VO2max), followed by a 3-h rest period. Venous blood and breath samples were collected before, immediately, 1h, 2h (breath sample only) and 3 h after exercise. Serum total ketone bodies (i.e., acetone, 3-hydroxybutyric acid) and breath acetone level were evaluated to assess fat metabolism during 3h post-exercise.
RESULTS: Breath acetone level (p=0.029), serum acetone (p=0.043), 3-hydroxybutyric acid (p=0.049) concentrations increased significantly in both trials after exercise compared with baseline and immediately after exercise. However, these responses did not differ significantly between trials.
CONCLUSION: Relative changes in each variable ranged from 180% to 2562% for serum total ketone body, 124% to 759% for breath acetone level. This may be caused by individual difference in fat oxidation capacity or exercise-induced endocrine (e.g., catecholamine, growth hormone) responses. In conclusion, our results suggested that 5-days LEAA supplementation did not affect either serum ketone body concentrations or breath acetone levels following a single bout of endurance exercise in active healthy males.
REFERENCES:
1. Fouré & Bendahan, Nutrients, 2017
2. Gualano et al., J Sports Med Phys Fitness, 2011
3. Kim et al., Sensors (Basel), 2020

## INFLUENCE OF TETRASOD® SUPPLEMENTATION ON EXERCISE-INDUCED OXIDATIVE STRESS AND SEVERE-INTENSITY EXERCISE TOLERANCE IN HEALTHY ADULTS

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INTRODUCTION: Oral consumption of antioxidants has the potential to mitigate exercise-induced oxidative stress and improve performance [1]. TetraSOD® is a natural marine product derived from the microalgae, tetraselmis chuii, which has been reported to confer antioxidant effects via increased gene expression of NRF2 and HMOX1, and increased gene expression and enzyme activities of SOD, GPx and CAT, in a skeletal muscle cell line [2]. The purpose of this study was to assess the potential of TetraSOD® supplementation to improve antioxidant markers in human blood and primary muscle cells and severe exercise tolerance (Tlim) in healthy adults.
METHODS: Fifteen healthy, recreationally-active, males (mean ± SD, age: 24 ± 4 years, peak pulmonary oxygen uptake (V̇O2peak): 48 ± 5 ml.kg-1.min-1) ingested a daily capsule for 2-weeks in a double-blind, randomised, crossover experimental design. At least 1-week of 'washout' separated each experimental condition. Capsules contained either 25 mg (TetraSOD®25) or 75 mg (TetraSOD®75) TetraSOD® with hemicellulose crystalline as an excipient, or hemicellulose crystalline only as a placebo (PLA). After separate ramp incremental and familiarisation cycling visits, participants completed step tests to an individualised severe-intensity work rate (70%Δ) for the determination of Tlim and V̇O2 responses on days 0, 7 and 14 of supplementation. A sub-set of five participants provided a single, un-supplemented, vastus lateralis muscle biopsy for the subsequent culture of primary myoblasts and treatment with TetraSOD®. Data were analysed using two-way repeated-measures ANOVAs with statistical significance taken as $p < 0.05$.
RESULTS: Compared to baseline, Tlim was significantly greater after 14 days TetraSOD®25 supplementation (Day 0: 411 ± 82 vs. Day 14: 480 ± 124 s; $p < 0.05$), and after 7 (Day 0: 415 ± 113 vs. Day 7: 465 ± 137 s; $p < 0.05$) and 14 (504 ± 182 s; $p < 0.05$) days TetraSOD®75 supplementation. Tlim was unaffected by PLA supplementation ($p > 0.05$). V̇O2 at exhaustion was significantly greater after 14 days TetraSOD®25 supplementation (3.49 %; $p < 0.05$), but not after 14 days TetraSOD®75 or PLA supplementation ($p > 0.05$). Preliminary gene expression analyses, in leukocyte RNA isolates, revealed no change in NRF2, HMOX1, SOD, GPx or CAT ($p > 0.05$). However, IL-10, a potent anti-inflammatory cytokine, was significantly greater from Day 7 to Day 14 of TetraSOD®25 supplementation (36.81 %; $p < 0.05$).
CONCLUSION: Two weeks of TetraSOD® supplementation improved Tlim, V̇O2 at exhaustion and IL-10 gene expression in RNA isolated from leukocytes. These findings suggest an ergogenic effect of TetraSOD® supplementation and that this effect may be linked to an anti-inflammatory response.

## INVESTIGATING THE SYNERGISTIC EFFECTS OF DIETARY NITRATE AND RESVERATROL SUPPLEMENTATION ON PERIPHERAL TISSUE MITOCHONDRIAL BIOENERGETICS

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INTRODUCTION: Supplementation with dietary nitrate (NIT) and resveratrol (RSV) independently enrich various aspects of mitochondrial biology in key metabolic tissues. Importantly, these compounds appear to elicit their beneficial effects via different mechanisms of action. While RSV, a potent ligand for sirtuins, initiates mitochondrial biogenesis and modulates substrate oxidation, the short half-life of nitric oxide suggests that the benefits of NIT occur quickly, likely via vasodilatory effects. Given the differing timescale and level of regulation between these compounds, we aimed to determine if supplementation with both RSV and NIT could prevent high-fat diet (HFD) associated metabolic impairments in an additive or synergistic manner.

METHODS: n=80 male C57Bl/6/N mice consumed one of four HFD variations: un-supplemented (HFD; n=20), supplemented with +RSV (172mg RSV/kg diet; n=20), +NIT (4mM sodium nitrate via drinking water; n=20), or +RSV+NIT (n=20) for eight weeks. Characterization of whole-body metabolism was established via calorimetry and intraperitoneal glucose tolerance tests. Following the intervention period, key metabolic tissues (skeletal muscle, liver, epididymal white adipose tissue; eWAT) were permeabilized to determine mitochondrial respiratory capacity, ADP-sensitivity, and $H_2O_2$ emission, or homogenized for analysis of various protein targets. Data are expressed as mean±SD. One-way ANOVA was applied to compare differences between groups, followed by a Fisher's LSD post hoc test where appropriate. Significance was assumed when $p<0.05$.
RESULTS: Within skeletal muscle, all supplements similarly increased mitochondrial ADP-sensitivity ($p<0.05$) compared to HFD, without altering mitochondrial content, respiratory capacity, or $H_2O_2$ emission. Within the liver, supplementation did not alter mitochondrial content or respiratory capacity. However, +RSV+NIT decreased hepatic lipid accumulation ($p<0.05$), in the absence of change with +RSV or +NIT, suggesting an additive effect of these compounds on liver lipid metabolism. Within eWAT, all supplements similarly reduced crown-like structure accumulation ($p<0.0001$) and adipocyte cross-sectional area (CSA; $p<0.005$), with further reductions in CSA observed with +RSV+NIT compared to +RSV. Additionally, while mitochondrial content nor respiratory capacity were altered within eWAT, all supplements reduced mitochondrial $H_2O_2$ emission ($p<0.005$), with a strong trend towards additivity following +RSV+NIT compared to +RSV ($p=0.08$). Despite these differences, +RSV+NIT did not increase whole-body fat oxidation, alter energy expenditure, or improve glucose tolerance beyond what was observed with +RSV or +NIT.
CONCLUSION: Altogether these data indicate that combined +RSV+NIT supplementation elicits additive improvements in markers of lipid/cellular metabolic homeostasis in liver and eWAT. However, these cellular changes are not sufficient to improve whole-body glucose homeostasis beyond what is observed with each compound individually.

### EFFECT OF B-GPA ON MITOCHONDRIAL OXIDATIVE PHOSPHORYLATION AFTER MUSCLE CONTRACTION

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INTRODUCTION: Creatine exists in skeletal muscle as creatine or phosphocreatine（PCr）. PCr works as an energy substrate in high-intensity exercise. β-guanidinopropionic acid（β-GPA） reduces PCr content in skeletal muscle. β-GPA is a creatine-analog that inhibits creatine transport into cells. When PCr is reduced in skeletal muscle with β-GPA, AMP-activated protein kinase is activated and stimulates mitochondrial oxidative phosphorylation (1). It has been reported that resistance exercise not only increases muscle protein synthesis but also enhances mitochondrial oxidative phosphorylation (2). Therefore, β-GPA may enhance mitochondrial oxidative phosphorylation to resistance training. In the present study, we aimed to determine the effects of β-GPA intake in combination with a resistance exercise model using electrical stimulation on the expression levels of mitochondria-related proteins.
METHODS: 7-weeks old male Sprague Dawley rats (n=2,3 /group) were subjected to a resistance exercise model in which electrical stimulation (100 Hz, 10-30V) was applied to the gastrocnemius muscle. Resistance exercises were performed every 48 hours for the right gastrocnemius (3 sec of maximal isometric contraction 50 times per session) for a total of 12 sessions. During training, the maximal exerted torque (N-m) for each session was recorded. β-GPA (0.3g/kg/day) was dissolved in 1.5 ml dextrose solution (5%) and administrated by sonde for 7days prior to the 1st training session. During training, β-GPA (0.05g/kg/day) was also administered. The same amount of dextrose solution (5%) was administered in placebo group. Muscle samples were removed 48h after the last training session. The left gastrocnemius muscle was used as an internal control. Western blotting was used to measure the expression of proteins involved in mitochondrial oxidative phosphorylation (ATP5A, UQCRC2, MTCO1, SDHB, NDUF8) in each muscle.
RESULTS: Peak torque during electrical stimulation in exercise with β-GPA group was significantly decreased compared with resistance training alone group on 2,8,10, and 11th session（$P<0.05$）. The protein expression levels of ATP5A, UQCRC, and NDUF8 were increased with positive main effect of resistance training and β-GPA respectively ($P<0.05$), but no significant interaction was observed. Only a positive main effect of exercise ($P<0.05$) was observed for MTCO1 expression, and only a positive main effect of β-GPA ($P<0.01$) was observed for SDHB expression.
CONCLUSION: Combining resistance exercise with the ingestion of β-GPA was suggested to result in greater expression of proteins involved in resistance exercise-induced mitochondrial oxidative phosphorylation, although the maximal torque exerted during the training period was reduced.
REFERENCES
1. Freyssenet D. et al., Biochimica et Biophysica Acta (BBA)-Bioenergetics, 1228(2-3), 211-215 (1995)
2. Kitaoka Y. et al., Journal of Applied Physiology, 121(3), 806-810 (2016)

### HIGH-FRUCTOSE CORN SYRUP CONTRIBUTES TO SYMPTOM DEVELOPMENT OF INSULIN RESISTANCE THROUGH WNT-SFRP5 SIGNALLING PATHWAY: PROTECTIVE EFFECT OF EXERCISE AND VANADIUM-ZINC SUPPLEMENTATION

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INTRODUCTION: There is a close and effective interaction between health status and insulin resistance (IR), due to the High-fructose corn syrup - 55% (HFCS-55) used in daily prepared foods and soft drinks. IR clusters are related to an imbalance in pro-and anti-inflammatory adipokines such as secreted frizzled-related protein 5 (SFRP5) and wingless-type mammary tumor virus integration site family, member 5A (WNT5A). WNT5A induces an inflammatory state to induce insulin resistance and further pathologic consequences. Regarding the non-invasive and anti-inflammatory effects of exercise training and vanadium-zinc supplementation, we aimed to investigate the effects of moderate-intensity continuous training (MICT) with vanadium-zinc supplementation on the modulation of insulin resistance induced by high-fructose corn syrup (HFCS) through Wnt-Sfrp5 signaling pathway.
METHODS: 40 male Wistar rats (aged 4-6 weeks, 100-150 g) were randomly categorized into 5 groups (n = 8/groups), including (NC) Normal Control, (FC) Fructose Control, and (FCT) Fructose Continuous Training, (FS) Fructose Supplement and (FSCT) Fructose Supplement Continuous Training. The training groups implemented the MICT for 8 weeks followed by the 8 weeks of the HFCS-55 (diluted by tap water to 20%) administration as ad-libitum syrup from the beginning. MICT protocol was 12 minutes of running in the first week increasing to 52 minutes in the last week (speed ~ 20 m/min and slope ~ 15°). About 48 hours after the final training session, serum samples were taken to measure the levels of Insulin, Glucose, GPX (Glutathione Peroxidase), TOC (Total Oxidant Capacity), TAC (Total Anti-Oxidant Capacity), MDA (Malondialdehyde), SOD (Superoxide dismutase) WNT5A, and SFRP5 by chemiluminescence technique. Data were analyzed by dependent sample T-test and one-way ANOVA ($P<0.05$).

RESULTS: Regarding the results of one-way ANOVA, the main effect of 8 weeks of MICT significantly decreased the serum levels of insulin resistance (glucose and insulin), MDA, TOC, Wnt, and increased GPX, TAC, SOD, sftrp5 (P<0.05); also the main effect of Vanadium-zinc supplementation was significant only in four variable of TAC (p = 0.001), Wnt (p = 0.002), MDA (p = 0.002) and Sfrp5 (p = 0.001). MICT with Vanadium-zinc supplementation has the greatest effect on increasing anti-inflammatory responses (increased GPX, TAC, SOD, and sftrp5) and reducing inflammatory responses (MDA, TOC, Wnt).
CONCLUSION: Implementation of 8 weeks of MICT combined with Vanadium-Zinc supplementation, more efficiently alleviated insulin resistance and metabolic dysfunctions via antioxidant defenses through Wnt- sftrp5 signaling pathway in IR rats, leading to improving physiological homeostasis and higher adaptation of the biological system.

## TIME COURSE OF TOLERANCE TO THE ERGOGENIC EFFECTS OF A MODERATE DOSE OF CAFFEINE ON BENCH PRESS EXERCISE.

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INTRODUCTION: Recent evidence suggests that habituation to caffeine through daily ingestion of this substance progressively reduces caffeine's ergogenic properties on endurance-based exercise. However, there is no evidence to determine if tolerance to the ergogenic benefits of caffeine is present during strength exercise. The main goal of this study was to determine the time course of tolerance to the ergogenic effects of 3mg/kg/day of caffeine on bench press exercise.
METHODS: Eight strength trained participants (men = 4; women = 4; 30 ± 7.7 yrs., 63.4 ± 11.4 kg, 169.8 ± 10.7 cm) took part in a double-blind, crossover and randomized experiment. In one phase, participants ingested 3 mg/kg/day of caffeine for 22 days, while in another phase, they ingested a placebo. Participants rested 12 days between phase. Each substance was administered 60 min before the experimental trials, except for day 11 of ingestion where exercise was performed without substance ingestion. Three times per week during each treatment, participants performed two maximal repetitions of the bench press exercise at different loads (30%, 45% 60% 75%, and 90% of 1RM). In each repetition, mean velocity during the concentric phase of the exercise was measured using a GymAware PowerTool (GYM; Kinetic Performance Technologies, Canberra, Australia). Differences between placebo and caffeine in each testing day were obtained compared with paired t tests. The significance level was set at p<0.05.
RESULTS: The effect size of caffeine ranged from 0.1 to 0.4 in the first 10 days of ingestion and it was reduced from -0.1 to 0.2 in the last days of ingestion. In addition, it was observed that the effect size was greater at medium-low loads (30 and 45% 1RM). In comparison to the placebo, the ingestion of caffeine increased mean velocity at 30% 1RM load on days 4, 6, 8, 13, 15 and 18 (p<0.05); at 45% 1RM load on days 1, 8 and 22 (p<0.03); at 60% 1RM load on days 1, 8, 13, 18, 20 and 22 (p<0.05); at 75% 1RM load on days 6 and 13 (p<0.04); and at 90% 1RM load on days 1 and 18 (p<0.04).
CONCLUSION: The daily ingestion of caffeine did not reduce the benefits of this substance on mean velocity during bench press exercise with increasing loads. Therefore, the ergogenic benefits of caffeine still persisted after 22 days of chronic ingestion.

## FLAVANOL-RICH COCOA INTAKE MITIGATES THE COMBINED NEGATIVE IMPACT OF PROLONGED COGNITIVE EFFORT AND EXERCISE ON MENTAL FATIGUE

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INTRODUCTION: We previously demonstrated that prolonged cognitive effort may increase the subjective intensity during aerobic exercise, possibly influencing sports performance (e.g., football) (1). Meanwhile, intake of flavanol-rich cocoa has been reported to acutely reduce cognitive load-enhanced mental fatigue (2), but it remains unknown whether high cocoa flavanol (CF; HCF) intake improves the negative impacts of prolonged continuous cognitive effort during aerobic exercise on psychophysiological factors. We aimed to examine the rating of perceived exertion (RPE), moods, and the saliva concentrations of cortisol and sIgA as the psychophysiological markers of mental stress during a 50-min aerobic exercise with cognitive effort after ingestion of HCF or Low CF (LCF).
METHODS: Fifteen healthy young men (aged 22 ± 1 yrs; VO2 peak = 47 ± 4 ml/kg/min) performed two trials [i.e., HCF (500mg) and LCF (50mg)] in a double-blind, randomized-crossover design. Both trials used a 50-min cycling exercise protocol (60% VO2 peak; 152 ± 13 W) and the prolonged cognitive effort was achieved via a 50-min Stroop task. Participants consumed either CF capsules 75-min before such interventions. Before asking RPE (Borg scale), heart rate (HR; HR monitor) was recorded during the first and final 5 minutes of 50 min exercise with cognitive effort in both trials. Moods (mental fatigue, ability to concentrate for Stroop test, motivation for Stroop test, comfort, annoyance, and arousal; visual analog scale) and the saliva cortisol and sIgA concentrations (lateral flow device) were measured before CF intake, before and immediately after exercise with cognitive effort. The data were analyzed by 2-way ANOVA (Trials × Time) when normal distribution was confirmed. If not, the data were analyzed using a Friedman test. If a significant interaction or overall effect was observed, the P-values were adjusted using Bonferroni correction for multiple comparisons using the t-test or Wilcoxon test.
RESULTS: RPE or HR elevated during both trials similarly (i.e., there was no difference between HCF and LCF, both P > 0.05). Nevertheless, the increased mental fatigue was significantly lower in HCF (median 37, IQR 8 to 86) than LCF (median 70; IQR 11 to 85; P < 0.05). The other psychological measurements and the saliva concentrations of cortisol and sIgA were not significantly different between HCF and LCF throughout the experiment (P > 0.05).
CONCLUSION: HCF intake has no effect on RPE, while the elevation of mental fatigue in response to exercise with continuous cognitive effort may be reduced by HCF intake. Probably, cognitive fatigue, but not exercise-induced fatigue, may be reduced by HCF intake given that HCF reduced cognitive effort-enhanced mental fatigue (2). Thus, HCF may be a useful strategy to mitigate cognitive fatigue in sports.
1) Dora et al. ACSM. 2022
2) Scholey et al. J Psychopharmacol. 2010

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### CP-SH05 Mental health and emotions

**TRAJECTORIES OF 24-H MOVEMENT GUIDELINES FROM ADOLESCENCE TO ADULTHOOD ON DEPRESSION SYMPTOMS**

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INTRODUCTION: Previous studies looking at the 24-h movement guidelines and health indicators have primarily focused on physical health outcomes. However, little is known about its relationship to mental health indicators. To our knowledge, the association between 24-h movement guidelines with depression symptoms from adolescence to adulthood has yet to be explored.
Objective: The aim of the study was two-fold: (i) to describe change in participant' movement behavior from adolescence (12-17 years old) to adulthood (33-39 years old); and (ii) to explore the association between change in movement behavior from adolescence to adulthood and depressive symptoms at adulthood.
Study design: We analyzed data from 7,069 individuals who participated in Waves I (1994-1995) and V (2016-2018) of the National Longitudinal Study of Adolescent Health (Add Health) in the United States, a representative sample of US adolescents. Physical activity, screen time, and sleep duration were self-reported in both waves. Adults at Wave V were categorized as having depression if they had self-reported history of depression ("Has a doctor, nurse, or other health care provider ever told you that you have or had depression?") and/or any prescription medication-use for depression in the past 4 weeks. Also, adults were asked in the prior seven days how often experienced the following symptoms using the 5-item depression scale (5-item CES-D): "felt depressed", "felt sad", "felt happy" (reverse coded), "could not shake off the blues", and "felt that life was not worth living". Trajectories of meeting all the three recommendations from adolescence to adulthood were assessed as follows: (i) always meets, which consisted of individuals who met the recommendation at adolescence and adulthood; (ii) increase, which consisted of participants who did not met the recommendation at adolescence but at adulthood; (iii) decrease, which consisted of participants who met the recommendation at adolescence but not at adulthood; and (iv) never meets, which consisted of individuals who did not met the recommendation at adolescence and adulthood.
Results: 21.0% of the sample were diagnosed with depression at adulthood. Overall, 17.6% of the sample met all the three recommendations in both waves. Individuals who met all the three recommendations at adolescence and adulthood had lower odds of depression than those who did never meet recommendations (adjusted Relative Risk=0.46, 95% CI 0.22 to 0.96).
Conclusion: Our findings highlight the importance of promoting and maintaining the adherence to the 24-h movement guidelines from adolescence to adulthood to prevent mental health.

**ROLE OF FITNESS ON THE ASSOCIATIONS BETWEEN SELF-RATED HEALTH AND DEPRESSIVE SYMPTOMS IN ADULTS WITH DIAGNOSED DEPRESSION: SONRIE STUDY**

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INTRODUCTION: Depressive symptoms have been shown to be associated with self-rated health (SRH) in healthy adults and those with comorbidities (1,2). Meanwhile, improved physical fitness seems to reduce these depressive symptoms (3). We aimed to study the effect of self-rated health (SRH) as predictor of depressive symptoms. Moreover, we also examined whether any protective effect of SRH on depressive symptoms was mediated by self-reported or objective physical fitness.
METHODS: SRH was assessed in 74 adults (11 males), aged 25 to 65 years and diagnosed with mild to moderate depression, by asking their perceptions of health. Based on their ratings, participants were categorized into 3 groups [(i) excellent/very good and good, (ii) fair and (iii) poor]. Depressive symptoms were collected by the Beck Depression Inventory-II. Fitness was measured by self-reported fitness (SRF) and physical appraisal. SRF was assessed by the International Fitness Scale, and objectively measured fitness by Senior Fitness Test and handgrip test. Multiple linear regression models were used to examine associations between SRH and depressive symptoms.
RESULTS: SRH was positively and independently associated with depressive symptoms after adjustments for sex and age and SRF ($r2=0.31$, $p<0.001$). However, the association between SRH and depressive symptoms did not remain significant when additional adjustment for physical appraisal were applied ($r2=0.12$, $p>0.05$).
CONCLUSION: SRH is an independent predictor of depressive symptoms. However, the protective effect of SRH on depressive symptoms is mediated by objectively measured fitness. Objective evaluation of fitness should be considered as a useful tool to provide additional info in depressive individuals at the clinical setting.
References: 1. Astutik E, Hidajah AC, Tama TD, Efendi F, Li CY. Prevalence and determinants of depressive symptoms among adults in Indonesia: A cross-sectional population-based national survey. Nurs Forum. 2021 Jan;56(1):37-44. 2. Rantanen AT, Korkeila JJA, Kautiainen H, Korhonen PE. Poor or fair self-rated health is associated with depressive symptoms and impaired perceived physical health: A cross-sectional study in a primary care population at risk for type 2 diabetes and cardiovascular disease. Eur J Gen Pract. 2019 Jul;25(3):143-148. 3. Kandola AA, Osborn DPJ, Stubbs B, Choi KW, Hayes JF. Individual and combined associations between cardiorespiratory fitness and grip strength with common mental disorders: a prospective cohort study in the UK Biobank. BMC Med. 2020 Nov 11;18(1):303. Grant: PI0068-2018.

**EFFECT OF EXERCISE INTENSITY ON MEMORY AND PSYCHOLOGICAL WELL-BEING IN YOUNG PEOPLE: INTERACTIONS WITH LACTATE AND BDNF VAL66MET POLYMORPHISM**

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Introduction
Currently, high-intensity interval training (HIIT) is on the rise compared to moderate-intensity (MICT) due to its benefits for health and performance. Recent studies show how physical exercise can also influence cognitive function, although the underlying mechanisms are

not clear. In this way, different explanatory hypotheses have been proposed, ranging from the cellular and molecular level, to other more macroscopic levels, such as brain or behavioural. Our study tried to include components from some of these levels, by comparing the effects of HIIT versus MICT on visuospatial memory, looking at aspects such as psychological well-being, lactate released after each session, and Brain-Derived Neurotrophic Factor (BDNF) genotype.
Methods
Twelve physically active female students participated in this study. The HIIT session, performed on a treadmill, consisted of a 3-min warm-up, four 2-min sets at 90-95% of the maximal aerobic speed (MAS) with 2-min of passive recovery between sets, and a 3-min cool down. The MICT session (60% of the MAS) had the same duration. Saliva samples were obtained from each subject to determine BDNF polymorphism (Kit Oragene, DNAGenotek, Kanata, Canada). Before and after each session we measured visuospatial memory using a digital version of the Corsi test, psychological well-being (questionnaires of affective state and subjective vitality), and blood lactate (Lactate Scout, SensLab GmbH, Leipzig, Germany). RM ANOVA and Pearsons correlation analysis were performed. Significance was set at $p < 0.05$ level.
Results
The results indicated a time and condition interaction effect on visuospatial memory, in favour of HIIT ($p=0.04$; $\eta p2 = 0.33$). Regarding well-being, there were no statistically significant differences between the two situations ($p > 0.05$). The BDNF genotype (Val/Val or met carrier) did not imply differences at the basal level nor in response to exercise. Correlational analysis showed associations ($p < 0.01$; $r = 0.73$) between visuospatial memory and post-exercise lactate release.
Discussion
Our results suggest that HIIT, through lactate mediation, would be an effective strategy against MICT to improve memory in young university students. Moreover, we studied BDNF Val66Met polymorphism as it has been identified as a possible influencing factor in cognitive function. Our findings indicate that memory levels, both at baseline and after exercise sessions, are independent of BDNF Val66Met polymorphism. Finally, we observed that there were no differences in the psychological well-being response between the two study situations of study. In this sense, our results suggest an important role for intensity in improving cognitive function with exercise, regardless of genotype and psychological well-being.

## RELATIONSHIPS BETWEEN WELLBEING AND PHYSICAL ACTIVITY, NATURE RELATEDNESS AND OUTDOOR ENVIRONMENTS IN A REPRESENTATIVE SAMPLE OF SAUDI ADULTS

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INTRODUCTION: Current government strategy in Saudi Arabia includes a focus on promoting quality of life across the population with one target area being increased physical activity. Growing evidence from other parts of the world suggests that exercising in outdoor natural environments provides added value to the wellbeing and general health benefits of physical activity. This study examined the relationships between wellbeing and physical activity in a Saudi population with specific attention on outdoor exercise environments and nature relatedness.
METHODS: A nationally representative sample of Saudi adults (n = 1018; 61% male; mean age 37.0 ± 11.6) completed an online questionnaire. This included the World Health Organisation-Five Well-Being Index (WHO-5), the International Physical Activity Questionnaire - Short Form (IPAQ-SF), the 6-item Nature Relatedness Scale (NR-6) and two questions on general health and exercise environment. The relationship between wellbeing and physical activity, nature relatedness, outdoor exercise and general health were explored with Spearman's correlations and multiple linear regression analyses.
Results: Wellbeing was positively correlated with overall physical activity (rho = .304, p < .001), general health (rho = .295, p < .001), outdoor exercise (rho = .205, p < .001) and nature relatedness (rho = .329, p < .001). These variables were entered into the multiple linear regression analysis producing a significant model (F (4,839) = 68.396, p < .001) that explained 25% of the variance in wellbeing (R-square of .246). Significant independent contributions to wellbeing were demonstrated for all predictor variables: physical activity levels (beta = 0.177, p < .001), nature relatedness (beta = 0.266, p < .001), general health (beta = 0.240, p < .001) and outdoor exercise (beta = 0.111, p < .001).
Conclusion: The results support the contribution of physical activity to wellbeing in a Saudi population and suggest the added value of exercising outdoors and encouraging connectedness with the natural environment. Providing appropriate outdoor environments for exercise should be one of the government's priorities in the effort to promote physical activity and quality of life.

## LONGER SEDENTARY TIME PREDICTS A LOWER LEVEL OF ENVIRONMENTAL MASTERY AMONG UNIVERSITY STUDENTS IN JAPAN.

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Introduction
Health is defined as "a state of complete physical, mental, and social well-being" (1), while Japanese university students and young populations suffer from mental problems such as severe depression (2)(3). It is well known that physical activities (PA) and sedentary behavior are associated with ill-being (e.g., anxiety and depression) (4)(5). Even though some previous studies have suggested the impact of PA for better psychological well-being (PWB) (6)(7), few studies have investigated the relationship between PA levels and PWB, including six aspects of concepts (personal growth, purpose in life, self-acceptance, autonomy, environmental mastery, and positive relationship with others). Given that the aspects of PWB have shown differences in cultural values and meanings, more investigations should be conducted to advance our understanding of these relationships, particularly in Japanese (8). The purpose of the present study was to examine the relationship between PA and PWB among Japanese university students.
Methods
Thirty-one Japanese university students (21 ± 1 yr) took part in an online-based questionnaire survey created by google form. The questionnaire consists of demographic variables (age, sex, grade point average (GPA) score, and major of study), PWB (9), and international physical activity questionnaire (IPAQ). Stepwise regression was used to determine the relationships between total PA (i.e. physical activity and sedentary times) and PWB (i.e. personal growth, purpose in life, self-acceptance, autonomy, environmental mastery, positive relationship with others).
Results

There was no relationship between PA and PWB (the scores of total and in each aspect) ($p > 0.05$). Sedentary time (h/week) significantly predicted environmental mastery in negative direction ($\beta = -0.459$、$p = 0.009$), but there was no relationship between any other variables ($p > 0.05$).
Conclusion
The findings revealed that longer sedentary time predicts a lower level of environmental mastery, which is defined as “the capacity to manage effectively one’s life and surrounding world” (10). Thus, reducing sedentary behavior may have a key role to promote well-being along with minimizing ill-being (i.e. anxiety and depression) (3) among Japanese university students in modern society.
References
(1) World Health Organization, 1948
(2) Zhao et al., International journal of environmental research and public health, 2020
(3)Ueda et al., Psychiatry and Clinical Neurosciences, 2020
(4) Farmer et al., American Journal of Epidemiology, 1988
(5) Ugwueze et al., American Journal of Men’s Health, 2021
(6) TY Lapa., Social and Behavioral Science, 2015
(7) Zang and Weiyun., Journal of Affective Disorders, 2019
(8) Yoo and Ryff., Frontiers in Psychology, 2019
(9) Nishida., educational psychology, 2000
(10) Ryff and Keys., Journal of personality and social psychology, 19

### HRV-BIOFEEDBACK TO OPTIMIZE THE EMOTIONAL STATE IN ATHLETES: BENEFITS OF VISUO-HAPTIC GUIDANCE

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INTRODUCTION: HRV-biofeedback (HRV-BFB) is used in sports contexts to improve one’s ability to maintain a robust emotional state, whatever the circumstances [1, 2]. It is based on benefits for the brain of synchronizing vagal and sympathetic modulations of the heart rate, which improves power in bottom-up brain stimulation. For that, breathing frequency that drives vagal modulations must be guided to resonate with sympathetic modulations. Yet, the classical 0.1 Hz resonant frequency may slightly vary among individuals. It is unclear to date if achieving a perfect resonance or achieving a perfect guidance provides more benefits. The aim of the study was to evaluate the impact of visual, haptic and visuo-haptic guidance on resonant power during one HRV-BFB session.
METHODS: 53 athletes (20 males) participated to the study. They firstly watched a neutral movie during which baseline HRV, and spontaneous breathing rate (BR) were collected. Then, using a specifically designed object, emitting light and/or vibration, athletes performed a 5-min HRV-BFB session at 0.1 Hz using either visual, haptic, visuo-haptic cues, or no feedback (video). HRV and BR were collected during HRV-BFB. Anxiety and stress were assessed through questionnaires at the beginning and after the experimental procedure.
BR and Power spectral density (PSD) of HRV were obtained at baseline and during HRV-BFB. The frequency at which the highest peak was observed in the classical LF band width (0.04-0.15Hz) was calculated at baseline (F0.1).
To quantify the athlete□s ability to achieve cardiac resonance, for each guidance condition: i) spectral power at 0.1 Hz was computed as a function of total power (P0.1); ii) Refined Composite Multiscale Entropy (RCMSE) of HRV was computed as an index of signal regularity.
RESULTS: Anxiety and stress significantly decreased after HRV-BFB. Resonance was achieved in each guidance condition as indicated by BR not different from 0.1Hz with no difference among guidance condition ($F=0.21$; $p = 0.81$). Yet, a clear distinction was observed both in P0.1 and RCMSE. Post-hoc comparisons highlighted greater P0.1 ($t=2.94$; $p<.01$) and smaller RCMSE ($t=-2.79$; $p<.01$) in visuo-haptic condition when compared to visual alone. By contrast, neither the spontaneous BR nor F0.1 was correlated to P0.1, thus indicating the greater influence of guidance compared to F0.1 in this population of athletes.
CONCLUSION: While both perfect resonance and perfect guidance might help optimize BFB-HRV [3], the present study focused on optimizing the effect of biofeedback in conditions where visual and haptic cues are combined. So, implementation of new techniques of HRV-BFB including haptic cues could be used to reinforce biofeedback effect especially in sports context where emotional state management is a determining factor of performance.
REFERENCES:
[1] S. Jiménez Morgan et al., 2017
[2] V. Deschodt-Arsac et al., 2018
[3] P. M. Lehrer et al., 2003

### MORE LOAD LESS HARM? PERCEIVED HARMFULNESS OF DAILY ACTIVITIES IN WEIGHTLIFTERS AND POWERLIFTERS

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Introduction.
Weightlifting (WL) and Powerlifting (PL) are popular strength-based sports, which are associated with large spinal tissue loads (1,2). Low back pain (LBP) is one of the most common disorders incurred by WL and PL (3). Fear of movement has been thought to be a risk factor for the onset and persistence of LBP (4), but this has only been investigated in the general population. Whether similar levels of fear exist in a cohort of athletes who frequently expose themselves to high and repetitive spinal loads is uncertain. In addition, the predictors of fear in people who perform WL and PL are unknown.
Methods.
Fear of movement was quantified using the Photograph Series of Daily Activities Short Electronic Version (PHODA-SeV) (scored from 0 = ‘Not harmful at all’ – 100 = ’Extremely harmful’) in a cohort of 70 WL and PL athletes (Age = 28 ± 8, Mass (kg) = 74 ± 12, Back squat (kg) = 129 ± 49). Pain intensity in the cohort was measured using the Oslo Sports Trauma Research Centre Overuse Injury Questionnaire (OSLO) (5). 13 variables were measured and included in the stepwise regression to predict fear. Independent t-test were used to compare the cohort mean PHODA-SeV score with the mean population score (PHODA-SeV = 40). A stepwise regression model was used to determine the strongest predictors of PHODA-SeV score.
Results.

PHODA-SeV scores were 19.8 (p<.001) lower than the general population score of 40. The top three predictors in the regression model were back squat (β = -.57, p<.001), age (β = -.22, p = .037), and Oslo Q4 (To what extent have you experienced LBP related to your sport in the past 7 days?) (β = 2.0, p <.001).
Discussion.
Athletes who train in WL and PL had lower fear levels compared to the general population. Similar findings have been seen within ACL recoverees (6), where modified PHODA scores were reduced in athlete's ACL recovery group compared to the sham group (6). This would suggest that regular exposure to movements deemed dangerous reduces fear of movement. Our findings were supported by our regression analysis which found greater back squat load was associated with reduced pain score. This supports previous research (6) and the suggestion that with exposure to heavier weights and dangerous movements, WL and PL athletes have reduced fear even when LBP prevalence is high (6).
Our findings suggest that repeated exposure to activities that incur high spinal load may help pain-related fear in a cohort of largely asymptomatic athletes. Whether WL and PL can be used to manage pain-free episodes to reduce risk of LBP remains to be investigated.
References
1. Cholewicki et al. Med Sci Sports Exerc. 1991;23(10):1179-86.
2. Eltoukhy et al. J. Orthop. 2016;13(3):210-9.
3. Aasa et al. Br. J. Sports Med. 2017;51(4):211-9.
4. Rainville et al. Spine J. 2004;4(1):106-15.
5. Clarsen et al. Br. J. Sports Med. 2020 Apr 1;54(7):390-6.6.
6. Baez et al. Phys Ther Sport. 2021;52:217-23.

## LOWER INTEROCEPTIVE BODY AWARENESS PERFORMANCE IN SOLDIERS WITH HISTORY OF EXERTIONAL HEAT STOKE COMPARED TO SOLDIERS WITHOUT HISTORY

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INTRODUCTION: Exertional heatstroke (EHS) is the most serious heat illnesses that can occur during physical effort often, but not always, under environmental stress. Despite substantial progress in primary care of EHS, physiopathology is still highly unknown. Besides dysfunction in muscle's metabolism and contractility, or alteration of gut permeability causing inflammation, first intrinsic risk factor declared by 18% of patients is the level of motivation during the trial (Abriat A, et al. Mil Med 2014). Our hypothesis is that EHS might be the consequence of failure in thermoregulatory behavior related to misjudgement of exercise cost-benefit balance. We propose that EHS might result from the overvaluation of benefits, as a consequence of overmotivation to succeed, and/or the undervalued costs of effort exertion that result from low interoceptive body awareness.
METHODS: In a pilot case-control study, we compared different psychological dimensions between soldiers with history of EHS compared to paired soldiers who had experienced similar EHS risk situations. The Multidimensional Assessment of Interoceptive Awareness questionnaire measures eight facets of body awareness. The Global Motivational Scale assesses three types of intrinsic motivation, three types of extrinsic motivation, and amotivation (lack of extrinsic or intrinsic motivation). The Freiburg Mindfulness Inventory measures dispositional trait mindfulness by indexing facets of Presence and Non-judgmental acceptance. Statistical analyses were performed using Mann-Whitney nonparametric tests.
RESULTS: Cases (n=51) and controls (n=43) did not differ for age (27.80 +/- 6.38 vs. 27.30 +/- 6.48), gender (94% vs 93%) and body mass index (24.79 +/- 2.45 vs. 24.65 +/- 2.76). Five dimensions of interoceptive body awareness were significantly lower in cases compared to controls: Body listening (2.37 +/-1.10 vs. 3.05 +/- 1.10, $p \leq 0.01$), Attention regulation (3.05 +/- 0.89 vs.3.55 +/- 0.76, $p \leq 0.01$), Emotional awareness (3.44+/- 0.95 vs. 3.88 +/- 0.81, $p \leq 0.05$,), Self-regulation (2.97 +/- 1.15 vs. 3.50 +/- 0.98, $p \leq 0.05$), and Noticing (3.52 +/- 0.87 vs. 3.88 +/- 0.72, $p \leq 0.05$). Cases and controls did not differ for almost all factors of motivation. Only the factor Amotivation was significantly lower in cases compared to controls (11.43+/-4.08 vs. 14.51+/-5.59, $p \leq 0.01$ ). Cases showed lower scores for the two mindfulness dimensions, relative to controls: Presence (18.69+/-3.02 vs. 20.30+/-2.67, $p \leq 0.05$) and Acceptation (21.57 +/-3.79 vs.23.77+/-3.70, $p \leq 0.01$).
CONCLUSION: We here showed EHS soldiers may have a lower interoceptive body awareness. The risk of EHS may be increased by reduced ability to recognize body exhaustion signals. Future work are required to precise the link between processing signals of internal physiological state, pacing strategy during exercise and the potential benefit of minfdulness-based programs.

## POORER FUNCTIONAL CAPACITY IS ASSOCIATED WITH IMPAIRED COGNITIVE FUNCTION AND WELL-BEING IN OLDER ADULTS

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INTRODUCTION: Functional and cognitive impairment are two of the most prevalent age-related conditions [1] and are important determinants of independent living [2]. An understanding of the relationship between functional capacity and cognitive function could provide insight for developing interventions to support healthy aging. The aim of this study was to examine the associations of various parameters of functional capacity with global cognition, executive function and well-being in older individuals across the spectrum of normal cognition and cognitive impairment.
METHODS: Ninety-seven older adults (age 80.6 ± 8.2 yrs; female n = 64) participated in this cross-sectional study. Measures of global cognitive function (Mini-Mental State Examination; MMSE) and executive function (symbol cancellation test) were obtained. Functional capacity was evaluated using three sit-to-stand tests (STS-5, STS-30 and STS-60), the timed–up-and-go test (TUG), the 6-min walk test (6MWT) and the handgrip strength test (HGS). For well-being, quality of life, sleep quality, daily sleepiness and fatigue levels were assessed by specific questionnaires. Data were analyzed using adjusted partial correlations (controlling for age, sex and education) to examine the relationships between variables.
RESULTS: According to their MMSE score, 41% of the participants had a normal cognitive function, whereas 35% and 24% had mild and moderate cognitive impairment respectively. Lower levels of all functional capacity parameters were associated with worst performance in cognitive and executive function tests, with the 6MWT showing the highest correlation with the MMSE ($r = 0.35$, $p = 0.001$) and the HGS with the symbol cancellation test ($r = -0.49$, $p < 0.001$). Reduced levels of functional capacity parameters were also associated with lower quality of life (all $p < 0.05$, r from 0.32 to 0.41) and higher fatigue levels (all $p < 0.05$, r from 0.23 to 0.37). Sleep quality was positively correlated with some of the functional capacity parameters (6MWT, STS-30 and STS-60; all $p < 0.05$, r from 0.23 to 0.24).

CONCLUSION: Poorer functional capacity was associated with worst cognitive performance, ultimately affecting well-being. Tailored interventions need to be implemented for maintaining functional independence and preventing cognitive impairment in older adults.
REFERENCES
1. Stijntjes, M., Aartsen, M.J., Taekema, D.G., Gussekloo, J., Huisman, M., Meskers, C.G., De Craen, A.J. and Maier, A.B., 2017. Temporal relationship between cognitive and physical performance in middle-aged to oldest old people. The Journals of Gerontology: Series A, 72(5), pp.662-668.
2. Gaugler, J.E., Duval, S., Anderson, K.A. and Kane, R.L., 2007. Predicting nursing home admission in the US: a meta-analysis. BMC geriatrics, 7(1), pp.1-14.

## Conventional Print Poster

### CP-BM06 Biomechanics in lower extremities

#### EFFECTS OF STATIC BALANCE EXERCISE COMBINED WITH DIFFERENT LEVELS OF BLOOD FLOW RESTRICTION ON PHYSIOLOGICAL AND PERCEPTUAL RESPONSES AS WELL AS MOTOR PERFORMANCE FATIGUE IN YOUNG MALES AND FEMALES

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INTRODUCTION: Blood flow restriction (BFR) can be combined with several exercise modalities (e.g., resistance and aerobic exercise) and involves the application of cuffs to the limbs to reduce arterial blood flow and block venous return in the respective extremities. The addition of BFR to low-load resistance exercise has been shown to increase physiological and perceptual responses as well as motor performance fatigue development (i.e., decrease in maximal motor performance). However, the effects of balance exercise combined with BFR on these aspects have not been investigated to date.
METHODS: Twenty-four active males and females (23.8±3.1yrs, 67.0±12.3kg, 1.7±0.1m) participated in a randomized, counterbalanced cross-over study. Subjects completed a familiarization session and three experimental conditions (SHAM, 40%, and 80% of individuals' arterial occlusion pressure (AOP)). The balance exercise consisted of standing on a BOSU ball (3 sets of 1min with 30s rest inbetween). During exercise, muscle oxygen saturation (SmO2) of the vastus lateralis and muscle activity of various leg muscles were recorded with near-infrared spectroscopy and electromyography, respectively. Effort and leg muscle pain were assessed at the end of each set (BORG 6-20 scale). Maximal squat jump height was measured before and after exercise (0,1,2,4,8min) to quantify motor performance fatigue and recovery. SmO2 and muscle activity data were normalized to SmO2 recorded at rest and muscle activity measured during MVCs, respectively. Data were analyzed with repeated measures ANOVAs (time×condition).
RESULTS: We found a time×condition interaction for SmO2 ($p<.001$, $\eta p2=.603$) with a greater drop in each set in the 80%AOP compared to the 40%AOP ($p\leq.012$) and SHAM condition ($p<.001$). A time×condition interaction was revealed for quadriceps muscle activity ($p<.001$, $\eta p2=.339$) with a significant increase from set 1 to 3 only in the 80%AOP condition ($p<.001$). There was a time×condition interaction for effort ($p<.001$, $\eta p2=.389$) and leg muscle pain perception ($p<.001$, $\eta p2=.321$) with significant increases from set 1 to 3 only in both BFR conditions ($p<.001$). A significant time×condition interaction for jump height ($p<.001$, $\eta p2=.375$) was found with significant differences in the performance decline between 80%AOP (16.4±5.2%) and the other conditions (40%AOP: 9.1±3.2%, SHAM: 5.4±3.3%) immediately after exercise ($p<.001$). Differences in recovery between 80% AOP and the other conditions were present after 1min ($p\leq0.007$), but not 2,4, and 8min after exercise.
CONCLUSION: A static balance exercise combined with a high BFR pressure (80%AOP) decreased SmO2 and increased quadriceps muscle activity, perceptual responses, as well as motor performance fatigue. However, maximal squat jump height was not different between conditions after 2min of recovery. These data collectively suggest that the balance exercises combined with a BFR pressure of 80%AOP induced a strong training stimulus without long-term impairments of maximal performance.

#### DEEPACSA – AUTOMATIC SEGMENTATION OF ANATOMICAL CROSS-SECTIONAL AREA IN ULTRASOUND IMAGES OF HUMAN LOWER LIMB MUSCLES USING DEEP LEARNING

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INTRODUCTION: Muscle anatomical cross-sectional area (ACSA) characterizes muscle function and helps to classify the severity of several muscular disorders. Ultrasound is a patient friendly, fast, and cheap method of assessing muscle ACSA, but manual analysis of the images is laborious, subjective and requires thorough experience. To date, no open access and fully automated program to segment ACSA in ultrasound images is available. Here, we present DeepACSA, a deep learning approach to automatically segment ACSA in panoramic ultrasound images of the human rectus femoris (RF), vastus lateralis (VL), gastrocnemius medialis (GM) and lateralis (GL) muscles.
METHODS: We trained deep neural networks using 1772 ultrasound images of 153 participants of different age groups (9 to 36 images per participant) acquired in previous studies by three operators (n = 153 (25 females, 128 males), age = 38.2 years (13 to 78 y)). Images of the RF, VL and GM/GL were captured with three devices using EFOV ultrasonography at several muscle regions. For each muscle, we randomly divided the images into a training set (n = 1127) for the deep neural network and a validation set (n = 90). Prior to model training, images and binary area masks were augmented, normalized, and resized. Within the training data set, we applied a random 90/10% training/test data split. We trained one model for each muscle using a U-net architecture. Following model training, we measured the ACSA in all images of the validation set using DeepACSA and compared it to manual segmentation.
RESULTS: Comparing DeepACSA analysis of the RF to manual analysis resulted in intra-class correlation (ICC), mean difference and standard error of the differences (SEM) of 0.96 (95% CI 0.939,0.973), 0.31 cm2 (0.04,0.58) and 0.91 cm2 (0.47,1.36). For the VL, ICCs, mean differences and SEMs were 0.941 (0.911,0.96), 0.25 cm2 (-0.21,0.7) and 1.55 cm2 (1.13,1.96). The GM/GL muscles demonstrated ICCs, mean differences and SEMs of 0.968 (0.948,0.98), -0.01 cm2 (-0.25, 0.24) and 0.69 cm2 (0.52,0.83). Comparability was increased for all muscles when wrong predictions of the model were removed based on visual inspection of the output. Whereas the time needed to manually segment ten ultrasound images is about ten minutes, DeepACSA requires thirty seconds for automatic segmentation on a common CPU and provides comparable results.

CONCLUSION: The segmentation of DeepACSA of RF, VL and GM/GL muscles in EFOV ultrasound images yielded comparable results to manual segmentation. Therefore, the DeepACSA tool can (automatically) segment lower limb muscles in EFOV ultrasound images using deep neural networks. DeepACSA is novel, because it objectifies and accelerates the evaluation process of EFOV ACSA ultrasound images, allowing large datasets to be evaluated quickly. However, our results demonstrated that visual inspection of the output may still be necessary to optimize predictions and avoid misclassifications.

**KINETIC CHARACTERISTICS DURING THE SIDE HOP TEST IN ATHLETES WITH CHRONIC ANKLE INSTABILITY**

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INTRODUCTION: Chronic Ankle Instability (CAI) is a well-known sequela after an ankle sprain that often occurs in ball sports. Athletes with CAI could have some typical movement. The Side Hop Test (SHT) is a valid test to identify individuals with CAI. Some studies have reported that the SHT time was delayed in individuals with CAI compared to healthy individuals1. Although previous studies have investigated kinematic characteristics during the SHT, few studies focused on kinetic characteristics that can explain the specific movement, especially in athletes. Therefore, this study aimed to examine the differences in lower extremity kinetic characteristics during the SHT between athletes with and without CAI.
METHODS: Twenty male athletes who play football participated in the study and were divided into the healthy control group (CON) and the CAI group (CAI). The presence of CAI was determined from the Cumberland Ankle Instability Tool score. Subjects completed the SHT with one leg, putting their hands on their hips, and hopping laterally ten times. Three-dimensional coordinates were collected using ten Vicon MX+ cameras, and ground reaction forces were collected using two force platforms. The time of SHT and the net internal joint torque of the ankle, knee, and hip were calculated as outcome measures. We looked at the peak joint torque at the lateral ground contact phase of the SHT. Differences between the two groups were examined using Mann-Whitneys U test ($p < 0.05$).
RESULTS: There was no significant difference in SHT times between the two groups (CON vs. CAI; 6.00 ± 0.39 vs. 5.91 ± 0.37, Mean±SD). The CON group demonstrated greater peak flexion (0.20 ± 0.17 vs. -0.11 ± 0.17) and abduction (-3.50 ± 0.38 vs. -3.08 ± 0.27) torques of the hip joint, greater peak flexion (0.76 ± 0.26 vs. 0.34 ± 0.20) and extension (-1.52 ± 0.39 vs. -0.83 ± 0.50) torques of the knee joint, and greater peak dorsiflexion (0.31 ± 0.18 vs. 0.02 ± 0.06), plantar flexion (-3.25 ± 0.35 vs. -2.86 ± 0.34), inversion (0.71 ± 0.10 vs. 0.41 ± 0.23), and eversion (-0.32 ± 0.15 vs. -0.16 ± 0.15) torques of the ankle joint compared to the CAI group.
CONCLUSION: Although subjects with CAI showed high performance as the CON group in the SHT, they had smaller peak joint torques than the CON group. Since previous studies have reported that athletes with CAI have specific movement characteristics, it is possible that a similar trend was observed in the SHT. However, it is noteworthy that no differences in SHT times were observed, and the possibility of compensatory strategies in athletes with CAI should be investigated in the future. This study found the kinetic characteristics of subjects with CAI who perform as fast as the SHT time in healthy athletes. Thus, the differences observed in this study should be considered when using the SHT for athletes.
1. Rosen, A. B., Needle, A. R., & Ko, J. (2019). Clinical journal of sport medicine: official journal of the Canadian Academy of Sport Medicine, 29(6), 509–522.

**SUBJECT SPECIFIC SENSITIVITY OF SEVERAL BIOMECHANICAL FEATURES TO FATIGUE DURING AN EXHAUSTIVE TREADMILL RUN**

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INTRODUCTION: Human movement may be similar among individuals but never identical. Movement is produced from a functional combination of the nervous, the muscular, and the skeletal system. Mechanically, the musculoskeletal system allows a relatively large but fixed number of functional degrees of freedom, whereas the neuromuscular system has predetermined branching and connections, but is highly complex and adaptable. Endurance running is a demanding and at the same time a fundamental human activity where all the above-described properties can be observed and affected as fatigue progressively accumulates. The present study examined the sensitivity of several movement features during running to exhaustion in a subject-specific setup adopting a cross-sectional design and a machine learning approach.
METHODS: Thirteen recreational runners that trained and competed regularly performed an exhaustive running protocol on an instrumented treadmill. The ventilatory threshold, established through respiratory data, was used as a reference point regarding the gradual accumulation of fatigue. A machine learning approach was adopted to analyze kinetic and kinematic data of each participant, using a random forest classifier (1) for the region pre and post the ventilatory threshold. SHapley Additive exPlanations (SHAP) analysis (2) was used to provide explanations about the models' predictions and insights about the most important variables that described each subject's technique.
RESULTS: The classification accuracy value range was from 0.853 to 0.962. The SHAP based variable importance ranked all the features according to their value for the model, to predict the state above the ventilatory threshold. Lateral flex/ext at C7 appeared to be the most important feature for prediction in 6 out of 13 participants. Also, the maximum value of rate of force development appeared first in 3 out of 13 and vertical rotation at PSIS in 2 cases, respectively. Max force value and impulse were the most important features for 1 out of 13 of the sample participants. SHAP dependence plots also showed increased vertical dispersion of predictions in stages around the ventilatory threshold, which is consistent with feature interactions.
CONCLUSION: These results suggested that each individual exhibited distinct changes in overall running mechanical parameters in predicting the fatigued state. These findings also support the efficacy of machine learning modeling approach for understanding the complexities of running gait patterns based on collecting large amount of data in a laboratory setting. Overall, the results showed that the production of work in a fatigued condition results in subject-specific changes in biomechanical running patterns, possibly to compensate and optimize the system function to account for the imposed demands based on individual movement characteristics or constraints.
1. Breiman L. Mach Learn 2001.
2. Lundberg et al. Adv Neural Inf Process Syst. 2017

### EFFECTS OF WHOLE-BODY EXHAUSTION ON SYNCHRONIZED WALKING GAIT KINETICS AND KINEMATICS ON A DOWNWARD 10˚ INCLINE

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INTRODUCTION: Walking downwards on a slope alters postural alignment to maintain equilibrium and involves an altered gait strategy to retain balance. Walking efficiency decreases with exhaustion and muscle fatigue, as the fatigue directly affects key features of the sensorimotor system, which disorganizes voluntary control of movement accuracy. Studies have shown that the effects of motor fatigue due to repetitive activities reduce human force generating capacities to a minimal level by decreasing the joint range of motion. Human often experience fatigue and become exhausted after performing laborious tasks throughout the day in many occupations including industrial and health care workers. The collective effects from prolonged standing, and a poor or awkward working position cause discomfort in the lower back, legs, and feet with an increase of overall body and local muscle fatigue (LMF) at the end of a working day.
METHODS: This biomechanics study investigated stride length (SL), stride duration (SDN), the peak values of gait ground reaction forces (GRFspeak), required coefficient of friction (RCOFpeak), joints' angles (anglepeak), angular velocity (angvelx peak), angular acceleration (angaccx peak), minimum angle (anglemin) of foot, and muscle electromyography (EMG) during the dominant leg stance phase (SP) following an exhaustive stair ascent on a stair machine. Data were collected by a three-dimensional motion capture system synchronized with EMG and force plate when walking downwards on a 10° inclined stationary walkway.
RESULTS: Although the leg muscles' EMG showed no significant results to claim local muscle fatigue (LMF) during post exhaustive downward walking, the SL was significantly ($p<.05$) shorter than pre-exhaustive. The mean vertical GRFpeak was significantly ($p\leq.01$) reduced during late stance (LS) phase, however, the antero-posterior GRFpeak was found significantly ($p\leq0.01$) higher. The RCOFpeak was significantly ($p\leq.05$) higher during the post-exhaustive walking downwards, LS phase. None of the post-exhaustive absolute foot angle peaks and mins, angvelx peaks, and angaccx peaks significantly changed in post-exhaustion walking except knee angaccx peak, which significantly ($p<.05$) increased during the LS period.
CONCLUSION: Physical exhaustion of the subjects was evidenced by the high mean lactate value of 14.4 mmol·l-1 at the end of their stair ascent at maximum speed, which was terminated by the subjects themselves due to high strain on both the cardiovascular system and legs. The end durational stair ascent electromyography results had evidenced the onset of leg's local muscle fatigue (LMF). Neither of the muscles' mean EMG AMPs during 5-25% (ES) and 75-95% (LS) periods of walking downward were significantly changed between the pre-exhaustion and post-exhaustion trials, except the tibialis anterior (TA) muscle. The constrained post exhaustive gait kinetics indicate perturbed gait and may increase the risks for fall accidents when walking downward.

### EFFECT OF TIGER-STEP WALKING ON LOWER EXTREMITIES DURING UPHILL WALKING

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INTRODUCTION: The walking can be classified according to the shape of the ground where it takes place (1). Previous studies on uphill walking claim that it requires more use of lower extremity muscles since it has to lift the body higher compared to level walking (2). Recently, many media have introduced the Tiger-step style walking as an efficient method in uphill walking (3). The Tiger-step, however, is a method conceived by the experience of some climbing experts and rather than being based on scientific evidences. Therefore, the aim of this study was to investigate the effects of Tiger-step walking on the movement of the lower extremities during uphill walking.
METHODS: Twenty healthy male adults who had no experience of musculoskeletal injuries on lower extremities in the last six months(age: 26.85±3.28 yrs, height: 174.6±3.72 cm, weight: 73.65±7.48 kg) participated in this study. All subjects were asked to perform normal walking (NW), straight tiger-step walking (STW) and cross tiger-step walking (CTW) with 60% of the pre-measured preferred speed of gait at an grades of 15° in treadmill. To investigate kinematics and kinetics differences among three types of walking, a three-dimensional motion analysis was performed using eight infrared cameras(sampling rate: 100 Hz) and seven channel of EMG(sampling rate: 1,000 Hz). An one-way ANOVA with repeated measure was conducted to verify the differences among the walking styles and statistical significance set as $\alpha=.05$.
RESULTS: Both STW and CTW showed a significant increase in stance time and stride length, and significantly reduced cadence compared with those of NW. In addition CTW also showed a longer swing time than that of NW ($p<.05$). For all lower extremity joints joint range of motion, STW and CTW revealed significantly increased compared with NW ($p<.05$). Gluteus maximus, biceps femoris, medial gastrocnemius, tibialis anterior revealed significantly increased muscle activation in STW and CTW compared with NW in gait cycle and stance phase. On the other hand, in swing phase, the muscle activity of the vastus medialis, biceps femoris, tibialis anterior of both STW and CTW significantly increased compared with those of NW.
CONCLUSION: The results of this study may solve the curiosity of many recreational hikers in club by quantifying tiger-step, which had not been scientifically proven. Moreover, our study results may be thought to help develop tiger-step more efficiently in the future.
REFERENCES:
1) Alexander & Schwameder, Gait & Posture, 2016
2) Franz & Kram, Gait & Posture, 2013
3) Kim, https://www.hidoc.co.kr/healthstory/news/C0000253740, 2017,

### EFFECTS OF LOAD CARRIAGE ON POSTURAL CONTROL DURING TREADMILL BASED UPHILL WALKING

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INTRODUCTION: Postural control refers to the mechanism based on which the central nervous system regulates the stimuli from the sensory organs in maintaining body stability. When postural control is jeopardized by changes in the intrinsic (e.g. somatosensory) and/or extrinsic stimuli (e.g. environment) body stability is challenged increasing the likelihood of injury. It is generally accepted that a condition that may affect postural control and elicit a wide range of musculoskeletal low back and limb injuries is load transfer. However, postural control may be further aggravated when a load is required to be transferred in different ways and/or on inclined surfaces. This study aimed to assess the effects of load transfer by means of a front- or a backpack on postural control during walking on inclined surfaces.
METHODS: Thirty asymptomatic, skeletal symmetric individuals aged 20-30 years participated in the study. Postural control was assessed by means of (i) the EMG activity of the neck, thoracic and lumbar extensors (NE, TE, and LE) and trunk flexors (TF) and (ii) the anteroposte-

rior and mediolateral displacement as well as the ellipse area of CoP during treadmill based uphill walking at a constant speed of 5 km/h. Participants had to walk for 10 minutes, during which the slope of the treadmill gradually increased every 2.5 minutes from 0 to 15 degrees, at 5-degree intervals, without and with carrying a front pack or a backpack equal to 15% of each individuals body weight. A device for recording physiological signals and an inertial sensor placed on the upper torso were used to assess the EMG activity of the muscles under investigation and the displacement of the CoP, respectively.
RESULTS: Significant differences between inclinations and ways of load carriage were obtained for the EMG activity of NE ($p<0.001$), TE ($p<0.001$), and LE ($p<0.001$) as well as TF ($p<0.01$). The EMG activity of the muscles tested increased as the slope increased and it was greater when the participants walk carrying a front pack compared to a backpack or no load. Similarly, the anteroposterior displacement and ellipse area of CoP was significantly increased as the slope of the treadmill's surface increased ($p<0.001$) regardless of the way used to carry the load. The greatest anteroposterior displacement and ellipse area of CoP were obtained while walking carrying a front pack as opposed to carrying a backpack or no load. The differences between inclinations and ways of load transfer for the mediolateral displacement of CoP were not significant.
CONCLUSION: Carrying a backpack remains the least provocative way of load transfer when an individual walks on a level or a sloped surface, at least as far as the EMG activity of the trunk musculature and the displacements of CoP are concerned. Carrying a front pack under the same surface conditions should be limited, as it significantly disrupts postural control predisposing an individual to injury.

**SCALING ANALYSIS OF FORCE PLATFORM RECORDS OF STANDING WITH TASKS AND INJURY**

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INTRODUCTION: We examined long-range temporal characteristics of two force platform records of quiet standing with or without injury, and of non-injured standing with eyes closed and on one leg only. We analysed two force platform recordings to assess balance dynamics for each leg separately.
METHODS: We used the detrended fluctuation analysis (DFA) and the local and global wavelet transform spectral analysis (WTS) to quantify force platform data temporal dynamics by DFA scaling exponents and WTS characteristic peaks, and to show how those parameters change with task or injury. DFA is a variant of a conventional fluctuation analysis, adapted for the analysis of non-stationary, non-linear data, in which a fluctuation function is calculated as a root mean square variation about the constantly changing local trend instead of the record's mean. WTS was introduced to achieve signal localization and decomposition in both time and frequency and thus expand the limits of Fourier analysis by two-dimensional time and scale decomposition of any signal with functions constructed by expanding by time scale and translating along real time of a specifically chosen original wavelet function.
RESULTS: We found long-range autocorrelated behaviour in all our records, with a visible crossover in long-range dynamics, a random behaviour on small time scales and a distinct non-linearity on higher time scales. Under the changes in experimental conditions or in injury to one leg, we found that only the scaling above the crossover, on time scales from 100ms to 1s, changes. We found increase in DFA and WTS slopes after the crossover point caused by visible change of amplitude of the mid-level characteristic peaks at about 250 and 650 ms in non-injured standing on one leg only. We observed two main types of response to injury: a compensation, seen as an increase of all the characteristic modes above the crossover point that causes a shift of the position of crossover to smaller scales, and an 'underachievement', which presents as a decrease of amplitudes of the characteristic WTS peaks above the crossover region that brings about a shift of the position of crossover point to higher time scales.
CONCLUSION: Our results further corroborate claims that DFA, WTS and similar time series analysis techniques may provide new, more sensitive discriminatory analysis framework for human balance assessments. This is particularly observable in probably the most important finding of our research, that DFA2 and WTS can distinguish injury even in quiet standing.

**EFFECT OF AROUSAL STATE AND STRETCH SPEED ON ANKLE FLEXIBILITY IN INDIVIDUALS WITH DIFFERENT MAXIMUM RANGE OF MOTION**

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INTRODUCTION: Several theories exist regarding the physiological mechanisms that underpin joint flexibility (maximum range of motion [ROMmax] and resistance to stretch). These contrast the importance of objective measures of the mechanical properties of the joint structures and the muscle-tendon unit (MTU) with the more subjective assessment of stretch tolerance. The present study used a cross-sectional design between nine flexible female participants who trained for flexibility for several years (age 27± 5.3 yr; ht 162.2 ± 6.7 cm; mass 58.8 ± 9.8 kg) and eight non-stretch-trained females (age 26.5 ± 5.5 yr; ht 160.5 ± 6.4 cm; mass 61.1 ± 8.8 kg). Purpose: To examine the effects of stretch rate (slow 5°·s-1; and fast 30°·s-1) and state arousal (control, arousal, and relaxation) on ROMmax and joint stiffness during passive ankle dorsiflexion.
METHODS: Participants attended the laboratory twice (Session 1 = familiarisation, Session 2 = experimental). In Session 1, participants were familiarised with the stretch trials during slow and fast ankle stretching manoeuvres on an isokinetic dynamometer. In Session 2, participants performed 4 ankle stretching 'control' tests (2 slow and 2 fast). Participants then performed stretches under 6 randomised conditions (control, arousal, and relaxation at slow and fast speeds). For the arousal and relaxation conditions, participants listened to classical music that professional musicians classified as arousing or relaxing (Kuan et al., 2017). Participants pushed a button to stop the machine at their perceived ROMmax. Joint stiffness was calculated from change of torque and angle over 80 to 100% ROMmax.
RESULTS: For ROMmax, two-way ANOVA (2 groups x 6 conditions) showed no interaction, but main effects for condition ($F_{1,5} = 6.7$, $p = 0.001$) and group ($F_{1,15} = 440.1$, $p = 0.001$) . Flexible participants (55.3 ± 4.5°) demonstrated greater ROMmax than inflexible participants (38.1 ± 6.5°) ($p = 0.001$). ROMmax in the arousal-fast condition (50.1 ± 9.0°) was 5.7% greater than the control-slow condition (47.2 ± 11.4°) ($p = 0.001$). No differences in joint stiffness analysed near the end of the ROM were observed under any conditions. However, flexible participants (112.6 ± 44.7 Nm/rad) demonstrated 35.8% lower stiffness than less flexible participants (175.6 ± 77.4 Nm/rad) ($p = 0.001$).
CONCLUSION: Individuals who are flexible and flexibility trained have lower plantar flexor musculotendinous stiffness than less flexible individuals. Yet, altering an individual's psychological state by adding arousing music improved ROMmax in both flexible and less flexible individuals but only at faster, not slower, stretch speeds. Therefore, from a practical viewpoint it might be of interest to individuals to perform stretches at a little faster speed and to add arousing music to their flexibility training. Such music can improve motivation and

overall mental state and is also used in medical rehabilitation settings to manage pain and discomfort, and reduce anxiety and muscle tension.

### VALIDITY AND RELIABILITY OF 3D ULTRASOUND IMAGING TO MEASURE HAMSTRING MUSCLE AND TENDON VOLUMES

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INTRODUCTION: Measuring muscle and tendon volume is important to understanding adaptations in response to immobilization, training or rehabilitation. For instance, small-sized grafts used during anterior cruciate ligament (ACL) reconstructions are highly predictive to be at risk of later risk of failure. In addition, atrophy of semitendinosus and gracilis can be observed 2 to 4 years after the ACL surgery, altering the recovery of force in these muscles (1). Therefore, quantifying architectural parameters of these muscles could be useful to identify patients at risk of small-sized grafts, and prepare accordingly using rehabilitation programs. The current gold standard to assess muscle and tendon volumes is Magnetic Resonance Imaging (MRI). However, its cost and accessibility make it prohibitive in many clinical/research settings. 3D ultrasound (US) imaging combines B-mode US imaging and 3D motion analysis of the US probe, would produce 3D images to overcome this problem (2). This study aimed to assess the reliability (test-retest) and the validity of 3D US imaging against MRI in measuring hamstring muscle and tendon volume in healthy participants.
METHODS: Thirteen healthy volunteers received two sessions of 3D US acquisitions (spaced by 24h on average) of biceps femoris long (BFlh) and short head (BFsh), semitendinosus (ST), semimembranosus (SM) and gracilis (GR) muscle , but also semitendinosus, in addition to one session of MRI.
RESULTS: The bias for 3D US ranged from -1.92 mL (-0.81%) to 1.21mL (0.97%) for muscle volume, and 0.01 mL (0.23%) and -0.03 mL (-2.58%) for tendon volume. The reliability analysis of 3D US imaging for muscle volume give intra-class correlation coefficients (ICC) from 0.98 (GR) to 1.00 (ST), and coefficients of variation (CV) from 1.13% (SM) to 3.37% (BFsh). The standard error of measurement was between 1.79 mL (GR) to 3.85 mL (BFsh), and the minimal detectable change between 4.95 mL (GR) to 10.67 mL (BFsh). For tendon volume, ICCs were 0.99, and CVs between 3.19% (STtd) and 3.43% (GRtd). The SEM were 0.06 mL (STtd) and 0.04 mL (GRtd), and MDC were 0.17 mL (STtd) and 0.10 mL (GRtd).
CONCLUSION: This study showed that 3D US, combined with the use of a gel pad, provides hamstring (Semitendinosus, Semimembranosus, Biceps femoris) and Gracilis muscle-tendon volumes with limited bias and limits of agreement when compared to MRI. In addition, a good test-retest reliability was observed for muscle and tendon volumes. These results provide opportunities for this technique to be used to assess hamstring volume (and adaptations) in exercise training and clinical settings. For that purpose, the effects of a 9-week muscular strengthening program on muscular and tendinous volume are set to be evaluated by this method. Preliminary results would be presented at the congress.
1. Konrath et al., 2016 2. Barber et al., 2009

## Conventional Print Poster

### CP-AP09 Monitoring water and ice sports

### TOWARDS A PHYSIOLOGICAL AND PHYSICAL MODEL OF SPRINT KAYAKING; A CURRENT REVIEW OF LITERATURE

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INTRODUCTION: In sprint kayaking, a tenth of a second can separate those who win a medal (e.g. male 200m finals at the 2020 Olympics). Therefore, practitioners need a comprehensive understanding of the variables which influence sprint kayaking performance (e.g. physiological and physical characteristics). Although studies have investigated how physiological and physical attributes may influence sprint kayaking performance, there is currently no review study conducted to draw the literature together. The aim of this study was to critically review the physiological and physical determinants of sprint kayaking performance. A secondary aim was to inform future research and provide guidelines for practitioners.
METHODS: The studies included for review were gathered according to the Preferred Reporting Items for Systematic reviews and Meta-analyses (PRISMA) guidelines (Page et al., 20211). After initial searches, twenty-five studies were included that met the inclusion criteria. In brief, these were observational studies that sought to examine the relationship between various types of physiological or physical variables and sprint kayak performance.
RESULTS: The relationship between VO2max/peak (200m r range = -0.71 to -0.86; 500m r range = -0.22 to -0.82; 1000m r range = -0.21 to -0.90) and anaerobic threshold (200m r range = -0.54 to -0.74; 500m r range = -0.52 to -0.89; 1000m r range = -0.71 to -0.83) with race performance is stronger as the race distance increased. However, the relationship between peak power, anaerobic capacity and aerobic threshold to race distance was unclear, and did not show an obvious trend. There is a plethora of literature (n = 11 studies) suggesting the importance of both upper-body pulling and pushing strength in improving sprint kayak performance and kayak ergometer power output. However, the literature concerning the relationship between lower body strength and sprint kayak performance is lacking.
CONCLUSION: The current literatures suggests that VO2max/peak and anaerobic threshold supports sprint kayak performance. Moreover, sprint kayakers should increase upper-body pulling and pushing strength and power to support their performance. Currently, the data regarding peak power, anaerobic capacity, aerobic threshold and the relationship between lower body strength on sprint kayak performance is unclear. Therefore, future studies should look to do this; in particular, work surrounding lactate threshold, transition from heavy-severe domain which is particularly lacking currently.

**EFFECTS OF AN OFFSHORE SAILING COMPETITION ON ANTHROPOMETRY, MUSCULAR PERFORMANCE, SUBJECTIVE WELLNESS AND SALIVARY CORTISOL IN PROFESSIONAL SAILORS.**

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INTRODUCTION: Evidence regarding the impact of offshore sailing on fatigue and readiness variables is conspicuous by its absence. This study investigated the acute effects of an offshore sailing regatta on anthropometry, muscular performance, subjective recovery and salivary biomarker cortisol.
METHODS: Ten professional offshore sailors from a mixed-sex crew partook in the study (n = 10; mean ± SD; age = 32.2 ± 3.96 years; stature = 179.1 ± 7.30 cm; body mass = 84.2 ± 12.1 kg). The race involved three offshore legs over a 3-week period. Baseline measures of anthropometry, lower- and upper body muscular function, perceptions of subjective wellness and salivary cortisol were assessed 3-hours prior to competition (i.e., before the first leg). These measures were repeated within 30-min after the cessation of each event leg. During each leg, boat movements were recorded via global positioning system units.
RESULTS: There were significant reductions in lower- (ES = 0.49) and upper muscular (ES = 0.21) functions as well as in subjective wellness (ES = 1.65). Salivary cortisol levels increased (ES = 0.84).
CONCLUSION: These results demonstrate that, during an intensified period of sailing competition, fatigue will progressively increase. This may impede sailing performance by reducing physical and cognitive efficiency. Furthermore, counter movement jump, handgrip strength, perception of subjective wellness and cortisol concentration appear to be sensitive measures for monitoring fatigue and readiness in professional sailors.

**EVOLUTION OF THE BODY POSTURE IN ELITE PARA SWIMMERS AS THE EFFECT OF BODY'S EXTRINSIC ADAPTATION TO SPORT-SPECIFIC TRAINING**

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INTRODUCTION: The dynamic development of the professional Paralympic sport has raised the need to progressively improve competitiveness. As athletes cannot influence individual genetic predisposition, physiological adaptations seem to be a key factor that can improve athletic performance. The human body always strives to maintain the state of equilibrium and, for this purpose, it activates compensatory yet not always beneficial compensatory mechanisms. Two closely related compensatory mechanisms are important in Para athletes: intrinsic (disability) and extrinsic (athletic training) [1-2]. While the intrinsic adaptation strategy is one-sided, the extrinsic adaptation strategy affects the athletes body in two ways, i.e. (a) it can induce new musculoskeletal adaptations, and (b) it can aggravate existing adaptations . The aim of the study was to evaluate the impact of sport-specific training on the body posture of elite para swimmers.
METHODS: The study included 22 male and female elite para swimmers (age: 19.7±4.8, body mass 63.3±10.9, body height: 1.74±0.1) from the Polish national team. The assessment of the body posture was performed with a non-invasive method Medi Mouse (Idiag M360). Spinal curvatures measurements were performed in three different trunk positions in the sagittal and frontal planes and included (a) the evaluation of the current depth and mobility of thoracic and lumbar curvatures and the differences between theirs current and proper physiological values and (b) identification of the sagittal and frontal spinal curvature deviations.
RESULTS: The analysis of the body posture relative to symmetry in the habitual position in the frontal plane show postural asymmetries and a significant tendency to mild left scoliosis in the majority of para swimmers. Moreover, regardless of the disability, lumbar lordosis and pelvic inclination in the sagittal standing were significantly less defined, whereas thoracic kyphosis showed either normal or decreased values. A significant decrease in mobility of the lumbar spine was observed in all three positions, while an increase in mobility was found in hip joints during the movement of flexion and extension.
CONCLUSION: Significant deviations both in frontal and anteroposterior curvatures of the spine might be associated with body's extrinsic adaptation to swimming training. Elite level sport-specific training can affect the quality of the body posture rather than the impairment.
1. Gaweł, E., & Zwierzchowska, A. (2021). Effect of Compensatory Mechanisms on Postural Disturbances and Musculoskeletal Pain in Elite Sitting Volleyball Players: Preparation of a Compensatory Intervention. International journal of environmental research and public health, 18(19), 10105. https://doi.org/10.3390/ijerph181910105
2. Zwierzchowska, A., Gawel, E., Celebanska, D., Mostowik, A., & Krzysztofik, M. (2022) The Impact of Internal Compensatory Mechanisms on Musculoskeletal Pain
in Elite Polish Sitting Volleyball Players – A Preliminary Study. Journal of Human

**A GLIMPSE OF THE DEVELOPMENTAL PATHWAY TO ELITE LEVEL SWIMMING – A MULTIDIMENSIONAL AND LONGITUDINAL ANALYSIS OF YOUTH SWIMMERS**

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INTRODUCTION: A thorough understanding of performance development and its underlying performance characteristics during an swimmers' career could facilitate the identification and development of talented swimmers. However, longitudinal studies on multidimensional performance characteristics in talented youth swimmers are scarce. Therefore, the aim of the present study is examine the development of anthropometric, physiological, technical and psychological characteristics in relation to performance level of talented youth swimmers over a 3-year period.
METHODS: We collected data on multidimensional performance characteristics and 100m freestyle swim performance of 207 talented youth swimmers (102 males, 14.9 ± 1.3 years; 105 females, 14.2 ± 1.3 years) over 3 competitive seasons between 2017 and 2020. Based on their season best performances, swimmers were assigned to the high performance level or lower performance level group. Multilevel models were created in which repeated measures (level 1) were nested within individual swimmers (level 2). The effect of the fixed variables age and current performance level on anthropometrics (body height and weight), physiological (sprint velocity and counter movement jump height), technical (stroke frequency, stroke length and stroke index) and psychological (self-regulation of learning) characteristics was tested for significance ($p<0.05$) for males and females separately.
RESULTS: Older male and female swimmers scored higher on anthropometric, physiological, technical and psychological characteristics. High-performing male and female swimmers scored higher on physiological (sprint velocity and CMJ) and psychological (reflection) charac-

teristics compared to lower-performing swimmers. High-performing males were taller and heavier than their peers whereas high-performing females outperformed their peers on technical characteristics (stroke index).
CONCLUSION: The present study emphasizes the importance of a multidimensional and longitudinal approach in talent identification and development, reporting that high-performing youth swimmers scored higher on multiple underlying performance characteristics over a 3-year period compared to their peers. Therefore, in the guidance of young talented swimmers to the top as well as in the detection of talented swimmers, more attention has to be paid to the development of anthropometrical, physiological , technical and psychological characteristics.

### RELATIVE AGE EFFECTS ON FRENCH SWIMMERS' PERFORMANCES

DIFERNAND, A., DE LAROCHELAMBERT, Q., PLA, R., ANTERO, J., TOUSSAINT, J.F., SEDEAUD, A.

*FRENCH INSTITUTE OF SPORT*

INTRODUCTION: This study aimed to identify a Relative Age Effect (RAE) among French swimmers and apply corrective adjustment procedures to better consider performance level in each category and event.
METHODS: 5,339,351 performances of French swimmers aged 10 to 18 were collected between 2000 and 2019. Birth quarters distribution was examined according to level of performance and event within each age category. A linear relationship between performance means and months within a same category provides a rebalancing coefficient allowing to rebalance the performance by considering the effect of RAE.
RESULTS: Proportion of swimmers born in the first quarter was higher than the proportion of born in the last quarter for all events and strokes ($p < 0.01$). RAE increases with the performance level. For example, in 50m Freestyle, proportion of swimmers born in the last quarter significantly decreases: 20.12% and 10.35% vs 30.61% and 46.55% in the first quarter respectively for 'All' and 'Top10%' of U13 (p-value < 0.01). Among U11 swimmers, in average, each month represents a 0.416 second gap, if interpreted in a year, it can be up to almost 5 seconds gap.
CONCLUSION: Once the rebalancing method applied, no significant differences were found between rebalanced performances and the original ones (excepted for U13). We proposed a new method to better consider a performance depending on the swimmer's birthdate for each age category and event.

### WORD CUP AND OLYMPIC GAMES ANALYSIS OF 3M AND 10M DIVING

BRATTA, C., DEMARIE, S., CORTIS, C.

*UNIVERSITY OF CASSINO AND LAZIO MERIDIONALE*

INTRODUCTION: Sex differences in world ranked performance has been suggested to follow a diminishing trend that could lead women to reach men's results, particularly in longer events (reference 1). The same trend has not been consistently reported either for short and middle-distance events, or for technical disciplines (references 2,3). Performance trend analysis could be useful to plan athlete's careers and to discriminate between men and women developmental patterns. The aim of this study was to analyze the trend of the differences in performances between male (M) and female (F) athletes in Olympic Games (OL) and World Cup (WC) from Sydney 2000 to Tokyo 2020 in 3m springboard and 10 m platform diving.
METHODS: Diving competition results were collected from the FINA official web site (reference 4). For the female (F) and male (M) medalists (OL: F=18, M=18; WC: F=15, M=15) of each event Degrees of Difficulty (DD mean, sum, and peak values), age (3m: F=24.4±0.6yrs, M=23.1±0.2yrs; 10m: F=20.1±0.6yrs, M=21.6±0.1yrs) and Total Points (TP) were analyzed. The trends of the differences between male and female were assessed as percentage (%) and slope of the regression line of the results over time (y).
RESULTS: Sex differences in 3m DD values continuously increased, particularly in Olympics (DDm from 0.16 to 0.55; DDs from 4.00 to 6.30; DDp from 0.33 to 0.77 with a peak in 2012), while the slope of differences over time in TP decreased in gold medalists (y=-4,2419) and followed a nonlinear trend in silver (y=0,1292) and bronze medalists (y=0,0121). In 10m divers the differences between men and women increased for DD mean (Gold y=0,0095; Silver y=0,0194; Bronze y=0,006) and peak (Gold y=0,0084; Silver y=0,0193; Bronze y=0,0193), while DD sum (Gold y=-0,0155; Silver y=0,102; Bronze y=0,0015) and TP (Gold y=-0,0774; Silver y=-0,5683; Bronze y=1,0428) did not show consistent trends. Age differences between sex decreased in 3m (Gold y=-0,0286; Silver y=-0,4321; Bronze y=-0,2036) and increased in 10m (Gold y=0,3036; Silver y=0,2536; Bronze y=0,179).
CONCLUSION: Sex differences in DD tends to widen, suggesting that men technical abilities develop faster than women's. The differences in TP does not present consistent trend, suggesting that the rise in DD did not guarantee men's better results. This relatively stable differences between men and women performances agrees with the trend of short and middle-distance sports (references 1,2,3). In 3m springboard diving, where more muscular power is requested, age of both sexes rises over time. In 10m platform, where more technical abilities are demanded, men's age increases while women's decreases. This could indicate that man relies more on muscular power, while women can also rely on fast rotational velocity.
1. Knechtle et al. Int J Environ Res Pub Health, 2020,17(10):3651
2. Demarie et al. Int J Environ Res Pub Health, 2022,19:2110
3. Sandbakk et al. Int J Sports Physiol Perform, 2018,13(1):2-8
4. FINA Official Website - www.fina.org

### DROWNING PREVENTION FROM JAPANESE COLLEGE SWIMMING EDUCATION

TORIUMI, T.

*KEIO UNIVERSITY*

Reasons for drowning are most commonly associated with failure to stay afloat or swim to safety. Some evidence suggests that victims drown because they cannot exit the water upon reaching the water's edge.
The purpose of this paper is to explore the real and perceived capacity of young adults to safely exit the water and ascertain what safety knowledge about exiting the water is promoted.
College-aged non-sports Japanese students (N = 62) completed a pretest survey of self-estimated capacity to exit the water under varied conditions. Participants were then tested in shallow water, deep water (flush edge), and deep water with a ledge (0.30 m) when fresh, after a 5-min swim in swimwear, in clothing, and while wearing a buoyancy vest.

Participants were Japanese young adults (N = 62) with a proven swimming capacity who were enrolled in an undergraduate Bachelor of non-Sports degree programs. Of these, 40 were male (64%) and 22 were female (36%), 80% were 19–20 years of age, 17% were 21–22 years of age, and the remaining 3% were 23 years and older. Before the commencement of an aquatics education program that focused on water safety, participants completed a pretest survey that was designed to provide a measure of self-estimated water competency and estimates of their capacity to exit the water under various conditions. Practical testing of exit skills was completed during 1.5 hr aquatics sessions/1 times per week over a 3-week period during the summer term (April–July 2021) in an indoor 50 m pool (water temperature 25 °C). Appropriate lifeguard supervision and safety equipment were available at all times. Ethics clearance for the study was obtained from Keio University Ethics Committee.
All data from the completed questionnaires were double entered into Microsoft Excel and data were transferred to SPSS version 24 for statistical analysis. Descriptive statistics expressed as frequencies and percentages were used to describe or characterize all numerical variables. These included four independent variables (gender, age, ethnicity, and self-estimated swimming competency) and four dependent variables related to previous experience, knowledge, perceptions of exiting task difficulty, and actual exiting competency. Chi-square tests of independence were used to test associations between the frequencies of the influences of age, gender, and ethnicity against the perceived and actual exertion required to perform the exiting tasks.
All participants were able to exit shallow and deep water when not fatigued, after a swim when wearing clothing or a buoyancy vest, but many failed to exit deep water over a 0.30 m ledge after swimming in clothing or in a buoyancy vest. Significantly more females than males found exiting deep water difficult. Most participants (especially males) underestimated the demands of exiting deep water. The value of situational learning via exposure to exiting difficulties in simulated pool practices is discussed.

**A MULTIDISCIPLINARY APPROACH OF A 100M BACKSTROKE SOUTH AMERICAN YOUTH CHAMPIONSCHIP RECORDIST**

LARA, J.P.R., JOAQUIM, D.P., SILVA, G.V., SILVA, R.R., COSTA, C.M., PAIXÃO, D.M., VANZELLA, F.A., ABAD, C.C.C.
*REFERENCE CENTER IN SPORTS SCIENCE -SESI SP*

INTRODUCTION: One way to understand better sport performance is analyzing well-succeeded athletes. The aim of this study was to describe a multidisciplinary profile of a female young athlete who broke the 100m backstroke South American record (time = 01:02.29s).
METHODS: A junior swimming female athlete was submitted to the 10s threatened swimming test, three vertical jumping tests, Brunel Mood Scale test (BRUMS), anthropometrical and body composition measurements, multi joint range of motion, a maximal muscle strength (1-RM) for bench press, half squat and strict pull-up exercises. All tests were obtained in three experimental sessions interspersed from 24 to 48 hours, one week before the South American Youth Championship of swimming, in 2021. A logarithmic scale was applied to the variables so that a measurement unit does not interfere in the interpretation of results. The profile of the multidisciplinary athlete was drawn using the radar chart.
RESULTS: The mean and the peak force during the threatened swimming were 92.4N and 182.2N, respectively. The high vertical jumping was 32.1cm, 35.2cm, and 46.2cm for the squat jump, countermovement jump and Abalakov test, respectively. The BRUMS scale presented values of 43,45,45,62,51 and 42 points for tension, depression, race, vigor, fatigue and confusion, respectively. The sum of seven skinfolds, as proposed by ISAK, of athlete was 84.5mm; Body mass=58.3Kg, body height=1.68m; lean mass index=30.16; body fat=14.6%; and arm-span=1.73m. The 1-RM was 53Kg for bench press, 86Kg half squat, and 62.3Kg for barbell. The respective right and left range of motion was 38.3° and 40° for shoulder internal rotation; 130° and 116° for shoulder external rotation; 5° and 12° for dorsi-flexors; 70° and 70° for plantar flexors; and 6.9° and 7.5° for knee hyperextension.
CONCLUSION: The profile described in the present study is a tool for helping coaches and sports professionals to understand the variables fluctuations across the next seasons and to make better decision concerning the long-term training process during the athlete's career. Finally, this result may be used for comparison with other top elite athletes aiming to reach the best perform.

**THE ESTABLISHMENT OF THE EVALUATION INDEX SYSTEM FOR THE SLIDING EXPERIENCE OF BOBSLEIGH AND SKELETON IN GENERAL POPULATION BASED ON DELPHI METHOD**

ANQI, L., WANG, D.
*SHANGHAI UNIVERSITY OF SPORT*

INTRODUCTION: Although Chinese skeleton team won a bronze medal in the 2022 Winter Olympic Games, Bobsleigh and skeleton is still under development in China. Therefore, it is vital to promote this sport in general population for the greater involvement of this sport. The objective of this study was to establish the evaluation index system for the sliding experience of bobsleigh and skeleton based on Delphi method.
METHODS: This study used a three-round Delphi survey to reach a consensus from fifteen experts who engage in bobsleigh and skeleton. The inclusion criteria of the experts were: 1) engaged in bobsleigh and skeleton research, 2) obtained a exercise physiology Ph.D. degree, 3) national bobsleigh and skeleton athletes, 4) national team staff of bobsleigh and skeleton. The survey included four main indicators, exercise physiology indicators, sports biochemical indicators, kinematic indicators, and subjective feelings. The second and third round of survey were adjusted based on the qualitative and quantitative analysis from the previous round of feedback. The indicators' inclusion and deletion were according to 70% concentration of the experts opinions. Data were analyzed by calculating experts authority coefficient (Cr), experts opinion coordination, and indicators coefficient of variation (CV%). The calculation of each indicator's weight was (Wi) via (Analytic hierarchy process, AHP).
RESULTS: Twenty items achieved consensus and were included in the evaluation index system for the sliding experience of bobsleigh and skeleton in general population. The index system is composed of one primary indicator (evaluation indicator of bobsleigh and skeleton sliding experience), four secondary indicators (exercise physiology indicators, sports biochemical indicators, kinematic indicators, subjective feelings), and twenty tertiary indicators (heart rate, blood pressure, respiration rate; testosterone, cortisol, epinephrine, norepinephrine and dopamine, nitric oxide, leptin, blood urea; speed, acceleration speed ； displacement, fear, emotional changes, excitement, boredom, pressure release, desire to repeat experience, and understanding of the sport). The experts authority coefficient Cr=0.84, experts opinion coordination 0.292 ($\chi 2=80.318, P<0.001$), exercise physiology indicators (CV% = 16.7,Wi = 0.1210), sports biochemical indicators (CV% = 23.6,Wi = 0.0391), kinematic indicators (CV% = 24.6%, Wi = 0.1796), subjective feelings (CV% = 21.3%,Wi = 0.6603).
CONCLUSION: Four main indicators were included in the evaluation index system for the sliding experience of bobsleigh and skeleton: exercise physiology indicators, sports biochemical indicators, kinematic indicators, and subjective feelings.

# Thursday, September 1, 2022

## 08:00 - 09:15

### Oral presentations

#### OP-PN19 Amino acids and proteins II

**EFFECTS OF PRE- AND POST-WORKOUT ENERGY BAR SUPPLEMENTATION ON BLOOD LACTATE AND FITNESS IN TRAINED CROSSFIT INDIVIDUALS: A RANDOMIZED CROSSOVER STUDY**

LIM, B.G.

*SEOUL NATIONAL UNIVERSITY*

INTRODUCTION: The energy bar supplementations continue to gain popularity among recreationally-active people. It is apparent that intaking of proper nutrition dose indeed affect the adaptive response to exercise but it is unknown if there is a difference between consumption timing of supplement and nutrient combination. The pre- and post-workout supplementation has their own strength, combining these benefits may have a positive impact on fitness and fatigue although research is lacking in regards to these two supplementations as a pair. The purpose of this study was to investigate the effect of pre- and post-workout supplementation on changes in fitness and blood lactate level in trained CrossFit individuals.
METHODS: In this randomized cross-over study, 20 trained CrossFit individuals (11 males, 9 females) performed CrossFit workouts (squat, clean & jerk and etc.) with pre- and post-workout supplementation. Subjects completed workouts three times per week, 60 min/day for 3 weeks with 1-week washout period. All subjects had been participating in at least three CrossFit classes per week for one year. Subjects were randomly assigned into one of two groups: chocolate bar (CH, 45g, 225kcal) or an energy bar group (ES: containing protein, caffeine, taurine, and branched-chain amino acids (BCAA), 48g, 238kcal). Subjects received 2 pieces of chocolate bar or energy bar at 5 minutes before and immediately after workout for 1 week. Following a washout period of no supplements, subjects received the alternate supplement (either chocolate bar or energy bar) for another 1 week. Blood lactate level and visual analog scale (VAS) were assessed before, immediately and 30 min after workout. And fitness tests (hand grip, broad jump and sit up) were conducted at baseline and 30 min after last workout. Data were analyzed by two-way repeated measures ANOVA ($p<.05$), 95% confidence intervals, and magnitude inferences.
RESULTS: Hand grip strength ($p<.001$, 5.6%), broad jump ($p<.05$, 2.7%) and sit up ($p<.001$, 13%) were significantly increased in the ES group. Compared to CH group, there was a significant time × group interactions for blood lactate level (F 4.9; $p=.02$) in the ES group, however, VAS did not reach significance. Blood lactate level at 30min postexercise was decreased to 7.31 mmol/L, reaching a baseline level in the ES group.
CONCLUSION: Additional ingredients in the energy bar included the BCAA, taurine and caffeine. The combination of BCAA, taurine and caffeine may effectively impact on muscle contraction and lactate clearance. These results confirm previous studies that caffeine can effectively increase anaerobic power and training volume and taurine develops energy production and general resistance to fatigue. Pre- and post-workout energy bar supplementation may have a beneficial effect on blood lactate clearance and fitness in trained CrossFit individual. The combination of proprietary supplements taken may provide benefits for removing the blood lactate during high-intensity functional exercise.

**A HIGH-PROTEIN VEGAN DIET IMPROVES BLOOD-BORNE INDICES OF CARDIOMETABOLIC HEALTH BUT DOES NOT ALTER MICRONUTRIENT STATUS COMPARED WITH AN ISONITROGENOUS OMNIVOROUS DIET DURING RESISTANCE TRAINING.**

VAN DER HEIJDEN, I., WEST, S., MONTEYNE, A.J., COELHO, M.O.C., FINNIGAN, T.J.A., STEPHENS, F.B., WALL, B.T.

*UNIVERSITY OF EXETER*

INTRODUCTION: A hypercaloric high animal protein diet is often advocated to meet increased macro- and micro- nutrient demands for optimal resistance training induced adaptations; though such diets are also associated with impairments in cardiometabolic health. Equivalent resistance-training induced increases in skeletal muscle mass and strength can be achieved consuming high-protein vegan diets which have also been used to improve markers of cardiometabolic health. Vegan diets, however, are potentially lower in key micronutrients required for optimal health and adaptation during prolonged training. In the current retrospective analysis, we investigated whether a hypercaloric, high-protein vegan diet consumed during high-volume resistance-training modulates blood-borne indices of cardiometabolic health or micronutrient status compared with an isonitrogenous omnivorous control diet.
METHODS: Twenty-two healthy young adults (age: 24±1 y, BMI: 23±1 kg·m2) undertook a 10-week progressive resistance training program (5-days/week), while following a high-protein (2 g·kg bm-1·day-1), hypercaloric (~10% daily energy surplus) omnivorous (OMNI: n=12; m=6, f=6) or mycoprotein-rich vegan (VEG: n=10; m=5, f=5) diet. Fasting venous blood samples were collected weekly to assess circulating glucose, insulin, micronutrient and lipid (using quantitative and targeted NMR-based metabonomics) statuses. Two-way repeated measures ANOVAs were performed to detect differences in each parameter. A false discovery rate of 0.276 was applied for metabonomics analyses.
RESULTS: Fasting plasma glucose concentrations remained unaltered, but serum insulin concentrations increased during training in OMNI only (from pre of 12±1 to post of 14±1 mU·L-1) resulting in an increased HOMA-IR index in OMNI (from pre of 2.4±0.2 to post of 2.9±0.2; $P<0.05$) but not VEG (from pre of 2.3±0.1 to post of 2.2±0.1; $P>0.05$). Out of 165 lipid targets, 5 differentially changed between groups throughout training ($P<0.05$). Large lipid classes (e.g. total cholesterol, triglycerides, phospholipids and fatty acids) did not change throughout training, but were higher in OMNI compared with VEG ($P<0.05$). Fasting serum ferritin concentrations decreased throughout training equivalently in both groups (OMNI: from pre of 54±14 to post of 38±9 µg·L-1, VEG: from pre of 73+31 to post of 52±20 µg·L-1, $P<0.05$) while serum vitamin B12, vitamin D and calcium concentrations did not change.

CONCLUSION: A hypercaloric and high-protein, mycoprotein rich, vegan diet can be followed during high-volume resistance-training to positively influence markers of cardiometabolic health without compromising micronutrient status when compared with a more traditional omnivorous dietary strategy.

### NO DIFFERENCES BETWEEN A NOVEL PLANT-BASED PROTEIN VS. WHEY PROTEIN ON BODY COMPOSITION AND PERFORMANCE OF PROFESSIONAL AND SEMI-PROFESSIONAL FUTSAL PLAYERS

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INTRODUCTION: Futsal is a demanding team sport that involves strenuous high-intensity bouts of running accelerations and decelerations along with kicking, tackling, turning, changes of direction and repeated sprinting; these demands require high strength and power of the lower limbs. Additionally, like other small-sided games, futsal requires a high level of aerobic capacity (VO2max 55.2 to 62.8 mL.kg-1.min-1).
Evidence indicates that protein supplementation enhances muscle strength and hypertrophy, while it may also play a role in muscle repair and recovery from endurance exercise, and further improve VO2max. However, to our knowledge no study has investigated the effects of protein supplementation in futsal players.
The purpose of this study was to compare the effects of a novel plant-based protein matrix and whey protein supplementation on body composition, power, and aerobic performance in trained futsal players. Given that both protein sources provided identical amounts of protein and essential amino acids, we hypothesized that changes would be similar between conditions.
METHODS: Fifty young (18-35 y) male futsal players from national level futsal clubs volunteered to participate in this 8-week study; forty participants completed the investigation. Participants were randomly assigned to one of two groups: novel plant-based protein (PB) or whey protein (WP). The final sample was comprised of both professional and semi-professional players. Players were assessed for weight (kg), height (cm) and whole-body composition [lean body mass (LBM, kg), absolute and percentage fat mass (FM, kg and %)] using Dual energy X-ray absorptiometry (DXA) according to the procedures recommended by the manufacturer.
Anaerobic power was assessed via a supramaximal cycling test – Wingate, performed on a cycle ergometer. Participants were instructed to cycle as fast as possible against a predetermined resistance (7.5% of the participant's body mass) for 30 s.
Aerobic performance was assessed via VO2max determined by a breath-by-breath gas analyzer in an incremental treadmill test. After a 3-minute warm-up at 5 km·h-1, participants began the test at 6 km·h-1 and 2% grade. Each minute the speed increased 1 km·h-1 until volitional exhaustion so that fatigue would be induced within 8-12 minutes.
RESULTS: No time or time*group interactions were observed in any of the studied variables ($p>0.05$) with only a time effect being observed regarding a FM reduction ($p<0.05$).
CONCLUSION: Our results are consistent with some, but not all studies comparing whey protein with plant-based proteins. Methodological and protein matrix differences may account for these discrepancies between studies. Our findings suggest that whey protein does not possess any unique anabolic properties over and above those of plant-based proteins when equated for the essential amino acid profile.

### BONE AND MUSCLE PROPERTIES IN HABITUAL MEAT EATERS COMPARED TO NON-MEAT EATERS: AN OMNIPLANT PILOT STUDY

PAGE, J.1, STEBBINGS, G.K.2, MURPHY, C.H.3, KILDUFF, L.P.1, WALDRON, M.1, HEFFERNAN, S.M.1

*1. SWANSEA UNIVERSITY, 2. MANCHESTER METROPOLITAN UNIVERSITY, 3. UNIVERSITY COLLEGE DUBLIN*

INTRODUCTION: Dietary patterns excluding meat consumption are becoming increasingly popular in both public and athletic populations [1]. To date, few studies have compared skeletal muscle health and performance in meat eaters (MEs) and non-meat eaters (NMEs). Early work suggests muscle size and maximal strength in recreationally active male NMEs is comparable to that of ME [2]. Further, NMEs have been shown to have lower bone mineral density (BMD) and a greater risk of fracture compared with MEs [3]; however, other studies suggest there are no differences in BMD between these diet groups [4]. The aim of this study was to use preliminary data, from the OMnivorous and Non-meat eater Integrative Physiology and NutriTion (OMNIPLaNT) study, to compare markers of bone and skeletal muscle health between MEs and NMEs (i.e. vegans and vegetarians).
METHODS: Forty-five participants were recruited, in a cross-sectional observational design, having followed their chosen dietary pattern for > two years (NMEs=6.2±5.1 years). Dietary patterns were self-reported, confirmed using three-day weighed food diaries and a food frequency questionnaire. Men (n=23 [MEs=17], age=29±10 years, height=1.79±0.08m, body mass=81.1±16.0kg) and women (n=22, [MEs=9], age=37±14 years, height=1.67±0.04m, body mass=66.3±11.8kg) were analysed separately. Dual-energy X-ray absorptiometry was used to assess whole body composition and right femoral neck (FN) bone mineral density (BMD). Muscle function was determined via hand grip strength, and vastus lateralis (VL) muscle thickness, anatomical cross-sectional area (ACSA), physiological cross-sectional area (PCSA) and muscle volume were determined using B-mode ultrasonography. Muscle quality was assessed as ultrasound-derived echo intensity of the rectus femoris. Data were analysed using analysis of covariance, controlling for physical activity (quantified via the Baecke questionnaire) and body mass index as appropriate.
RESULTS: There were no differences between MEs and NMEs for any skeletal muscle or anthropometric phenotypes, in either men or women ($P>0.05$). FN BMD was significantly lower in male NMEs compared with MEs (NMEs=0.98±0.13g/cm2 vs MEs=1.32±0.17g/cm2, $P=0.003$), but no differences were observed between groups in women (NMEs=1.01±0.12g/cm2 vs MEs=0.97±0.11g/cm2, $P=0.527$).
CONCLUSION: The current study found no difference between MEs and NMEs for any of the assessed muscle properties (VL thickness, ACSA, PCSA, muscle volume and RF EI) which is in line with existing literature. Similar to some previous findings [3], FN BMD was lower in NMEs, but only in men and not women. Whilst the small sample size is a limitation of the current study, recruitment is ongoing and comparisons between individual plant-based/plant-predominant dietary patterns will be considered in the future.
References
1.Wirnitzer, 2020, Int J Spor Ex Med.; 2.Page et al., 2021, Eur. J. Spor. Sci; 3.Iguacel et al., 2018, Nutr. Rev.; 4.Knurick et al., 2015, Nutrients.

## OP-MH13 Obesity

### MUSCLE QUALITY IN PATIENTS AWAITING BARIATRIC SURGERY: THE EFIBAR PROJECT

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INTRODUCTION: Greater levels of both total and visceral body fat have been found to be associated with lower levels of muscle mass, with the latter being in turn associated with physical performance impairments in individuals with obesity. Muscle quality, defined as the expression of muscle function per unit of muscle mass, is recognized as a prognostic factor to detect individuals at risk of functional incapacity. The aim of this study is to assess the muscle quality index in patients with a high obesity rate (body mass index [BMI] ≥ 35 kg/m2) awaiting bariatric surgery.
METHODS: This cross-sectional study included 80 patients awaiting bariatric surgery (58 women; mean age: 41.1 SD 9.8, mean BMI: 47.1 SD 6.8). Specific muscle power was calculated as the ratio of sit to stand power [W] (based on the 30-s chair stand test) and skeletal muscle mass (bioelectrical impedance analysis) [kg]. Specific muscle strength was calculated as the ratio between handgrip strength [kg] and skeletal muscle mass [kg]. Muscle quality was individually categorized as normal, low, or poor based on the sex and age-specific (categorized as young adults [18-44 years] and middle-aged/older adults [45-74 years]) cut-off values according to the criteria provided by Barbat-Artigas.
RESULTS: Our results show a very high prevalence of normal muscle quality (84.4%) among our participants. In middle aged adults (>44 years old) there was a significant difference in muscle quality index between men and women (p=0.049). Middle-aged men had more specific strength (p=0.002) and power (p<0.005) than middle-aged women. However, in the younger group there were any differences. Regardless of age and BMI, men presented a higher skeletal muscle mass and strength than women.
CONCLUSION: Most of our sample presented a normal muscle quality index contrary to previous findings. This difference could be due to our sample being comprised of mostly young women and the different formulas used to obtain specific power which is the most important variable when categorizing for muscle quality. Future research studies should study the role of physical activity and body fat mass in the muscle quality index of this population.

### EFFECTS OF HIGH INTENSITY INTERVAL TRAINING (HIIT) AND MODERATE INTENSITY CONTINUOUS TRAINING (MICT) ON METABOLIC AND INFLAMMATORY MARKERS IN OBESE YOUNG WOMEN

LOPES, W.A., MENDES, V.H.S., SIMÕES, C.F., OLIVEIRA, G.H., RECK, H.B., LOCATELI, J.C., COSTA, C.E., OKAWA, R.T.P.

*STATE UNIVERSITY OF MARINGA*

INTRODUCTION: Obesity is characterized by the excessive accumulation of body fat, being considered a global pandemic and a risk factor for cardiovascular diseases [1]. Excess adiposity can lead to low-grade chronic inflammation which has been considered the link between obesity and other comorbidities [1]. Both high intensity interval training (HIIT) has been and moderate intensity continuous training (MICT) have been showing similar results in reducing body mass, body fat and visceral fat [2]. However, the effects of HIIT or MICT on metabolic and inflammatory markers have not yet been clarified [3]. Therefore, we investigated the effects of HIIT and MICT on metabolic and inflammatory markers in young obese women.
METHODS: Twenty-five obese women (28.4±4.8 years) with obesity were randomized to receive 8 weeks of HIIT (4 bouts of 4 min at 85% and 95% of HRmax alternated by 3 min of active recovery at 65% and 75% of HRmax) or MICT (41 min at 65 and 75% of HRmax). Body composition, cardiorespiratory fitness, insulin resistance (HOMA-IR), glycosylated haemoglobin (HbA1c) and levels of C-reactive protein (CRP), interleukin-10 (IL-10), tumoral necrose factor-α (TNF-α) were evaluated before and after intervention. ANOVA for repeated measure was used to analyze of the data.
RESULTS: Both training modalities reduced HbA1c (HIIT: Δ=-0.12±0.16 %, p=0.008 and MICT: Δ=-0.10±0.12 %, p=0.009). Only MICT reduced CRP (-0.36±0.16 mg/L, p=0.042). There were no significant changes in insulin resistance and other inflammatory markers measured. In terms of body composition and cardiorespiratory fitness, only HIIT significantly reduced body mass (Δ=-1.95±0.54 kg, p=0.002), body mass index (Δ=-0.72±0.20 kg/m², p=0.002), % body fat (Δ=-2.91±0.66 %, p<0.001) and increased peak oxygen consumption (Δ=1.90±0.54 ml/kg/min, p=0.024).
CONCLUSION: Although HIIT is superior in improving body composition and cardiorespiratory fitness in obese women, both training protocols were favorable for improving glycemic control and only MICT improved the inflammatory state associated with obesity.
REFERENCES:
1. Wu, H., Ballantyne, C.M. Metabolic Inflammation and Insulin Resistance in Obesity. Circ Res, 2020. 126(11): p.1549-64.
2. Chang, Y.H, Yang, H.Y, Shun, S.C. Effect of exercise intervention dosage on reducing visceral adipose tissue: a systematic review and network meta-analysis of randomized controlled trials. Int J Obes, 2021. 45(5): p.982-97.
3. Maturana, F.M., et al. Effectiveness of HIIE versus MICT in Improving Cardiometabolic Risk Factors in Health and Disease: A Meta-analysis. Med Sci Sports Exerc, 2021. 53(3): p. 559-73.

### COMPARISON OF MAXIMAL FAT OXIDATION, BODY COMPOSITION AND MAXIMUM OXYGEN CONSUMPTION VALUES AMONG HEALTHY, DIABETIC AND OVERWEIGHT/OBESE WOMEN.

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(co-authors) Orellana Pecino, J., Ávila, L., Ponce-González, J.G., Casals, C. INTRODUCTION: Obesity and type 2 diabetes (T2D) are related to reduced maximal fat oxidation (MFO) (1) which is an important indicator of metabolic flexibility (2). Thus, the aim of this study was to compare MFO values between healthy, diabetic and overweight/obese women.

METHODS: Fifty-two women including 33 healthy women (L) (age: 21,8±2,9; BMI: 21,2±1,7) 13 overweight/obese (OWOB) (age: 28,1±5,9; BMI: 33,7±6,9) and 6 with T2D (DM) (age: 50,5±10,7; BMI: 37,4±4,6) were included in the study. An incremental stress test was performed on a cycloergometer with two consecutive stages. The first stage consisted in 3-min increments of 15-30W depending on the weight of the subject with a cadence of 60-80 rpm until RER ≥1 in order to calculate MFO Once reached, an active rest of 3-5 minutes was taken after which the second stage began with 1-min increments until exhaustion to determine the VO2max. A 1-way ANOVA was used with Bonferroni comparisons.
RESULTS: The MFO relativized by body weight (kg) showed significant differences (p=0.01; p=0.00) between the DM-L and OWOB-L groups as well as when relativized by fat mass. L women had the highest values (mean: 0.053 g/min/kg), followed by OWOB women (mean: 0.032 g/min/kg) and DM group (mean: 0.027 g/min/kg). There were no differences in absolute values.
As for VO2max/kg, there is a significant mean difference in DM-L and L-OWOB (p=0.00) with L women having the highest values (mean: 40.02ml/kg/min), followed by OWOB women (mean: 23.6ml/kg/min) and diabetics with a mean of 17.5ml/kg/min. Otherwise, in absolute values, there is a significant mean difference in DM and L (p=0.012). No statically significant differences in the rest of comparisons.
CONCLUSION: Healthy normal-weight women have higher MFO and VO2max values relative to weight than diabetic and/or obese women. Diabetic women have a significantly lower VO2max than normal-weight women in absolute values.
References:
1.Vittori, L.N, Manners, D. N., Belli, G., Corazza, I., Latessa, P. Maietta. (2015). A RAPID AND AUTOMATED METHOD TO DETERMINE APPROPRIATE EXERCISE PARAMETERS FOR TAILORED SUBSTRATE CONSUMPTION DURING AEROBIC EXERCISE. Journal of Mechanics in Medicine and Biology, 15(2). https://www.worldscientific.com/doi/abs/10.1142/S0219519415400382
2.Perez-Suarez, I. (2022). Maximal Fat Oxidation: Determinant Factors and Metabolic Flexibility. International Journal of Environmental Research and Public Health. https://www.mdpi.com/journal/ijerph/special_issues/Maximal_Fat_Oxidation
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## Oral presentations

### OP-LAG02 Health and Fitness

#### NOT ALL SEDENTARY BEHAVIOURS CONTRIBUTE THE SAME WAY TO ADOLESCENTS COGNITIVE-ACADEMIC PERFORMANCE. THE COGNI-ACTION PROJECT.

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INTRODUCTION: Adolescence is a key life stage for development and engrain healthy behaviours. Today evidence shows that adolescents spend excessive time in sedentary behaviours that could potentially negatively affect cognitive performance and in turn, academic achievement. However, studies report heterogeneous results depending on the sedentary behaviour type analysed. Therefore, this study aimed to establish the multivariate association of different sedentary behaviours with diverse cognitive and academic achievements.
METHODS: A total of 1,296 adolescents (10–14-years-old, 50% girls) from 19 public, subsidized, and private schools of the Valparaiso region (Chile) participated in this study. Sedentary behaviours (n=8) were self reported using two different questionnaires. Cognitive performance was evaluated through eight neurocognitive tasks from the NeuroCognitive Performance Test and the academic achievement was established by asking students their general average of the last semester in language, mathematics, history, English, and science. A canonical analysis was performed to determine the association between the two sets of variables adjusting for sex, school vulnerability, maturation, body mass index, and physical activity. Moreover, the analysis accounts for the random effect of schools.
RESULTS: Our findings show a single and significant mode of covariation related to a set of sedentary behaviours and cognitive-academic achievements (rho = 0.23, p= 0.015). Overall, some adolescents' sedentary behaviours contribute negatively (i.e., sitting at class, watching TV, using cellphone and transport), while others contribute positively (i.e., sitting doing tasks, eating, playing video games, and using computers) to the association with the cognitive-academic mode. The greatest contributions for the sedentary behaviour mode were for sitting doing tasks (rho=0.13), using computers (rho=0.13), and playing video games (rho=0.11), while for the cognitive-academic mode were the processing speed cognitive task (rho = 0.12), history grade (rho = 0.11), language grade (rho = 0.09), and working memory cognitive task (rho = 0.09).
CONCLUSION: Our findings give insights into the differentiated contribution of several sedentary behaviours related to cognitive-academic achievements. Therefore, this study could suggest that not all sedent activities might be associated with detrimental adolescents' cognitive and academic achievements. Educating adolescents to manage the time they spend on seated behaviours seems to be crucial to enhance their performance at the school level.

#### MYOFASCIAL ACTIVATION AT SUSPENSION EXERCISES IN ELDERLY AND YOUNG

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INTRODUCTION: The fascia provides connections between different body structures, transmits tension between different body segments, as well as body balance [1]. Best of our knowledge we don't find researches about anterior myofascial line activation or aging effects on fascial activation. Understand the role of fascia musculoskeletal system in dynamics situations is essential [2]. Purpose: analyse the myofascial activation of superficial back line (SBL) and superficial front line (SFL) on suspension exercises in elderly and compare with young people.
METHODS: Participated 10 elderly (65±0.5 years, 165±14cm, 70.5± 9.1kg), 10 young (22.6±1.3 years, 168±18cm, 64.3±7.2kg), both groups were physically active. The subjects performed 10 cycles, divided with accelerometry, of push-up and pull-up exercises with the suspension training apparatus (like TRX).
Surface EMG with Delsys Trigno (2000Hz), at 12 different regions of myofascial continuity, at SBL: gastrocnemius lateralis (GL), biceps femoris (BF), iliac spine (EIPS), longissimum (LG), T6, splenius head (EC). At SFL: tibialis anterior (TA), rectus femoris (RF), rectus abdominis

inferior (RAI), superioris (RAS), pectoralis major sternum (PM), sternocleidomastoideus (SCM) [3]. Followed SENIAM to processing EMG data. Then RMS values were calculated in the ABS software (Analysis of Biomechanical Signal -LIBiAM). Two-way ANOVA and Tukeys post hoc were used (α=0.05). Ethics Committee approved the protocol.
RESULTS: Elderly: great values at EC (40 ± 9 mV) in SBL; TA (70 ± 10 mV) and ECM (50 ±11 mV) in SFL (p=0.0002) both for the pull-up.
Young: great values for core regions (RF, RAI, RAS, PM) in SFL (p<0.0001) during the push-up exercise.
Comparing exercises, push-up are different for all SFL of younger (p=0.002).
Interestingly, elderly (for SBL and SFL) shows smaller values for all 12 regions compared to young "fascia" group (p=0.01).
CONCLUSION: The myofascial activation was different in the elderly compared to the young. In both SFL and SBL present different behaviors between groups and exercises too. Aging decrease fascia hydration, reduces body balance, stability and probably the efficiency of force transmission [1,2]. Younger has greater activation in the core, possibly reflecting in better force transmission of the SBL and SFL. Postural muscle line, in the elderly, increases the amount of type I collagens [1]. The position of the body can generate changes in the transmission function of the fascial tissues, as seen between exercise variations. So, results suggest different patterns of postural and central regions activation and/or connectivity of the musculoskeletal fascia system for each exercise movement. The interactions between agonist, synergist, antagonist, other adjacent muscles and fascia are active components of the body system to generate movement.
- Supported by CSIC (UdelaR)
REFERENCES
[1] Schleip. Clin Anat, 32:891-95, 2019
[2] Krause et al. J Anat, 228: 910-18, 2016
[3] Vulfsons et al. J BackMuscRehab, 31: 785-93, 2018

**PHYSICAL TRAINING IMPROVES THE SARCOPENIA CRITERIA IN A MICE MODEL OF CHRONIC LIVER DISEASE.**

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INTRODUCTION: Sarcopenia is one of the complications of Chronic Liver Disease (CLD), which affects the quality of life and survival of those who suffer from it, being an independent predictor of mortality. Its diagnosis is based on decreased strength, decreased muscle mass (MM), and impaired physical function (PF). For its treatment, endurance training (ET) and resistance training (RT) a non-pharmacological tool recommended based on their broad benefits. Still, there is no clarity regarding which one is more effective. In sarcopenia due to aging, RT increases MM and strength, but in sarcopenia, due to CLD, it is minimally used. The ET is commonly applied, but it has shown positive effects only on PF in patients with CLD. We, therefore, compare the effects of RT and ET on the sarcopenia criteria in a murine model of CLD.
METHODS: Forty-seven male C57BL/6J mice (20 weeks old) were separated into two groups: chow diet (control) and hepatotoxin 5-diethoxycarbonyl-1,4-dihydrocollidine (DDC) diet (CLD). Then, the animals were randomly subdivided into 1 sedentary group (SED) and exercise groups (ET and RT). Physical training was performed for 6 weeks at moderate intensity. In vivo muscle strength (MS) was assessed (Grip Strength (GF/tibia length (mm))). MM was assessed ex vivo by muscle weight (mg/ tibia length (mm))). PF was assessed by maximal running capacity on a treadmill (meters (m)). Muscle fiber's diameter was determined in cryosections (10 µm) of the TA and Soleus (SOL) stained with WGA and quantified in Image J software. Data are presented as mean ± standard deviation. Differences between groups were determined with 2-way ANOVA and Tukeys post hoc test. p= 0.05. 95% confidence interval. Approval of the Universidad Andrés Bello Bioethics Committee 015/2019.
RESULTS: RT, but not ET, prevents MS loss induced by CLD in the hind legs [RT-CLD: 8.61±1.53 GF/mm vs. SED-CLD: 6.65±0.68 GF/mm, p=0.01]. Depending on the muscle type, the decrease in MM induced by CLD is prevented by the RT and/or ET [TA: RT-CLD: 3.06±0.51 mg/mm vs SED-CLD: 2.54±0.19mg/mm; p=0.04], [Extensor digitorum longus (EDL): RT-CLD: 0.73±0.08mg/mm vs SED-CLD: 0.51±0.07mg/mm; p=0.02], [SOL: ET-CLD:0.66±0.21 mg/mm vs SED-CLD: 0.49±0.09 mg/mm; p=0.04] and [Gastrocnemius (GA) ET-CLD: 8.31±2.41mg/mm and RT-CLD: 7.91±1.27 mg/mm vs SED-CLD: 6.36±1.64 mg/mm; p<0.05]. The alteration of the PF induced by CLD is prevented by the ET [ET-CLD: 191.77±71.07 m vs. SED-CLD: 46.70±28.88 m; p<0.0001], but not by RT. Quantification of the Feret's diameter revealed TA and SOL tissue from SED-CLD has a distribution curve with a peak of 31–35µm, whereas the fibers' size distribution from ET-CLD and RT-CLD was displaced to the right with a peak in the range of 36–40 µm.
CONCLUSION: During CLD, RT prevents the loss of MS and the MM but not the PF. ET prevents PF and MM loss, but not strength. The results suggest that combined training could improve all parameters of sarcopenia secondary to CLD.

## Invited symposia

### IS-AP04 Combat sports performance optimization: physiology, testing and rapid weight loss

**COMBAT SPORTS PHYSIOLOGY**

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Understanding the physiological response to the most common training modalities and competition of combat sports athletes may help to improve the prescription and monitoring of training programs. The focus of this presentation will be on the Olympic combat sports: boxing, fencing, karate, judo, taekwondo, and wrestling. Studies reporting estimates of energy systems contributions, physiological (e.g., oxygen consumption, heart rate) and metabolic (e.g., blood lactate) responses for striking (boxing, karate, and taekwondo), grappling (judo and wrestling), and arm-based (fencing) combat sports during simulated and official competition will be presented. Based on the evidence presented, specific manipulation of effort: pause ratio, total session duration, number, and duration of individual sets for combat sports-specific exercise modalities will be suggested; with the overarching aim to provide evidenced-based suggestions for appropriate training protocols.

### WEIGHT LOSS IN COMBAT SPORTS: PREVALENCE, MAGNITUDE, METHODS, PHYSIOLOGICAL AND PERFORMANCE RESPONSES

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Combat sports athletes are normally classified according to their body mass at competitions in what has been denominated as weight categories. These weight categories differ between combat sports, however, the upper limit of BM for each weight category is commonly separated by 10-15% intervals. The weigh-in process also varies among combat sports, with 'official weigh-ins' occurring anywhere from 16h to 3h before the competition. Despite the differences between weight categories, weigh-in processes and physiological demands of combat sports, the prevalence of weight loss prior to competition is higher than 60% in most Olympic combat sports; with weight loss of approximately half of the percentage interval between weight categories (i.e., 5% to 8%) being common. The main methods used by combat sports athletes to decrease body mass include dieting, dehydration, and exercise using heavy clothes or in hot environments. Increased dehydration and the depletion of energy stores are common consequences of such procedures and have a negative impact on aerobic and anaerobic performance when no nutritional intervention is allowed post-weigh-in. For athletes familiarized with these weight loss processes and who use specific refeeding procedures, aerobic and anaerobic performances decrements may be reduced or eliminated. However, the development of eating disorders and other health-related problems are commonly reported in these athletic groups, especially in female combat sports athletes.

### COMBAT SPORTS-SPECIFIC TESTS

MORALES, J.

*UNIVERSITAT RAMON LLULL*

Training prescription is a complex task and regular testing is considered a key element in this process. Combat sports performance is determined by different physical capacities depending on the characteristics of the competition (i.e., grappling, striking, or mixed combat sport; lighter or heavier weight categories; number and duration of matches, as well as the interval between them, in a given competition, etc.). Therefore, specific tests are needed to assess different physical capacities or to simulate the physiological demand of a combat sports match, while considering the specificity principle. In the last two decades, many combat sports-specific tests were proposed. In this lecture, the main tests, their validation process, sensibility, and applicability will be presented. Special consideration will be presented regarding the use of such tests for training prescription and monitoring.

## Oral presentations

## OP-MH06 COVID-19: Physical activity and inactivity

### CHANGES IN PHYSICAL ACTIVITY IN SWEDEN DURING COVID-19: A COMPARATIVE CROSS-SECTIONAL ANALYSIS

ANDERSSON, K., JANSSON, A., HEDENBORG, S., SVENSSON, D.

*UNIVERSITY OF MALMÖ*

Introduction
According to accumulated data, COVID-19 related restrictions can lead to considerable inactivity and sedentary lifestyles. The Swedish COVID-19 response consisted of guidelines rather than restrictions, which could possibly have a positive impact on activity levels remaining high. To investigate to which extent self-rated physical activity changed during the Swedish COVID-19 response, two cross-sectional surveys (N = 10,560) were conducted. The data constitutes the most comprehensive material on COVID-19 and physical activity extracted from Sweden. The aim is to contribute with new knowledge about general trends in physical activity during the Corona-pandemic in Sweden.
Methods
The method used is based on a quantitative cross-sectional retrospective approach. This approach makes it possible to clearly illustrate how the respondents' (N = 10,560) answers differ depending on whether the questions referred to physical activity "before COVID-19" or "during COVID-19". The data was collected on two different occasions (dataset 1 & dataset 2). Both surveys were digital questionnaires. The first dataset was distributed through social media, and The Swedish Research Council for Sport Science, whereas the second survey was distributed via e-mail. Dataset one was collected between 8 April 2020 to 14 august 2020, while dataset two was gathered from 8 December 2021 to 22 January 2021. The analysis included descriptive statistics, t-tests, correlations, and ANOVA. Cohen's guidelines were used to establish what should be considered small, medium, and large differences.
Results
Overall, the results convey that there are significant differences for many people in everyday exercise performance during COVID-19. The most striking result is that many respondents report the same amount of everyday exercise, however, less physical training, and more sedentariness. Moreover, the result shows that elderly respondents were more affected than younger people, yet younger people reported more increased time sitting down. In terms of gender, although the Cohen guidelines categorize the difference as small, women had higher scores on sedentariness and reduced physical activity.
Discussion
Both datasets reveal that patterns of physical activity have changed during COVID-19. However, contrary to what some studies conducted in Sweden have argued, within our datasets, differences across gender and age yielded only small differences. This deviates from studies that report that COVID-19 had a substantial negative impact on certain demographic groups. We conclude that respondents report less physical training regardless of demographic specificities. That elderly report less movement aligns with the outcomes of similar large-scale studies conducted in other countries. Finally, we suggest that one reason for differing results could be the use of different definitions when employing questionnaires to gain information on perceived physical activity.

## EXERCISE AS AN INTERVENTION TO MITIGATE METABOLIC CHANGES DUE TO SEDENTARISM: A RANDOMIZED CONTROLLED TRIAL DURING COVID-19 PANDEMIC

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INTRODUCTION: The current COVID-19 pandemic and the implemented policies have impacted people's work, recreation, levels of physical activity and sedentary behaviors (SB) [1]. Physical inactivity and SB are considered the major causal factors for obesity, insulin resistance, and type 2 diabetes development [2]. Potential strategies to overcome these negative effects include home-based exercise [3]. This study aimed to analyse the effects of a combined training program performed during the first national COVID-19 lockdown on insulin resistance markers in non-diabetic sedentary workers.
METHODS: This study was designed as a randomized, parallel-group clinical trial of 16-weeks. Thirty-one participants (48.26 ± 7.89 years old; 77.4% women, BMI: 27.83 ± 4.26 kg/m2) concluded the study; participants were randomly assigned to an exercise group (i.e., performed 16-weeks of combined training) and to a control group (i.e., did not perform any type of exercise). The combined training program (i.e., aerobic plus resistance exercise) occurred 2-3 times/week for approximately 55 min/session. Anthropometric measures (i.e., stature, body mass, waist, and hip circumferences) and fasting blood samples were taken pre and post-intervention. Fasting insulin concentration was analysed by ELISA (Crystal Chem, USA) and fasting glucose was analysed using the standard enzymatic assays (ABX Pentra, Germany). The homeostatic model assessment of insulin resistance (HOMA-IR) was calculated as (insulin [µU/L] x glucose [mg/dL] / 405). Descriptive statistics were performed for all variables. A two-way ANOVA for repeated measures was used for intra- and inter-group comparisons.
RESULTS: A significant decrease of waist ($p < 0.001$) and hip circumference ($p = 0.001$), waist-to-height ratio ($p < 0.001$) and waist-to-hip ratio ($p = 0.011$) were observed in the exercise group compared with the control group at the post-intervention. Regarding the insulin resistance markers, a significant increase of fasting glucose ($p = 0.029$) and HOMA-IR ($p = 0.010$) were observed in the control group at the post-intervention, while no significant changes were observed in the exercise group.
CONCLUSION: Our findings suggest that the participants that performed the home-based exercise program during the first pandemic-related lockdown were able to mitigate the metabolic changes associated with a sedentary lifestyle.
References:
1. Stockwell S, Trott M, Tully M, et al. Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: a systematic review. BMJ Open Sp Ex Med, 2021. 7(1):e000960.
2. Eaton SB & Eaton SB. Physical inactivity, obesity, and type 2 diabetes: An evolutionary perspective. Res Q Exerc Sport, 2017. 88(1):1–8.
3. Chtourou H, Trabelsi K, H'mida C, et al. Staying Physically Active During the Quarantine and Self-Isolation Period for Controlling and Mitigating the COVID-19 Pandemic: A Systematic Overview of the Literature. Front Psychol, 2020. 11:1708.

## DID THE COVID-19 PANDEMIC AFFECT THE SECULAR TRENDS IN MOTOR PERFORMANCE AND BODY MASS INDEX OF FIRST-GRADERS IN A SWISS URBAN AREA?

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INTRODUCTION: The reduced ability to attend leisure time sporting activities and lockdowns disabling children from attending school during the Covid-19 pandemic presents a threat to the maintenance or uptake of unstructured and structured physical activity. It may be speculated that this potential reduction in physical activity at an early age leads to a negative effect on the physical development of children. Whether the Covid-19 pandemic had a negative influence on the development trends of children in motor performance and body composition is unclear. We hypothesize, that children performed worse in 2021 and were less fit than the observed trends from 2014 to 2020 would predict.
METHODS: As part of the ongoing monitoring of childrens' motor performance tests in the first grade in the city of Basel, Switzerland, every year all first graders are tested with four motor performance tests: 20 meter shuttle run, 20 meter sprint, side hopping and balancing backwards. Also, their height and weight is measured. Children are categorized as overweight, when they are above the 90. percentile for their age and sex in BMI and as obese when above the 97. percentile. Only data of the 13 schools that were also tested in 2020 were used. Linear regression for the performance parameters and logistic regression for weight status was used to predict 2021 performance based on data from 2014 to 2020. This prediction was then compared to the performance achieved in 2021.
RESULTS: 4454 children (637 ± 23 per year) were tested from 2014 to 2020 (50.9% male, ) and 639 (50.2 % male) in 2021. The 2021 cohort outperformed the predicted values by 6.1% for shuttle run [95 % CI: 1.8; 10.4], 0.2% for 20 meter sprint [-0.6; 1.0], 6.4% for side hopping [3.7; 9.2], and 4.0% for balancing backwards [-0.5; 8.4]. Whereas the 95 % confidence intervals of the predicted and the actual data overlapped for balancing backwards and sprint performance, they did not for side hopping and shuttle run. The proportion of overweight and obese children was 47.4 % [32.6; 62.0] and 55.9 % [37.2; 74.5] higher, respectively, than was expected from the secular trends (16.4 vs 11.1% and 10.1 vs 6.5 %).
CONCLUSION: The 2021 cohort showed better performance than predicted in all motor performance parameters but sprint time, suggesting that the safety measures for combatting the Covid-19 pandemic did not limit their motor development. However, the vastly increased number of overweight and obese children is alarming. Potential reasons for this diverging findings remains speculative. It might be assumed that an increased caloric intake in combination with increased sedentary time in the already inactive and overweight children may be partly responsible for this finding. Public health interventions in this cohort should focus on maintenance or reversion of a healthy body composition.

## PHYSICAL ACTIVITY AND SEDENTARY TIME DISTRIBUTION AMONGST ADULT RESIDENTS DURING COVID-19 LOCKDOWN IN SINGAPORE- A PUBLIC HEALTH PERSPECTIVE

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INTRODUCTION: To mitigate the spread of COVID-19 in the community, home confinements, social restrictions and closure of public facilities has become a global public health strategy. Singapore imposed a lockdown called as circuit breaker movement restrictions (CBMR) during April-June 2020. While these risk mitigation measures are imperative, they may have led to unintended consequences on physical activity (PA), sedentary behavior and health. This study investigated the PA and sedentary time (ST) distribution patterns in adult residents of Singapore during the CBMR period.

METHODS: This study used a cross-sectional, retrospective design. A 44-item questionnaire was developed. The survey link was distributed via different socially popular online platforms. The questionnaire included sections to determine PA and ST distribution patterns before and during the CBMR. It also included information on sleep duration, PA preference and routine, awareness on local initiatives and perceptions on barriers toward PA during the CBMR period.
RESULTS: There was an overall decrease in PA, and a significant increase in physical inactivity and ST during this period suggesting negative lifestyle adaptations to CBMR, with the potential to adversely affect health and fitness. A greater proportion of participants reported sleeping for longer hours during the CBMR period. Respondents had high perception of proficiency in using screen-based gadgets but there was low awareness on local governmental and organizational initiatives for exercise and health promotion on various online platforms. The Singapore society seemed to prefer outdoor and facility-based exercise venues and closure of these locations was reported as the most common barrier to be physically active during the CBMR.
CONCLUSION: Reduced PA and increased ST during the CBMR reflecting negative lifestyle adaptations and may have led to an increased the risk of chronic diseases, reduced cardiorespiratory fitness, and adverse health implications. Increased sleep duration was suggestive of successful coping with fear and anxiety related to the pandemic, and consequently may have lead to physical and mental health benefits. Majority were unaware of online exercise initiatives and programs offered during the CBMR period, and >50% respondents reported never using an online resource for exercise. While Singaporean adults may be flexible with certain aspects of being physically active, they seemed less adaptive to changes in exercise type, facility, and environment.

**NEUROVEGETATIVE BP AND HR REGULATION IN SARS-COV-2 POSITIVE ELITE-ATHLETES**

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INTRODUCTION: Current studies in the general population provide evidence that persisting symptoms after SARS-CoV-2 infection may relate to a dysfunction in the autonomic nervous system regarding blood pressure (BP) and heart rate (HR) regulation (1,2,3). In many studies, the measurements have been performed in resting state or with the tilt table test (TTT). In the absence of definitive data, there is ongoing uncertainty about how the autonomic nervous system adapts to physical stress in elite athletes.
The aim of the study was to evaluate the dynamics of BP and HR and physical performance during exercise test in elite athletes before and after SARS-CoV-2 infection.
METHODS: 17 German Olympic Sports Confederation athletes (15 men, 2 women; mean age 23 years ± 5) aged between 20 and 35 with laboratory-confirmed SARS-CoV-2 infection were included in this panel study, which was implemented from December 2020 to September 2021 at the Institute of Cardiology and Sports medicine of the German Sport University Cologne (DSHS). SARS-CoV-2 infection as determined by reverse transcription–polymerase chain reaction (PCR) or serum immune globulin G antibody against the SARS-CoV-2 virus. To evaluate autonomic regulation of systolic BP and HR including rate pressure-product (HR × BPsyst.) incremental exercise test was conducted as soon as possible, after initial SARS-CoV-2 infection (t0) and 16 weeks later (t1). Physical performance was determined by peak power output (Wpeak). All results were compared with existing pre-covid data (t-1) of the athletes.
RESULTS: Our analysis showed a significant increase in HR at 250 Watt (p=0.035) at t0.The mean Wpeak (t-1: 261,06 ± 64,61, t0: 257,20 ± 69,44, t1: 256,64 ± 55,38), BPsyst. and rate pressure - product (p>0.05) showed no significant difference between all time points of measurement.
CONCLUSION: In conclusion, the study indicates that the autonomic regulation of BP and HR was not critically altered by SARS-CoV-2 infection in elite athletes. Although significant increases in HR at the pre maximum intensity levels were observed 4 weeks after acute infection, no limitations in HR regulation could be identified. Further long-term research including spiroergometry data is needed to draw reliable conclusions.
(1) Dani, M., Dirksen, A., Taraborrelli, P., Torocastro, M., Panagopoulos, D., Sutton, R., & Lim, P. B. (2021). Autonomic dysfunction in long COVID: rationale, physiology and management strategies. Clinical medicine (London, England), 21(1), e63–e67. https://doi.org/10.7861/clinmed.2020-0896
(2) Blitshteyn, S., Whitelaw, S. Postural orthostatic tachycardia syndrome (POTS) and other autonomic disorders after COVID-19 infection: a case series of 20 patients. Immunol Res 69, 205–211 (2021). https://doi.org/10.1007/s12026-021-09185-5
(3) Goldstein, D.S. The extended autonomic system, dyshomeostasis, and COVID-19. Clin Auton Res 30, 299–315 (2020). https://doi.org/10.1007/s10286-020-00714-0

## Oral presentations

### OP-AP12 Training monitoring in team sports

**A NEW TRAINING LOAD QUANTIFICATION METHOD AT SUPRA-MAXIMAL INTENSITY AND ITS APPLICATION IN INJURIES AMONG MEMBERS OF AN INTERNATIONAL VOLLEYBALL TEAM.**

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INTRODUCTION: In volleyball (VB), the quantification of the training load (TL) is based on the number of jumps (Piatti et al., 2021), however the jump height is not considered. The repetition of intense jumps is source of significant mechanical stress and promote the injury occurrence (Bahr and Bahr, 2014). To optimize jump performance and reduce the occurrence of injuries, it's necessary to monitor and quantify specifically TL in VB (Debien et al., 2018). The aims of this study were (i) to propose a new method for quantifying TL for explosive exercises, (ii) to determine the nature of the relationships between the dynamics of TL and injury occurrence and (iii) to find a limit TL in terms of jumps, above which the risk of injury occurrence become unacceptable, for optimizing the training schedule.
METHODS: This study was conducted in 11 male VB players of the French national team (age: 25.5 ± 2.9 years; size: 197.9 ± 7.3 centimeters; weight: 89.7 ± 10.6 kilograms) over a 5-month international competitive period (23 games and 37 specific training). During these sessions, a G-Vert accelerometer(Damji et al., 2021) was used to quantify TL provided by the players during each sessions. The proposed new TL quantification method is based on considering the relative intensities of the jumps according to the maximum jump height (MJH)

and the introduction of a weighting factor(Banister and Hamilton, 1985) for high-intensity exercises based on the relationship between the number of possible jumps and their intensities. The relationships between TL dynamics occurrences of injuries were assessed using a variable dose-response model of Busso (Busso, 2003). An injury score was determined based on the injury severity score (Stevenson et al., 2001).
RESULTS: A high coefficient of determination was found ($r2 = 0.94 \pm 0.14$, $p < 0.001$), indicating a strong physiological law between the intensity of the jumps and the constraints imposed. The injury risk was dependent of the dynamics of the TL ($r2 = 0.47$; mean error = 0.7%; $p < 0.001$). A number of 12 jumps at >80% of MJH during the game sessions, in addition to the 143 jumps at <80% of MJH, seems to be the daily limit not to be exceeded.
CONCLUSION: A new approach makes it possible to quantify explosive exercises and the application of the variable dose-response model offers practical advice for the conduct of the training in VB.

**RELATIONSHIP BETWEEN EXTERNAL LOAD FROM SIMULATED ICE-HOCKEY GAMES AND PHYSICAL TEST PERFORMANCE**

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INTRODUCTION: Well-developed physical fitness is regarded as an important factor for ice hockey game performance. Hence, off- and on-ice physical performance testing is regularly performed [1]. Despite its wide application, the importance and relevance to game performance is however uncertain due to limited game characterization data. Recent developments and application of indoor tracking systems have made such physical game performance data available and is suggested as a useful method in narrowing this research gap [2]. The purpose of this study was therefore to explore the association between physical performance measures and external load variables from simulated games.
METHODS: The study was performed over two weeks and included two days of testing and four simulated games (scrimmages). During games, players wore a Local Positioning System-tracking device. Each game included three 20-min periods and two intermissions, in accordance with official regulations. However, the games were standardized to a non-stop play design, with shifts performed every 1-min. Physical performance tests included 30-m on- and off-ice sprint, countermovement jump (CMJ), standing long jump, pullups and 1-repetition maximum in bench-press and trap-bar deadlift. External load variables from simulation games included total distance, maximum velocity (max vel), distance in speed skating zones, number of sprints, PlayerLoadTM, high intensity events (HIEs), accelerations, decelerations and change of directions (CODs). Initially, 34 players participated in the simulation games and physical tests. 14 players (age: 17.8±1.1 yrs, height: 179.5±6.5 cm, body mass: 71.2±6.0 kg, n=4 defensive, n=10 Forwards) participated in all games and completed all the physical performance tests, and thus were included in the analysis.
RESULTS: Bayesian pairwise correlation analyses showed strong evidence for associations between pullups (r=0.61) as well as on-ice top speed (r=0.55) to HIEs and max vel, respectively. There was moderate evidence for an association between on-ice top speed (r=0.44), CMJ (r=0.44) and sprint speed skating distance, while there also was moderate evidence for an association between CMJ (r=0.46) and number of sprints. Furthermore, there was moderate evidence for associations between pullups (r=0.50) as well as trap-bar (r=0.45) and CODs and max-vel, respectively.
CONCLUSION: This explorative study shows that only a few of the physical performance tests were likely to have any meaningful association with external load variables from simulated games. Specifically, only 7 of 132 correlations showed evidence for associations between fitness tests and external load performance. Based on these findings, top-speed from on-ice sprint and CMJ seem to be relevant for sprinting abilities, while pullups suggest that upper body strength plays an important role in acceleration derived data, such as CODs, accelerations, and decelerations during gameplay situations.
1. Haugen et al. (2021)
2. Huard Pelletier et al. (2021)

**TIME-INTENSITY MODELS FOR INTERMITTENT SPORTS GAMES USING THE EUROPEAN HANDBALL CHAMPIONSHIP 2020 AS AN EXAMPLE: MIXED MODELS AND MORE**

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INTRODUCTION: Training load terminology can be confusing. Parameters like the “normalized distance” are commonly used to describe the load profile in sports games. The interpretation of such parameters is not always straightforward and depends on the question asked and the data processing. Causal effect estimates are often the target, but this is even harder for observational studies (e.g., analysis of tournament data) compared to experiments. In handball, research interest was placed on positional differences and decreasing intensity over time. Our aim is to highlight methodological pitfalls when interpreting observational data from intermittent sports games and show techniques to overcome t
METHODS: The data in this example were obtained from the European Handball Championship 2020 and recorded with the Kinexon Local Positioning System (LPS). The raw data were processed to obtain summary statistics for each player in each game, which were used for statistical modelling. A three-step procedure is used to interpret the causal effects of playing position, intensity and time played: First, I discuss a simple definition of volume, time and intensity. Second, I am going to identify the underlying causal effects using a graphical causal model. Third, I discuss and compare different models to estimate causal effects for positional differences and decreasing intensity over time.
RESULTS: The terminology of “time-normalized distance” conceals the correct interpretation: It’s the average velocity and, thus, a measure of intensity by definition. A mediation model guides the regression analysis: To identify the direct effects of intensity change over time and positional differences in intensity, we must include position and time in the same regression model. Thus, the direct effect for time yields an intensity decrease of 0.21 W/kg [CI95% [0.17; 0.25] per 10 minutes played. In the same model, positional differences were observed between wings, mid backs, left and right backs and pivots. The direct effects differed substantially from the total effect, e.g. mid backs had lower intensity estimates as direct effect (8.17 CI95% [7.93; 8.41] vs. 7.85 CI95% [7.68; 8.03]). Importantly, modelling individual observations as random effect yields larger confidence intervals compared to a simple factorial (ANOVA) design, e.g. the mean standard error was 39% higher. The random slope/intercept model outperformed other models in fit parameters (information criteria, p-values).
CONCLUSION: Causal identification strategies should generally be used when interpreting observational data from sports games. Current practice is to present simple means. This can be misleading and marginalized effects should be presented according to the assumed causal

model structure. Violation of the independence assumption may lead to narrower standard errors and might thus increase the risk of false-positive results. Also, visualizing raw data and model predictions should be a standard rather than an exception.

### METABOLIC POWER AND SUCCESS IN MEN'S HANDBALL IN THE EUROPEAN CHAMPIONSHIP

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INTRODUCTION: Strong physical performance is a fundamental part to accomplish success in professional handball. Since accelerations are a crucial part of movement in handball, it is not sufficient to evaluate total distance as volume and average velocity as intensity parameter. Metabolic power (MP) implements both acceleration and velocity and might better reflect (metabolic) demands in terms of match intensity (metabolic) in team sports. We hypothesize, that higher metabolic demands might lead to a better match outcome in top-level handball.
METHODS: 414 elite male handball players were included. During 65 matches of the EURO 2020, local positioning system data (Kinexon Precision Technologies) were collected (16.6 Hz), yielding 1853 datasets. We analyzed net playing time only with durations above 1 min. Goalkeepers and games resulting in a draw were excluded from the analysis. Average Metabolic Power (W/kg) an energy at high metabolic power (HE; >35 W/kg) per minute were processed and further used as predictors for success. We first standardized these values across the whole dataset and then calculated means and standard errors on those for each team and match. Next, a (Bayesian) logistic mixed effect measurement error was fitted with the brms package with match and team as random effects.
RESULTS: The logistic regression shows favorable tendencies for higher metabolic demands toward success (MP: 0.67 W/kg; CI95% -128|2.66; HE: 1.03 J/kg/min; CI95% -0.88|3.08). However, these results are not conclusive due to widespread credibility intervals. The metabolic power and energy at high MP in winning teams is higher on average compared to the losing teams (MP: +0.12 W/kg; SE: 0.04; T=2.9; HE: +0.01 J/kg/min; SE: >0.01; T=3.3) when the win is the outcome. A sensitivity analysis using the goal difference outcome showed fewer benefits toward higher metabolic demands.
CONCLUSION: Our study confirms that the playing intensity in winning teams is higher on average. Recent research show that wing players expend more energy at high metabolic power compared to other positions. Winger are the preferred position for fast counter-attacks which yield a high metabolic power, thus, a simple and efficient way of scoring is a big contributor to winning. For achieving success, greater involvement with the ball, more successful passes and the completion of skill-related activities might be of great importance and contribute more directly to success in comparison with match running performance.

### APPLICATION OF TACTICAL PERIODIZATION TO PRESEASON TRAINING PERIOD IN PROFESSIONAL RUGBY UNION PLAYERS

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INTRODUCTION: Tactical periodization (TP), as an alternative paradigm to periodization, gained considerable traction in recent years for strength and conditioning (S&C) coaches [1]. It considers all training factors and contains three principal acquisition training days (i.e., Strength, Endurance, and Speed days) that allow corresponding three crucial physical capacities development [1, 2]. However, no scientific research has reported the effects of three TP acquisition days during the preseason training on physiological characteristics in rugby union (RU). Therefore, this paper aims (i) to investigate the effect of 6-weeks TP preseason training on neuromuscular function performance and aerobic fitness, as well as (ii) to characterize external workload (EWL) variation of TP in professional RU players.
METHODS: Thirty-two professional RU players (25.0±4.0 years, 103.4±16.8 kg, 185.5±8.8 cm) from a team competing in the 2nd France RU division were assessed. Based on the concept of TP, the three main acquisition days were arranged following the specific needs of the team. Subjects completed lower-body neuromuscular power (countermovement jump; CMJ) and aerobic ability (Bronco) tests before and after the preseason period. EWL was monitored using wearable 10-Hz GPS (Vector X7, Catapult Sports®, Melbourne, Australia) to characterize preseason training loads by total distance (TD), high-speed running (HSR; >15 km/h), very high-speed running (VHSR; >21 km/h), sprint running (SR; >25 km/h) distance, PlayerLoad (PL), repeated high-intensity efforts (RHIE), and the number of accelerations (ACCnum; >2 m/s/s). Statistical assessments used paired sample t-tests and independent groups one-way ANOVA with post-hoc Scheffe test.
RESULTS: Throughout the preseason, there were no differences in CMJ results. In contrast, significant improvements were found in all participants' aerobic performance ($p<0.001$; effect size=0.49). During the TP training, RHIE did not differ among acquisition days. However, PL and ACCnum were higher ($p<0.001$; effect size=0.24-0.30) on Endurance day compared to Strength day. Furthermore, Endurance (3236.57±42.28 m; $p<0.001$; effect size=0.37) and Speed (3236.86±49.65 m; $p<0.001$; effect size=0.40) days reached a greater distance than Strength day (2966.00±49.84 m). The main results indicate that there were significant differences in training intensity for HSR, VHSR, and SR among three acquisition days ($p<0.001$; effect size=0.34-1.27).
CONCLUSION: These results provide S&C coaches with insight into TP effects on the physical profiles and EWL variation of RU players during the preseason period. Especially, practitioners could use EWL variation of three acquisition days to assist with physical adaptation and technical complexity at different preseason stages.
REFERENCES:
1. Afonso J, et al. 2020.
2. Buchheit M, et al. 2018.

## OP-PN22 Hypoxia I

### SIX WEEKS OF STATIC APNEA TRAINING DOES NOT AFFECT HBMASS AND EXERCISE PERFORMANCE.

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INTRODUCTION: Acute apnea is known to induce decreases in oxyhemoglobin desaturation (SpO2) and increases in erythropoietin concentration ([EPO]). This study examined the potential of an apnea training program to induce erythropoiesis and increase hematological parameters, such as EPO, reticulocytes and hemoglobin mass (Hbmass), maximal oxygen uptake (VO2peak) and exercise performance.
METHODS: Twenty-two male subjects, naïve to breath-holding, were randomly divided into an apnea and control group. The apnea group performed a 6-week apnea training program consisting of a daily series of 5 maximal static apneas. Before and after the apnea training period, subjects visited the lab on three test days to perform 1) a ramp incremental test measuring VO2peak, 2) a CO-rebreathing protocol for Hbmass determination and a 3-km time trial, and 3) an apnea test protocol consisting of a series of 5 maximal static apneas with continuous finger SpO2 registration. Venous blood samples were drawn before and 180 minutes after the apnea test for analysis of [EPO].
RESULTS: Maximal breath-hold time improved from 118 ± 54 s before to 155 ± 53 s after six weeks of apnea training ($p < 0.001$). Minimal SpO2 reached during the apnea test protocol was 91 ± 7% before and 82 ± 7% after the apnea training period ($p < 0.001$). The apnea test protocol did not elicit an acute increase in [EPO] ($p = 0.685$) before nor after the training program. Consequently, resting [EPO] ($p = 0.170$), Hbmass ($p = 0.134$), VO2peak ($p = 0.796$) and 3km cycling time trial performance ($p = 0.509$) were not affected either.
CONCLUSION: This study was the first to provide longitudinal data on the impact of apnea training on both the hematological parameters and its effect on exercise performance. The apnea test and training protocol consisting of 5 maximal static apneas, separated by 30 second intervals, did not induce a sufficiently strong hypoxic stimulus to cause an acute increase in [EPO] in a population naïve to breath-holding. The training protocol therefore did not result in an increase in resting [EPO], Hbmass, VO2peak and performance on a 3km cycling time trial. Longer and/or more intense apnea training sessions inducing a stronger hypoxic stimulus are probably needed to obtain changes in hematological parameters and exercise performance.

### EFFECTS OF HIGH-INTENSITY, LOW-INTENSITY AND LOW-INTENSITY WITH BLOOD FLOW RESTRICTION EXERCISE TO VOLUNTARY MUSCULAR EXHAUSTION ON METABOLIC AND IONIC HOMEOSTASIS AND VENOUS VASCULAR FUNCTION IN HEAL

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INTRODUCTION: Training under blood flow restriction causes faster muscular fatigue than training under free flow conditions. However, the remaining issue is whether the metabolic and ionic changes of BFR exercise differ from high mechanical intensity (HI) or light intensity (LI) exercise when the exercise is performed to voluntary muscular fatigue. In addition, the effects of BFR-induced venous hypertension or HI and LI exercise on venous vascular function are still unknown. Therefore, the present project investigated metabolic and ionic alterations as well as venous function during and after BFR, HI and LI exercise to voluntary muscular exhaustion by intravascular catheter measurements.
METHODS: In a randomized cross-over design, ten healthy male subjects underwent three trials of unilateral leg extension exercise. These trials were differentiated into a high intensity (HI, 75% 1RM), low intensity (LI, 30% 1RM) and LI with BFR trial (LI-BFR). The exercise protocol consists of 4 sets to voluntary failure. The additive BFR protocol involved the proximal occlusion of the exercising thigh by a blood pressure cuff system at a pressure of 50% of the individual arterial occlusion pressure. For analysis of changes in intravascular pressures, blood gases, oximetry and electrolytes, a venous catheter (Rete venosum dorsale pedis) were placed at the exercising leg before exercise. Venous blood gases and intravascular pressures were analyzed before, during and 5 min after exercise. In order to determine the functionality of the venous system, a phlebodynamometry was performed before and after the exercise.
RESULTS: The total workload was significantly lower in the LI-BFR condition compared to LI- and HI-condition ($p < 0.05$). The peripheral venous pressure increased significantly during the exercise ($p < 0.001$), with no difference between conditions ($p = 0.33$). Additionally, there were no significant changes in venous function assessed by phlebodynamometry all forms of training ($p = 0.56$). Analyses of the BGAs showed that venous pCO2 increased significantly during the exercise ($p < 0.001$), with no difference between conditions ($p = 0.64$). At the same time, the analyses of pO2 showed a significant reduced oxygen availability for working muscle during the exercise regardless of conditions ($p < 0.001$). Regardless of conditions, venous [K+], [Na+], [La-] showed a periodic increase during exercise ($p < 0.001$) which decreased to baseline levels 5 min post exercise, respectively.
CONCLUSION: This is the first study investigating venous vascular function before and after BFR, LI and HI exercise to voluntary muscular exhaustion. Based on the obtained data, there is no acute adverse effect on venous function after BFR or HI and LI training in young male subjects. Similarly, the data from this study shows that although BFR training leads to accelerated muscle fatigue compared to LI, the metabolic and ionic changes are equivalent to HI or LI condition, when the exercise is performed to voluntary muscular exhaustion.

### CHANGING INSPIRED FRACTION OF OXYGEN AFECTS HOMEODYNAMIC RESPONSE TO CONSTANT LOAD EXERCISE

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INTRODUCTION: Hypoxia disrupts body internal dynamics, increases energetic demand requiring a coordinated systemic network response of the body to reestablish equilibrium [1]. This study aimed to observe how the manipulation of inspired fraction of oxygen (FiO2) during constant load cycling exercise impacts internal homeodynamics.
METHODS: Twenty-seven male moderately trained X-country cyclists volunteered to perform a single-blinded constant-load exercise test in a SRM cycloergometer either with the manipulation of FiO2 (CLEST: n=20) or in normoxia (NOR: n=7). Experimental protocol included two visits to the laboratory. During the first visit an incremental stress test was performed to establish first ventilatory threshold (LV1) to prescribe exercise intensity for the CLEST, performed in the second visit. CLEST consisted of continuous exercise at a power corresponding to

80% of the LV1 in four different FiO2 plateaus (NOR: normoxia; H1: 17.3%; H2: 15.3%; H3: 13.5%) without stopping, each with a 6-minute duration. During exercise, partial arterial saturation (SPO2), cardioventilatory parameters and vastus laterallis muscle local oxygenation were monitored continuously and at the end of each plateau capillary lactate concentration ([La]) and the rating of perceived exertion (RPE) on a 20 scale. Data was analyzed by a mixed ANOVA for repeated measures with the condition as the between-subjects factor (CLEST X NOR) and hypoxia severity as the within-subjects factor (NOR x H1 x H2 x H3). Significance was set at p≤.05.
RESULTS: During the CLEST (within-subjects effect), the decrease in FiO2 induces a drop in the SPO2, an increase of ventilation (Ve), heart rate (HR), deoxygenated hemoglobin content (DEOXY-Hb) in the vastus laterallis, and carbon dioxide production (VCO2), between all plateaus (p<0.01). However, [La] only increased at H3 (p≤.05). At H3 these variables presented the follow mean values: SPO2: 75.36±15.44 %, Ve: 63.63±12.62 L.min-1, HR: 150.84±15.99 bpm, DEOXY-Hb: 46,82±13.71 µM, VCO2: 2.84±0.41 L.min-1, and [La]: 3.51±1.36 mmolL-1. On the other hand, oxygen consumption, oxygenated hemoglobin content in the vastus laterallis and respiratory exchange ratio did not change. RPE also significantly increased along CLEST, changing from a perception of light activity at the beginning to very hard at the end (NOR: 1.85±2.10; H1: 12.90±1.89; H2: 13.80±1.40; H3: 14.95±1.61, p≤.01). The NOR group showed no differences between plateaus across the duration of exercise for any of the variables studied. Between-subjects a significant effect was only observed in SPO2, Ve, HR, and DEOXY-Hb, [La-1] and RPE (p≤.05).
CONCLUSION: Reduction in the FiO2 promotes an imbalance in internal homeodynamic stability changing exercise intensity domain for the same external power. This can be important to prescribing exercise intensity for sports and health related exercise in hypoxia.
REFERENCES
[1] Ivanov PCh. The New Field of Network Physiology: Building the Human Physiolome. Frontiers in Network Physiology 2021

### THE OXIDATIVE-GLYCOLYTIC BALANCE INFLUENCED BY EFFORT DURATION IS KEY DURING REPEATED CYCLING SPRINTS TO EXHAUSTION IN HYPOXIA

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INTRODUCTION: Repeated sprint ability is a key performance determinant in team sports. Repeated sprints exercise (RSE) performed in hypoxia (RSH) induce greater performance improvement than in normoxia (1). Manipulation of effort duration and exercise-to-rest ratio influences the oxidative-glycolytic balance for energy supply. Therefore, this study aims to compare acute performance and psycho-physiological responses during RSE to exhaustion with the same exercise-to-rest ratio (1:2) but different sprint durations (5, 10 or 20 s) either in normoxia (RSN) or hypoxia (RSH; FiO2 = 0.13).
METHODS: On separate visits, 10 active participants completed in random order three RSH and three RSN sessions (5:10; 10:20 and 20:40) to exhaustion on a cycle-ergometer (Excalibur Sport, Lode). Psycho-physiological responses and vastus lateralis muscle de-reoxygenation (Oxymon, Artinis Medical Systems) were continuously recorded.
RESULTS: Number of sprints to exhaustion was lower during RSH than RSN for 5:10 (20.8 ± 8.6 vs 14.7 ± 3.4; p = 0.014) and 10:20 (13.7 ± 6.3 vs 8.8 ± 2.5; p = 0.018) but not for 20:40 (5.6 ± 1.9 vs 5.6 ± 2.5). Fatigue index was higher during RSH only for 5:10. Blood lactate concentration increased with RSE, independently of the condition, with higher values for 20:40 than 5:10 (13.1 ± 2.7 vs 11.45 ± 2.2 mmol.l-1; p = 0.027). Ratings of perceived exertion, limb discomfort and difficulty breathing did not differ among all RSE. Change in muscle total hemoglobin during sprint tended to be lower in RSH compared to RSN (p = 0.093). The normoxia-to-hypoxia decrease (%) in number of sprints to exhaustion during 5:10 was correlated with the highest power output achieved over 5 s (r2 = 0.55; p = 0.013) or 10 s (r2 = 0.53; p = 0.016) efforts.
CONCLUSION: During RSE with short sprints and short recoveries, energy supply comes mainly from phosphocreatine breakdown and O2 bound to myoglobin. Hence the resynthesis of phosphocreatine and the myoglobin reloading during recovery period depend on O2 availability, leading to an altered performance in hypoxia in such type of RSE; i.e. 5:10 and 10:20.
The correlations between the normoxia-to-hypoxia decrease in the number of sprints and the highest best mean power over 5 s or 10 s only found for 5:10 (i.e., relying more on the oxidative pathway) show that individuals with predominantly fast twitch fibers were less impacted by the decreased O2 availability than their counterparts.
Hypoxic exposure manly impacts RSE, which relies more on the oxidative pathway (5:10 and 10:20), whereas it only has a negligible influence on RSE relying more on the glycolytic pathway (20:40). The oxidative-glycolytic balance, partly influenced by the duration of sprints, is pivotal during repeated sprints in hypoxia.
1. Brocherie, F., Girard, O., Faiss, R. & Millet, G. P. Effects of Repeated-Sprint Training in Hypoxia on Sea-Level Performance: A Meta-Analysis. Sports Med

### HORMONAL, IMMUNE AND NITRIC OXIDE STRESS RESPONSES TO BLOOD-FLOW RESTRICTED LOW-LOAD RESISTANCE EXERCISE VERSUS FREE-FLOW RESISTANCE EXERCISE: A SYSTEMATIC REVIEW AND META-ANALYSIS

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INTRODUCTION: Low-load blood flow restricted training (LL-BFRT) has gained increasing popularity for strength training and as a rehabilitation tool for musculoskeletal injuries as LL-BFRT can induce muscular hypertrophy and strength gains comparable to those accompanying heavy resistance exercise (HRE). Recently, LL-BFR has also demonstrated promising physiological and clinical effects in the treatment of musculoskeletal disorders such as tendon injury. Although, adaptive mechanisms are not fully understood, it has been hypothesized that increases in systemic hormones e.g., Growth Hormone (GH), immune system signaling and nitric oxide (NO) stress responses following LL-BFR may be key factors. Therefore, the aim of the present systematic review and meta-analysis was to evaluate the acute, mid-term (10-20 minutes) and long-term (30+ minutes) hormonal, immune and oxidative stress responses following LL-BFRT compared to conventional free-flow strength training in healthy adults. We hypothesized that LL-BFRT would yield similar hormonal, immunological and NO responses compared to conventional free-flow heavy resistance exercise (HRE), but would demonstrate amplified responses compared to work-matched low-load resistance exercise (LL-RE).
METHODS: A systematic literature search was conducted in PubMed, EMBASE, Cochrane CENTRAL, CINAHL and SPORTDiscus in august 2021 and a secondary updated search will be performed in April 2022. Randomized and non-randomized studies were included in the meta-analysis. The Cochrane Risk of Bias (RoB2, ROBINS) and the TESTEX were used in order to evaluate Risk of Bias and study quality. Data

extractions were based on mean change within-groups where SDchange was computed if not reported. Authors were contacted to retrieve relevant data for analysis.
RESULTS: A total of 12,191 hits were located of which, 37 articles were included by two independent researchers and the total overall TESTEX score was 7.55 out of 15. LL-BFR demonstrated an increase in acute GH responses when compared to LL-RE (SMD 0.87; CI 0.05 – 1.69) but did not differ compared to HRE (SMD -0.18; CI -1.00 – 0.64). Similar results were retrieved when LL-BFR was compared to LL-RE at mid-term time points (SMD 2.81; CI 1.13 – 4.48). LL-BFR compared to HRE produced a similar testosterone response (SMD -0.18; CI -0.75 – 0.39) in the acute stage. Analyses were also performed for IGF-1, VEGF-1, Cortisol, IL-6 and noradrenaline where LL-BFR was compared to HRE and LL-RE (data analysis awaited).
CONCLUSION: LL-BFRT seems to elicit similar hormonal, immune system and nitric oxide responses compared to HRE, while in contrast demonstrating greater physiological responses compared to LL-RE, which could explain the beneficial clinical effects in different patient populations not tolerating heavy load during rehabilitation. These results are based on a low number of studies comprising a low number of participants and therefore, interpretations should be made with caution.

## Oral presentations

### OP-PN24 Cardiovascular I

#### THE ACUTE EFFECT OF EXERCISE INTENSITY ON PERIPHERAL AND CEREBRAL VASCULAR FUNCTION IN HEALTHY ADULTS

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INTRODUCTION: High-intensity interval training is known to improve peripheral vascular function, and there is a growing interest in the effects of high-intensity interval exercise (HIIE) on cerebrovascular health. Since the chronic benefits of exercise are likely related to the repeated acute responses following a single bout of exercise , it is important to investigate changes in endothelial function following a single bout of exercise. However, the effect of exercise intensity on cerebrovascular function has received little investigation, and no study has compared the acute effect of exercise intensity on cerebrovascular function, and whether this mirrors changes in peripheral vascular function. The aim of this study was to explore the acute effect of exercise intensity on cerebral and peripheral vascular function in healthy young adults.
METHODS: Ten participants (7 females, 22.7 ± 3.5 years) completed four experimental conditions on separate days: high intensity interval exercise (HIIE) with intervals performed at 75% maximal oxygen uptake (V̇O2max; HIIE1), HIIE with intervals performed at 90% V̇O2max (HIIE2), continuous moderate intensity exercise (MIE) at 60% V̇O2max and a sedentary control condition (CON). All exercise conditions were completed on a cycle ergometer and matched for time (30 min) and average intensity (60% V̇O2max). Brachial artery flow-mediated dilation (FMD) and cerebrovascular reactivity (CVR) of middle cerebral artery blood velocity were measured before exercise, and one- and three hours post-exercise. CVR was assessed using transcranial Doppler ultrasonography to both hypercapnia (carbon dioxide breathing) and hypocapnia (hyperventilation).
RESULTS: FMD was significantly elevated above baseline one and three hours following both HIIE conditions ($P<0.05$), but FMD was unchanged following the MIE and CON trials ($P>0.33$). CVR to both hypercapnia and hypocapnia, and when expressed across the end-tidal CO2 range, was unchanged in all conditions, at all time points (all $P>0.14$).
CONCLUSION: This is the first study to identify that acute improvements in peripheral vascular function following high-intensity interval exercise are not mirrored in the cerebrovasculature in healthy young adults. High-intensity interval exercise completed at both 75% and 90% V̇O2max increased brachial artery flow-mediated dilation one and three hours following exercise, compared to continuous moderate intensity exercise and a sedentary control condition. By contrast, cerebrovascular reactivity was unchanged following all four conditions. These data suggest that the peripheral and cerebral vascular systems may share a different mechanism of change, which should continue to be explored in future research.

#### VASCULAR AND CARDIAC INTERACTIONS DURING LEG AND WHOLE-BODY HYPERTHERMIA: INSIGHT INTO THE PERIPHERAL AND CENTRAL MECHANISMS CONTROLLING THE HUMAN CIRCULATION

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INTRODUCTION: As with exercise, passive whole-body hyperthermia increases cardiac output (Q) (1,2). The concomitant rise in peripheral blood flow is thought to be mechanistically linked to enhanced cardiac function and blood flow redistribution from visceral organs. Recent evidence reveals that single leg hyperthermia increases regional leg blood flow and Q equally despite no elevation in core temperature (Tc) (3). This observation supports that peripheral thermosensitive mechanisms can explain at least part of the circulatory adjustments to whole-body hyperthermia, but direct evidence for this hypothesis is still lacking. We therefore investigated the regional vascular and cardiac responses to prolonged leg and whole-body hyperthermia to gain insight into the peripheral and central mechanisms controlling the human circulation.
METHODS: Skin (Tsk), muscle (Tm) and Tc; leg, arm, head and systemic haemodynamics; left ventricular (LV) volumes, intraventricular pressure gradients (IVPG) and ventriculoarterial (VA) coupling were assessed in eight healthy males during: (i) 3 h control (CON); (ii) 3 h of one leg heating (OLH); (iii) 3 h of two legs heating (TLH); and (iv) 2.5 h of whole-body heating (WBH). A water-perfused garment was used for heating.
RESULTS: All variables remained unchanged in CON. Leg Tsk and Tm increased rapidly by 4–10°C in all heating trials, whereas Tc increased gradually up to 0.4 ± 0.2, 0.7 ± 0.2 and 2.3 ± 0.4°C in OLH, TLH and WBH, respectively (all $p < 0.05$). Leg, forearm and extracranial blood flow increased in association with the rise in local temperature while brain perfusion remained unchanged despite elevations in Tc. The increase in Q in all heating trials was associated with an augmented stroke volume, owing to either increased LV end-diastolic volume, decreased LV end-systolic volume or both, and occurred alongside an unchanged IVPG (indicative of sucking force contributing to cardiac filling), and a gradual shortening of LV ejection and filling times with increases in heart rate. In all trials, the Q response was positively correlated to

increases in limbs and head blood flow (R2 = 0.983, p < 0.001), beat volume (R2 = 0.722, p < 0.001) and VA coupling (R2 = 0.927, p < 0.001). The latter reflected increases in LV function and reductions in the net arterial load.
CONCLUSION: Local hyperthermia induces selective elevations in peripheral tissue blood flow and reductions in net arterial load, which are met by increases in cardiac function and Q. These observations support the notion that local thermosensitive mechanisms increasing limb perfusion and venous outflow to the heart play a crucial role in the control of the human circulation during hyperthermia. These findings have implications for the use of heat therapy in exercise recovery, injury rehabilitation and treatment of circulatory diseases.
References
1. Pearson et al. (2011). Am J Physiol 300, R663-R673.
2. Stöhr et al. (2011). Exp Physiol 96, 114-124.
3. Koch Esteves et al. (2021). Physiol Rep 9, e14953.

## THE EFFECT OF CHRONIC PASSIVE HEATING ON VASCULAR FUNCTION AND CENTRAL HAEMODYNAMICS IN INDIVIDUALS WITH TYPE 2 DIABETES MELLITUS

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INTRODUCTION: Type 2 diabetes mellitus (T2DM) is a metabolic disease which can lead to macro- and microvascular impairments [1] and increased risk of cardiovascular disease [1, 2]. Chronic passive heating has the potential to act as an exercise mimetic and improve cardiovascular health [3].
METHODS: In a pre-post experimental design, seven individuals completed the study to date (a priori power calculation = 15). Participants completed two experimental visits, undertaken pre and post (<72 h) eight to ten 1 h hot water (40° C) immersions over a 14 day period. During immersions body position was adjusted to clamp deep body temperature between 38.5 and 39° C. Macrovascular function was assessed via brachial flow mediated dilation (FMD) using ultrasound; stroke volume index (SVi), cardiac output (Q), resting heart rate (RHR) were assessed via thoracic impedance; microvascular endothelial function assessed via transdermal delivery of acetylcholine (Ach) and insulin; systolic blood pressure (SBP) and diastolic blood pressure (DBP) were also recorded. Results (mean [SD]) were analysed using a paired t-test or Wilcoxon Signed Rank test for non-parametric data (significance p < 0.05, trend p <0.1) with effects sizes by Cohen's d or Rosenthal's r.
RESULTS: Interim analysis showed that brachial FMD was unchanged (pre: 7.47 (6.95) %, post: 7.48 (4.92) %, p = 1.00, d < 0.01). SVi trended downward (pre: 56.9 (16.4) mL·m-2, post: 50.8 (15.3) mL·m-2, p = 0.06, d = 0.89), while RHR (pre: 65 (14) bpm, post: 63 (13) bpm, p = 0.14, d = 0.64) and Q (pre: 7.0 (1.3) L·min-1, post: 6.1 (1.7) L·min-1, p = 0.10, d = 0.74) did not change, but had medium effect sizes. Microvascular endothelial function was unchanged but had a medium effect size with Ach (Ach max, pre: 0.67 (0.23) CVC, post: 0.86 (0.50) CVC, p = 0.46, r = 0.28; Ach AUC, pre: 1.84 (0.82) CVC, post: 3.13 (3.55) CVC, p = 0.67, r = 0.16) and insulin (insulin max, pre: 0.26 (0.24) CVC, post: 0.37 (0.31) CVC, p = 0.25, r = 0.44; insulin AUC, pre: 0.73 (0.63) CVC, post: 0.94 (1.05) CVC, p = 0.23, r = 0.45) mediated dilations. SBP (pre: 141 (12) mmHg, post: 131 (19) mmHg, p = 0.05 d = 0.92) trended downward but DBP (pre: 79 (14) mmHg, post: 77 (12) mmHg, p = 0.57, d = 0.23) was unaffected.
CONCLUSION: Interim analysis suggests chronic passive heating does not improve macro or micro vascular function in individuals with T2DM, but may improve cardiac efficiency and blood pressure.
1. Stratton, I.M., et al., Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. Bmj, 2000. 321(7258): p. 405-412.
2. Casanova, F., et al., The impact of cardiovascular co-morbidities and duration of diabetes on the association between microvascular function and glycaemic control. Cardiovascular diabetology, 2017. 16(1): p. 1-11.
3. Cullen, T., et al., The health benefits of passive heating and exercise: to what extent do the mechanisms overlap. Journal of Applied Physiology, 2020.

## THE SUPPLY OF OXYGEN TO SKELETAL MUSCLE AND REGULATION OF THE MICROVASCULATURE DURING SMALL MUSCLE MASS EXERCISE IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE VS. CHRONIC HEART FAILURE

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INTRODUCTION: We investigated muscle convective and diffusive oxygen (O2) transport in chronic obstructive pulmonary disease (COPD) compared with healthy controls (CON) and heart failure (HF) patients during one-legged knee-extensor exercise to determine disease-specific differences in peripheral determinants during exercise with a small muscle mass.
METHODS: Eight patients with moderate to severe COPD, eight patients with HF (NYHA Class II) and eight age- and sex-matched controls were studied. We measured leg blood flow (LBF) by Doppler ultrasound during submaximal one-legged knee-extensor exercise at 10 W, while sampling arteriovenous variables across the leg in all subjects during rest and exercise. The capillary oxyhemoglobin dissociation curve was reconstructed from paired femoral arterial-venous oxygen tensions (PO_2) and saturations (SO_2), which enabled the estimation of O2 parameters in the capillaries of the contracting muscle.
RESULTS: At rest COPD patients had lower PaO2 compared to the other groups (CON: 12(1); COPD: 10(1); HF: 11 (1) kPa; p<0.05). The resting capillary oxygen tension (CON: 6(0.5); COPD: 5(0.5); HF 4(1) kPa) and saturation (CON: 76(6); COPD: 69(5); HF: 65(4) %) were significantly lower in the COPD and HF patients compared to the CON group (both p<0.05). Exercising LBF increased to a similar extent in HF (2.0(0.4) L/min) compared to CON (2.3(0.3) L/min), but was lower in COPD patients (1.8(0.3) L/min)(p<0.05). Muscle O2 extraction increased in COPD and CON during exercise (p<0,05), but not in HF. Muscle O2 consumption increased during exercise in all three groups, with no differences between groups, and the blood flow conductance (DO2), defined as VO2 divided by the capillary oxygen pressure, increased similarly across all groups, but when adjusting for flow, the DO2 was unchanged in the HF group.
CONCLUSION: When cardiorespiratory limitations are minimized by small muscle mass exercise, disease-specific factors may play a role in peripheral exercise capacity in patients with COPD vs. HF. Thus, low convective O2 transport to contracting muscle seemed to predominate the exercise limitation in COPD, whereas muscle O2 diffusive capacity was blunted in HF.

**HEMODYNAMIC RESPONSE TO METABOREFLEX IN HEART FAILURE WITH REDUCED AND PRESERVED EJECTION FRACTION**

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INTRODUCTION: Chronic heart failure (CHF) is a syndrome characterized by reduced cardiac output (CO) with inability to meet metabolic demands of the working muscle. Ejection fraction identifies two types of CHF: with reduced (HFrEF) or with preserved ejection fraction (HFpEF). Evidence has emerged that metabolic reflex arising from skeletal muscle evokes cardiovascular adjustments during exercise, i.e., the muscle metaboreflex (MM). Hemodynamic response to MM activation is defined as a rise in mean arterial pressure (MAP) achieved by an increase in systemic vascular resistance (SVR) and/or by an increase in CO. In healthy individuals, the MM-induced increase in MAP mainly depends on CO increment, whereas in CHF SVR increments is the principal drive. The aim of the present study was to assess the cardiovascular adjustments during MM activation in both HFrEF and HFpEF patients and to compare their response to that of a control group of healthy individuals (CTL).
METHODS: Three groups of age-matched subjects were studied: 1) 12 males patients diagnosed with HFrEF; 2) 8 males patients diagnosed with HFpEF; 3) 12 healthy males (CTL). All participants underwent a general medical examination, an incremental exercise test on a cycle ergometer, and a MM activation test consisting in a post-exercise muscle ischemia (PEMI) and in a control exercise recovery (CER) session. Hemodynamic parameters were measured by impedance cardiography.
RESULTS: Statistical analysis showed no differences in heart rate (HR) or mean blood pressure (MAP) among groups. Stroke volume (SV) and CO were not significantly different between the two groups of CHF patients. However, SV and CO responses were significantly higher in the CTL than in both CHF groups. SVR response was significantly higher in the HFrEF as compared to the CTL group, while no difference was detected between the CTL and the HFpEF. MAP response to PEMI was not different among groups. Ventricular Filling Rate (VFR, a measure of diastolic function) was significantly higher in CTL group in comparison with both groups of patients. Ventricular Emptying Rate (VER, a measure of systolic function) was significantly higher in the CTL as compared to patients.
CONCLUSION: Despite the reduced capacity to enhance CO, the MAP response was not different among groups, thus indicating that in the CHF patients there is the possibility to reach an effective MAP response. This response was the consequence of an exaggerated SVR response (i.e., vasoconstriction) due to sympathetic overdrive in both groups of patients. These findings are in good agreement with previous research, which demonstrated that the MAP target during the metaboreflex is mainly achieved by a vasoconstriction-mediated rather than a flow-mediated mechanism in CHF. The SVR increase was more accentuated in the HFrEF than in the HFpEF group, and this phenomenon suggests that the cardiovascular impairment was more pronounced in the former than in the latter group.

## Oral presentations

### OP-PN17 Molecular Biology and Biochemistry III

**MIR-16-5P, MIR-19A-3P, MIR-451A, AND MIR-25-3P CARGO IN PLASMA EXTRACELLULAR VESICLES AS BIOMARKERS OF SEDENTARISM AND EXERCISE ADAPTATION**

FERNANDEZ-SANJURJO, M., PINTO-HERNÁNDEZ, P., DÁVALOS, A., DÍAZ-MARTÍNEZ, A.E., AMADORODRIGUEZ, L., TOYOS-RODRIGUEZ, C., CASTILLA-SILGADO, J., TERRADOS, N., FERNÁNDEZ-GARCÍA, B., IGLESIAS-GUTIÉRREZ, E.

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INTRODUCTION: A sedentary lifestyle is a leading risk factor for global mortality. Objective measures of training status, as well as a deeper understanding of the molecular mechanisms underlying the effects of sedentarism, are indispensable. Extracellular vesicles have been validated as key players on interorgan crosstalk in response to exercise (1). The extracellular vesicles cargo comprises a variety of macromolecules, including microRNAs (miRNAs), which have been described to response to exercise(2).
Our aim was, first, to analyse the extracellular vesicle microRNA (miRNA) profile of chronically trained young male athletes, endurance and resistance, compared to their sedentary counterparts. Then, we aimed to analyse the changes in this epigenetic profile over the course of a training macrocycle in elite athletes.
METHODS: A descriptive case-control design and a prospective cohort study were carried out. 16 sedentary young men (SED, 23.2±2.9 y), 16 Olympic male endurance athletes (END, 25.1±7.0 y) and 16 male resistance athletes (RES, 22.1±5.2 y) volunteered to participate in the case-control study. For the prospective cohort study, 8 elite male athletes (26.2±3.6 y) were recruited from Olympic kayak team, a sport with both a high endurance and resistance requirement. The plasma extracellular vesicle miRNA cargo was analysed by means of Next Generation Sequencing, followed by internal and external validation using RT-qPCR. An in silico functional analysis was performed. Physiological and biochemical parameters were also determined.
RESULTS: miR-16-5p, miR-19a-3p and miR-451a were significantly upregulated in SED compared to END and RES. TUB and TENT5C genes are common validated targets of these miRNAs, with a potential role in the anti-obesity and anti-tumour effects of training. Besides, miR-25-3p was specifically down-regulated in END compared to SED. These miRNAs show an individual response in elite athletes during a macrocycle of training. Furthermore, miR-19a-3p and miR-451a correlate with maximal aerobic capacity (VO2max) and maximal heart rate (HRmax) of the athletes, respectively.
CONCLUSION: These facts highlight the potential of these microRNAs for personalised training interventions and allow for greater resolution in the description of training adaptation. As a common perspective between the two designs, low miR-451a levels correlate with lower HRmax and lower HRmax has been reported in aerobically and anaerobically trained athletes compared to their sedentary counterparts(3). To conclude, miR-16-5p, miR-19a-3p, miR-451a and miR-25-3p from extracellular vesicles provide an objective signature of sedentary lifestyle and are also able to describe an individual response to training.
1. Whitham M, et al. Cell Metab. 2018;27(1):237-51 e4.
2. Fernandez-Sanjurjo M, et al. Exerc Sport Sci Rev. 2018;46(3):160-71.
3. Whyte GP, et al.. Int J Sports Med. 2008;29(2):129-33.

### MIR-29 FAMILY IN RESPONSE TO ENDURANCE AND RESISTANCE EXERCISE IN MOUSE BRAIN TISSUE

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INTRODUCTION: Regular exercise before or during the preclinical stage of Alzheimers disease (AD) has been shown to have an effect as a potential adjuvant treatment to delay cognitive decline. Moreover, exercise can modify the expression of certain circulating miRNAs in humans 1 and at the brain level in animal models of the disease 2. miR-29 family, miR-29a/b1 and miR-29b2/c clusters, is decreased in the brain tissue of 30% of patients with late-onset AD. Bace1 levels on these patients have a higher expression in accordance with the down-regulation of these miRNAs. This target is the main determinant of β-amyloid peptide formation 3. Therefore, the aim of the study was to examine the effect of 4 weeks of endurance and resistance training on miR-29a, b, c and Bace1 expression in the brain of wild-type (WT) and miR-29a/b1 knock-out mouse model group (miR29KO).
METHODS: Brain areas samples were collected from 26 C57BL/6N WT and 23 C57BL/6N miR-29KO mice, divided into three groups: sedentary (WTCON; KOCON), endurance training on a treadmill (WTEND; KOEND), and resistance training on a vertical ladder (WTRES; KORES). After 2 weeks of adaption, mice were trained for 4 weeks, 5 days/week. Maximal endurance and resistance capacity test were performed before and after training. The expression of miR-29a-3p, miR-29b-3p and miR-29c-3p and Bace1 were determined in the hippocampus, striatum, cortex and cerebellum of every group.
RESULTS: KOCON had a lower level of strength, but a same endurance capacity compared to WTCON. In response to training, KORES did not improve their strength performance, but on the contrary, KOEND improved their performance as the same way as a WT did. In both sedentary groups, KOCON mice had no miR-29a-3p expression in the four brain areas studied. Interestingly, only the hippocampus and striatum showed significant differences compared to WTCON. Both types of exercise increased only miR-29b-3p expression in the hippocampus of both genotypes. However, in the WT group these data were not significant.
CONCLUSION: The miR-29a/b1 cluster plays a relevant role in adaptation in resistance training, while its absence seems to have no effect in endurance training. Interestingly, prior to exercise intervention, miR-29a-3p expression is tissue-specific in WT mice, with the cortex and cerebellum showing similar expression levels to KO mice. However, both exercise intervention, in both genotypes, increases the expression of the other cluster partner, miR-29b1-3p, which may be a compensatory response to the other miR-29b2/c cluster.
1. Fernandez-Sanjurjo M et al. Circulating microRNA as Emerging Biomarkers of Exercise. Exerc Sport Sci Rev. Jul 2018.
2. Cosin-Tomas M et al. Epigenetic alterations in hippocampus of SAMP8 senescent mice and modulation by voluntary physical exercise. Front Aging Neurosci. 2014
3. Hebert SS et al. Loss of microRNA cluster miR-29a/b-1 in sporadic Alzheimers disease correlates with increased BACE1/beta-secretase expression. Proc Natl Acad Sci U S A. Apr 29 2008

### BDNF AND C10ORF71 METHYLATION LEVELS ARE ASSOCIATED WITH HANDGRIP STRENGTH IN APPARENTLY HEALTHY SCHOOL-AGE CHILDREN AFTER A 3-MONTH INTEGRATED NEUROMUSCULAR TRAINING

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INTRODUCTION: Integrated Neuromuscular Training (INT) is a training designed to improve physical fitness and motor competence. BDNF is a gene involved in cognitive function, associated with higher percentage of fast-twitch muscle fibers and handgrip strength in power athletes (1). C10orf71 is a gene expressed in muscle and cardiac tissue, with a role in cardiomyocyte hypertrophy and cardiovascular health (2). However, no studies have examined its connection to physical exercise. Our objectives are: 1) to assess the effects of a 3-month INT on body composition (BC), physical fitness (PF), motor competence (MC) and DNA methylation levels of BDNF and C10orf71; and 2) to test the association of BDNF and C10orf71 with BC, PF and MC before and after the INT.
METHODS: A total of 160 apparently healthy children at the age of 7-8 years were recruited from schools in Cassà de la Selva and Salt (Northeastern Spain) who underwent a 3-month INT. INT was organized in different training circuits and applied twice/week during physical education (PE) lessons. Children were evaluated before and after the INT. BC (ponderal index, fat mass, lean mass, and bone mass), PF (endurance, handgrip strength and balance) and MC were assessed at schools. Saliva samples were collected to assess DNA methylation in a subset of the same children (sample size estimated by GRANMO 7.12 program).
RESULTS: There was a significant decrease in ponderal index, increase in lean and bone mass, improvement in endurance, handgrip strength, balance and MC after the INT ($p<0.001$). Moreover, DNA methylation levels of BDNF ($p=0.021$) and C10orf71 ($p=0.028$) decreased after the INT. There was a negative association of BDNF methylation levels with handgrip strength ($p=0.035$) and balance ($p=0.024$) after the INT that was not present at baseline. Finally, there was a negative association between C10orf71 methylation levels and handgrip strength, again after the INT ($p=0.05$). All correlations were maintained after correcting for age, sex and ponderal index.
CONCLUSION: A 3-month INT during PE lessons is effective to improve BC, PF and MC, as well as to decrease DNA methylation levels of BDNF and C10orf71 in healthy school-age children, thus suggesting a potential improvement of the cognitive function and the cardiovascular health. The decrease in DNA methylation of BDNF might be induced by the increase in handgrip strength and balance after the INT, while the decrease of C10orf71 might be induced by the increase in handgrip strength.
References:
1. Guilherme JPLF et al. The BDNF-Increasing Allele is Associated With Increased Proportion of Fast-Twitch Muscle Fibers, Handgrip Strength, and Power Athlete Status. J Strength Cond Res, 2020.
2. Dierck F et al. The novel cardiac z-disc protein CEFIP regulates cardiomyocyte hypertrophy by modulating calcineurin signaling. J Biol Chem, 2017. 292(37):15180.

### EFFECT OF THE MCT1 T1471A POLYMORPHISM ON THE LACTATE-LOAD RELATIONSHIP: A PILOT STUDY

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INTRODUCTION: The membrane transport of lactate is mediated by MCTs, being MCT1 expressed in most tissues (1). This transporter seems to be affected by the T1470A SNP in the MCT1 gene (rs1049434), leading to differences in lactate levels between genotypes (2).

However, there is a lack of studies investigating lactate kinetic during an incremental effort. Thus, the purpose of this study was to analyse the influence of the MCT1 SNP on the lactate response during an incremental test a cycle ergometer in females and males.
METHODS: Twenty trained males (AA: n=10, 23.7±4.3years, 73.13±6.71kg and 177.04±5.24 cm; TT: n=10, 23.6±6.93years, 70.08±5.23kg and 177±5.78cm) and twenty-four females (AA: n=12, 18.16±6.09years, 58.4±8.03kg and 164.69±8.15cm; TT: n=12, 22.58±5.48years, 55.39±4.81kg and 161.78±5.22cm) were classified according to their genotype. Genotyping was done using real-time PCR. The incremental test (cycle ergometer) started at 75 W, increasing 35 W every 3 min until exhaustion. Capillary lactate levels were analysed using a lactate analyser (Lactate Plus, Germany) at rest, in the last thirty seconds of each step and immediately post-maximal effort. Threshold (LT) was determined via D-max method (3). Mann-Whitney U test was used to analyse differences between genetic groups. The level of significance was set at p≤ 0.05.
RESULTS: No differences between genotypes were found in the power output at the LT (Females: AA=144.09±12.65W, TT=134.77±10.96W, p=0.072; Males: AA=179.57±19.28W, TT=189.25±21.31W, p=0.436) or the position of the LT relative to peak power (Females: AA=72.48±7.18%, TT=72.95±7.59%, p=0.918; Males: AA=64.23±8.39%; TT=66.68±4.6%; p=0.631). Also, similar final lactate (Females: AA=10.95±2.47mmol/L, TT=9.78±1.52mmol/L, p=0.291; Males: AA=11.92±2.31mmol/L, TT=10.77±1.60mmol/L, p=0.105) and peak power (Females: AA=194.42±31.4W, TT=185.67±19.95W, p=0.671; Males: AA=281.50±25.82W, TT=285.00±36.89W, p=0.796) were found between genotypes.
CONCLUSION: Our results indicate that the influence of the T1470A SNP in the MCT1 gene could not be relevant in LT during an incremental test in cycle ergometer, in accordance with a previous data (4). In contrast, final lactate in males was higher in T allele carriers compared to A allele carriers after an incremental test on a rowing ergometer, without differences in females (5). Contrary to cycling, rowing involves upper and lower extremities, suggesting that a greater muscle mass involvement is needed during exercise to expose the effect of this SNP (rs1049434) during an incremental test. Moreover, the effects of the T1470A SNP in the MCT1 gene seem to be similar in both sexes.
FUNDING: Universidad Politécnica de Madrid: PINV18ENW9ML92B2287R
REFERENCES
1. Halestrap AP. 2013.DOI:10.1016/j.mam.2012.05.003
2. Cupeiro R. 2012.DOI:10.1016/j.jsams.2012.03.009
3. Cheng B. 1992.DOI:10.1055/s-2007-1021309
4. González-Haro C.2015.DOI: 10.1519/JSC.0000000000000994
5. Fedotovskaya ON.2014.DOI: 10.1123/IJSPP.2013-0026

## Oral presentations

### OP-BM10 Balance II

#### ALTERATIONS IN BELLY GEARING AND RATE OF TORQUE DEVELOPMENT IN PARKINSON'S DISEASE PATIENTS

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INTRODUCTION: Although Parkinsons disease (PD) is a degenerative disorder of the central nervous system, the strength deficit of the affected limb can be partially explained by peripheral alterations (Smart et al., 2019). Recent studies demonstrated that the muscle-tendon mechanical parameters (e.g. muscle and tendon stiffness) are impaired in early-stage Parkinson's disease patients, negatively affecting their ability to produce force (Murusiak et al, MovDisord, 2011). This study aimed to investigate how muscle and tendon mechanical properties affect the ability to produce torque rapidly (e.g. rate of torque development, RTD) in PD patients.
METHODS: Seven participants with early stage PD (UPDRS<30) and seven age matched healthy controls participated to the study. They were asked to perform six maximum voluntary contractions (MVC) where the torque of the quadricep muscles, the elongation of the patellar tendon, the EMG activity and the fascicle behavior of the vastus lateralis (VL) were recorded. After that, participants performed 6 explosive contractions at the optimal knee angle. In the entire procedures a dynamometer, an EMG apparatus and an ultrasound were utilized. Maximum isometric torque, maximum EMG activity and patellar tendon stiffness (PTStiff = ΔForce/Δlength) were determined during the MVCs. RTD (Maffiuletti et al., 2016) and belly gearing (ΔBelly length/Δfascicle length) (Azizi et al., 2008) were determined in 5 different time windows before torque onset (0-25,25-50,50-75,75-100 and 100-125ms). RTD and EMG were normalized (nRTD, nEMG) for their maximum values collected during MVCs.
RESULTS: Lower nRTD values were observed in PD than in control subjects, with significant differences from 25 to 100 ms (group: P<0.05, time*group: P<0.01), whereas similar values were observed in the first and in the last time windows (0-25 and 100-125 ms). In both groups, belly gearing decreased significantly over time (time: P<0.05), whereas nEMG showed an opposite trend (time: P<0.01). PD subjects showed lower values of belly gearing (group: P<0.01, time*group: P<0.05) and nEMG when compared with control subjects in all the investigated time windows (group: P<0.01). Although PTStiff was higher in PD patients, no significant differences were observed between populations.
CONCLUSION: The observed changes in RTD could not be entirely explained by changes in the EMG signal, but also by muscle and tendon mechanical properties. The lower RTD values (from 25 to 100 ms) in PD patients are, indeed, associated with lower values of belly gearing compared to controls (the lower the belly gearing the less effective the transmission of force along the muscle-tendon unit). On the other hand, the comparable values of RTD between groups in the first-time window (0-25 ms) could be attributed to the larger (albeit not significant) values of tendon stiffness in PD subjects.

#### TEST-RETEST RELIABILITY OF CORTICOSPINAL EXCITABILITY MEASUREMENTS DURING BALANCE PERTURBATION

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INTRODUCTION: Posterior balance perturbation evokes short- (SLR ~30-50ms), medium- (MLR ~50-60ms), and long-latency responses (LLR ~70~90ms) in soleus muscle after ankle activation and before voluntary muscle contraction. Corticospinal and spinal mechanisms could contribute differently to each response, which can be investigated using transcranial magnetic stimulation (TMS) and peripheral nerve stimulation (PNS) methods, respectively (1). Good reliability of TMS-induced motor evoked potential (MEP) and PNS-induced Hoffman-

reflex (H-reflex) responses has been shown in several tasks, such as dynamic muscle contraction and standing (2, 3). However, it is not well known how reliable TMS and PNS methods are in dynamic balance conditions. This study investigated the test-retest reliability of MEP and H-reflex amplitude from TMS and PNS delivered at different muscle response phases during balance perturbation.
METHODS: 14 subjects completed two test sessions (S1 and S2). In each session, the balance perturbation system operated at 25cm/s, accelerating at 2.5m/s2 over 30cm displacement. Single-pulse TMS at 110% active motor threshold and PNS at 5% (±2%) of maximum M-wave elicited MEPs and H-reflexes in the right leg soleus muscle at four phases after ankle activation (10ms: Onset; 40ms: SLR; 80ms: LLR; and 140ms: voluntary activation), respectively. Test-retest reliability of MEPs and H-reflex were assessed via intraclass correlation coefficients (ICC2,1) with an absolute agreement analyzed between- and within-sessions.
RESULTS: MEPs showed good to excellent test-retest reliability (ICC=0.823-0.960) between sessions, while H-reflex demonstrated moderate to good reliability (ICC=0.626-0.887). Within-session ICC of MEPs showed excellent reliability in S1 (ICC=0.927-0.983) in all phases. In S2, ICC of all MEPs was excellent (ICC=0.917-0.978) except at 80ms (ICC=0.6). Within-session reliability of H-reflex was good to excellent in both sessions (S1: ICC=0.945-0.985; S2: ICC=0.874-0.994).
CONCLUSION: TMS measurements showed acceptable test-retest reliability for both between- and within-session comparisons in different phases. The highest reliability was observed at the voluntary activation phase (140ms), indicating that MEPs are less variant during voluntary activation compared with reflex response phases. This is supported by an earlier finding of higher MEP reliability in active muscle compared to muscle at rest (3). H-reflex demonstrated lower reliability in balance perturbation tasks compared to TMS, which is also in line with previous study (3). Within-session reliability was extremely robust. In conclusion, these methods can be considered usable in measuring corticospinal excitability during future balance perturbation experiments.
References
1) Taube et al, Appl Physiol, 2006
2) Hopkins et al Electromyorgr Clin Neurophysiol, 2000
3) Tallent et al, PLoS One, 2012

### A SYSTEMATIC REVIEW AND META-ANALYSIS OF THE FOAM ROLLING TRAINING EFFECTS ON RANGE OF MOTION

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INTRODUCTION: In the last decade foam rolling has become a popular technique in sports practice (1). A recent meta-analysis showed that a single foam rolling exercise can acutely increase the range of motion (ROM) of a joint (2). However, evidence on the training effects of foam rolling on joint ROM, is limited and inconsistent (3,4). Hence, there is a need to conduct a meta-analysis on the long-term training effects of foam rolling on ROM. Therefore, the purpose of this meta-analysis was to investigate the effects of foam rolling training interventions on joint ROM in healthy participants.
METHODS: For the main meta-analysis we applied a random-effect model, whilst subgroup analyses were performed by applying a mixed-effect model. Subgroups included comparisons of the intervention total load (i.e., time under tension; ≤ 1520s vs. > 1520s), duration (≤4 weeks vs. >4weeks), comparisons between muscles tested (e.g., hamstrings vs. quadriceps vs. triceps surae), and study designs (RCT vs. CT).
RESULTS: In total 11 studies with 46 effect sizes were included in this meta-analysis. The main meta-analysis revealed a moderate effect of foam rolling training on ROM increases in the foam rolling group compared to the control group (ES = 0.823; Z = 3.237; CI (95%) 0.325 to 1.322; p = 0.001; I2 = 72.76). Subgroup analyses showed a significant difference in the intervention duration in favor of interventions >4 weeks compared to ≤4 weeks for ROM increases (p=0.049). Moreover, a further subgroup analysis showed significant differences between the muscles tested (p=0.047). While foam rolling increased joint ROM when applied to hamstrings and quadriceps, no such increase was observed in ankle dorsiflexion ROM after triceps surae rolling.
CONCLUSION: Our meta-analysis showed that a longer duration (i.e., > 4 weeks) foam rolling intervention can increase joint ROM in young healthy participants. However, ROM increases may be muscle-and/or joint dependent as foam rolling on the triceps surae muscle did not increase ankle dorsiflexion ROM. Although not much evidence, it is assumed that altered pain perception is a possible mechanism for long-term increases in ROM after a foam rolling intervention rather than changes in soft tissue stiffness (3).
REFERENCES:
1. Behm D. et al. (2020) Foam Rolling Prescription: A Clinical Commentary. J. strength Cond. Res. 34:3301–3308
2. Hodgson D. et al. (2018) Four weeks of roller massage training did not impact range of motion, pain pressure threshold, voluntary contractile properties or jump performance. Int J Sports Phys Ther 13:835–845.
3. Kiyono R. et al. (2020) Effects of 5-Week Foam Rolling Intervention on Range of Motion and Muscle Stiffness. J Strength Cond Res
4. Wilke J. et al. (2020) Acute Effects of Foam Rolling on Range of Motion in Healthy Adults: A Systematic Review with Multilevel Meta-analysis. Sport Med 50:387–402.
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### THE ACUTE EFFECTS OF VOLUNTARY BREATHING PATTERNS ON POSTURAL CONTROL DURING WALKING

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INTRODUCTION: Breathing and postural control are reported to be both neuromuscularly and mechanically interdependent, as the use of breathing muscles during respiration affects how these muscles are used for non-breathing movements and postural control. Previous studies have reported conflicting results regarding the effects of voluntary breathing patterns on postural control during static postural tasks (Hamaoui et al., 2010; Hernandez et al., 2019). The purpose of the current study was to evaluate the acute effects of thoracic and abdominal breathing pattern on trunk muscles activation level and spatiotemporal gait parameters during walking in healthy individuals.
METHODS: Twelve healthy, physically active participants with normal spirometric values volunteered for the study. Participants were instructed to walk barefoot for 2 minutes on an instrumented treadmill at the speed of 5.0 km/h. First with involuntary/neutral breathing (NB) and then, in a randomized order, with voluntary/abdominal breathing (AB) and voluntary/thoracic breathing (TB). Respiratory inductive plethysmography was used to assess breathing pattern, and each participant received real-time feedback regarding thorax and abdomen displacement during trial and testing. The EMG activity of sternocleidomastoid (SCM), upper trapezius (UT), and erector spinae muscle at the level of 9th thoracic vertebrae (EST9) and 5th lumbar vertebrae (ESL5) was recorded simultaneously on the right side of the body during each testing condition. The EMG signal was reported as a percentage of each muscle's maximum voluntary contraction (%MVC).

RESULTS: The findings of the current study revealed that the percentage of rib cage contribution to breathing was significantly lower during AB (35.1+/-8.1%) compared to TB (74.2+/-7.5%) and NB (65.0+/-6.6%) ($p<0.001$). Thoracic breathing elicited significantly greater activity of SCM (4.5+/-2.0 %MVC) compared to AB (3.7+/-1.4 %MVC) ($p<0.05$), whereas no significant differences were detected compared to NB (4.2+/-2.4 %MVC). No significant differences were detected between NB, AB, and TB with respect to the EMG activity of UT, EST9 and ESL5. Regarding dynamic center of pressure parameters, no significant differences were detected between the 3 breathing patterns on antero/posterior and mediolateral symmetry.
CONCLUSION: Postural control during walking was not affected by the voluntary control of breathing. Although TB demonstrated increased activation of the SCM, which has been associated with breathing pattern disorders, AB does not appear to emphasize diaphragm's stabilizing function as far as trunk muscles activation level is concerned. In addition, trunk and lower limbs movements during walking appear to compensate for the respiratory induced postural perturbations caused by the voluntary breathing patterns.
References:
Hamaoui, A., Gonneau, E., Le Bozec, S., 2010. Neurosci. Lett. 475, 141–144.
Hernandez, L., Manning, J., Zhang, S., 2019. Gait Posture 68, 488–493.

## Invited symposia

### IS-SH02 Social inequalities in sports, physical activity and health – interdisciplinary and cross-cultural perspectives

#### YOUNG PEOPLE, PHYSICAL ACTIVITY AND HEALTH; INTERSECTIONS OF RACE AND SOCIAL CLASS.

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With the current global economic uncertainties, recession and projected increases in poverty especially amongst young Black Asian and Minority Ethnic (BAME) people, understanding how cultural dispositions toward physical activity (PA) and health shape young people's engagement is crucial. This paper will draw on social theory in an effort to explore the ways in which the culturally diverse family in cultivating young peoples dispositions towards physical activity and health. Interviews with 10 families' (n=43) explored determinants to sport and PA participation and gained further insights in the way families conceptualise sport and PA. A series of accounts of these BAME families' voices were produced using thematic analysis. The paper suggests that cultural transmissions within the family can influence pedagogical orientations and establish embodied practices. These cultural transmissions are closely related to economic, cultural and physical capital where agency within the family environment is structured through certain socioeconomic, racial and religious backgrounds that are crucial to the development of embodied dispositions, which can facilitate or constrain experiences based on place, locality, and environment. The paper suggests that a perception of BAME families as a homogeneous group is not helpful in understanding existing inequalities or health disparities. BAME young people within similar social groupings experience inequalities in various forms and levels.

#### DEALING WITH PHYSICAL ACTIVITY AND HEALTH NORMS IN SOCIALLY UNDERPRIVILEGED CONDITIONS

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Socially underprivileged populations are more likely to experience health problems than socially privileged populations. Nevertheless, national health promotion programmes mostly neglect social conditions, and stress the importance of self-management in health questions. However, in order to tailor health education programmes to the needs and interests of socially disadvantaged populations, it is important to understand the ways they understand health in the context of their daily experience, and how they deal with the given social and environmental circumstances. Thus, we conducted a comparative study in Germany, France, Switzerland, and Italy. All study participants were living in socially disadvantaged neighbourhoods. In total, 167 children aged 7 to 11 years (mean = 8.76 years, SD = 0.68) participated in 36 focus groups; 35 parents were involved in semi-structured interviews. The results show that both, children and parents, independently of the country, repeat the simplistic health education messages like being physically active and eating healthy to avoid overweight. They focus exclusively on the individual´s responsibility. We can identify strategies of dealing with barriers and adapting the norms to their own lifestyle. So, the overemphasis on self-causation in health education programmes may have unwanted side effects evoking increased guilt in the victims of illness, and thus causing double discrimination effects for socially underprivileged populations.

#### TACKLING PHYSICAL INEQUALITIES AND INCREASING PUPILS' MOTIVATION IN PE: AN OVERVIEW OF THE BELGIAN IMPLEMENTATION OF THE OBLOMOV METHOD

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Levels of physical fitness, motor skills and/or body image can influence dramatically pupils' motivation towards physical activity. Moreover, a lack of movement towards the development of youths' physical literacy that contributes to their involvement in an active lifestyle. This vicious circle is sometimes reinforced in PE/sports settings when the learning goals and tasks proposed to the children do not correspond to their capabilities and personal resources. Individualized approaches are recommended but teachers experience at present many difficulties to implement it. Integrating short periods of High Intensity Intermittent Training (HIIT) in theatre open scenarios represents an original approach to motivate youths who are not at ease with physical activities. The foundations of this approach refer to the motivational power of playful situations and the imaginary of the pre-adolescents. It is the core of an Erasmus+ project called OBLOMOV (https://www.oblomovproject.eu/). In Liege, two studies have been conducted to analyze youths' reactions to the scenarios that have been elaborated: (1) an unit of 10 PE lessons with 8 classes of 5th-6th graders; (2) a series of 3 afternoons proposed to overweight primary school children by the university obesity clinic. Findings confirm the potential impact of the methodology respecting the PAMIA principles (Pleasure, Achievement, Movement, Interaction, and Autonomy). Physical educators should integrate it more often in their lessons.

# Oral presentations

## OP-BM17 Paralympics

### A PRELIMINARY PROFILING OF THE PARALYMPIC POWERLIFTING ATHLETE: ANTHROPOMETRIC, NEUROMUSCULAR AND TECHNICAL CORRELATES OF PERFORMANCE

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INTRODUCTION: In Paralympic sport, the evaluation of athlete's characteristics within the domain of performance-impairment relationship is the basis of classification to guarantee a fair competition [1]. At present, the scientific literature on Paralympic powerlifting is very limited and the evidence-based knowledge about such aspects is sparse. This study aims at understanding which factors (i.e., anthropometric, neuromuscular and technical) are related to performance to gain knowledge for evidence-based classification in this sport.
METHODS: Seven Paralympic powerlifters of elite international level participated in the study (disability types: 1 arthrogryposis, 2 spina bifida, 3 mono-lateral and one bilateral amputation). After a standardized warm-up, four attempts of one repetition maximum (1RM) paralympic bench press were performed and data from the best valid lift was considered for the analysis. Anthropometric measures (e.g., body mass, fat mass, sitting height, arm span, upper body segments length, breadths and circumferences, etc.) were taken before 1RM testing. Electromyographic activity during the concentric phase of the lift was bilaterally recorded in the deltoid anterior, pectoralis major, triceps, latissimus dorsi and abdominal external oblique muscles, and normalised to maximal voluntary isometric contractions. Linear displacement and velocity parameters of barbell trajectory were obtained from video analysis and extracted from both concentric and eccentric phases of the lift. Correlation analysis was performed between 1RM load corrected by the Haleczko formula and the anthropometric, neuromuscular and technical parameters, and significant strong correlates were included in a multiple regression model.
RESULTS: Among the anthropometric measures, forearm and trunk length, and wrist width were positively associated with corrected 1RM load ($r > .82$, $p < .05$). The drift of barbell real trajectory from the straight-line displacement during the eccentric phase was the only technical factor to be significantly and strongly positively correlated with corrected 1RM ($r > .77$, $p < .05$). No neuromuscular factor showed a significant correlation. Results from the multiple regression model indicated the trunk length as the main predictor of 1RM corrected value ($R= .93$, $R2= .87$, adjusted $R2= .85$, $p = .002$).
CONCLUSION: Upper body anthropometric factors appear to have the highest degree of association with Paralympic powerlifting performance compared to both neuromuscular and technical factors. Unlike the previously reported impact of lean body mass on 1RM bench press in non-disabled powerlifters [2], body composition factors seem to not play a significant role in performance outcome in Paralympic powerlifting. Although preliminary, the current findings provide a starting point for advancing evidence-based classification in this Paralympic sport.
REFERENCES
[1] Mann DL et al. (2021). J Sports Sci, 39(sup1).
[2] Reya M et al. (2021). J Strength Cond Res, 35(8).

### LONGITUDINAL FUNCTIONAL ASSESSMENT OF A TRANSFERMORAL AMPUTEE PATIENT TREATED WITH OSSEOINTEGRATION SURGERY

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INTRODUCTION: The socket-type prosthesis is the treatment of election for the lower-limb transfemoral amputation. However, patients often report skin abrasions, skin sweating, lack of balance, and walking difficulties [1-2]. The osseointegration technique is an alternative treatment for amputee patients that limits the socket-related problems and provides a more physiological mechanical loading [1].
After surgery, a critical functional recovery and dedicated rehabilitation phase is required. Little functional assessment of these patients has been reported in the literature. The purpose of the present study was to provide the functional assessment of a transfemoral amputee patient before osseointegration surgery and after rehabilitation by means of wearable sensors.
METHODS: A transfemoral amputee patient (male, 47 years, time from amputation 18 years) scheduled for osseointegration surgery was enrolled. The patient was able to walk without aids and performed a gait test the day before surgery with his standard socket-type prosthesis, consisting in 10-meters walking in a hospital indoor hall, two at self-selected speed and two at the fastest speed possible. The test was repeated 3 months after surgery (after the clearance from the rehabilitation, 3M FU), and 6 months after surgery (6M FU).
A set of 15 wearable inertial sensors (Awinda, Xsens Technologies) was used to collect full body kinematics. Complete gait cycles were isolated and spatiotemporal and kinematical parameters were extracted. The differences between the amputee (AL) and the sound (SL) limb among the follow-ups were reported. One-way ANOVA with post-hoc comparisons was conducted in Spm1D ($p<0.05$).
RESULTS: Shorter step length and longer swing phase were found for the AL at pre-op, with greatest differences in the midstance. Also, hip abduction and rotation, pelvis forward tilt and obliquity, trunk forward tilt, and lateral bending on the AL were also noticed. At follow-ups, symmetry index progressively improved (1.14, 1.09, 1.06 at pre-op, 3M FU, and 6M FU, respectively). Asymmetries in hip abduction, hip rotation, and pelvis rotation decreased at follow-ups and no more trunk forward and lateral tilt were found.
CONCLUSION: The altered spatiotemporal and kinematical parameters found preoperatively were in line with the current literature [1]. After rehabilitation, the patient showed higher time spend on the AL and lesser kinematical asymmetries. The osseointegration surgery showed to progressively restore a physiological kinematics in the transfemoral amputee patient.

### PROSTHESIS STIFFNESS AFFECTS INTACT AND RESIDUAL LIMB STIFFNESS DIFFERENTLY IN A UNILATERAL TRANSTIBIAL AMPUTEE RUNNER.

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*SALOMON SAS*

INTRODUCTION: Recent developments in the prosthetics field have helped people with lower limb amputation run by providing carbon fiber blades with spring-like properties. A spring-like behavior can also be applied to the entire leg, in a so called "spring-mass" model of

running (1). In unilateral transtibial amputee runners, the spring-mass behavior was shown to be dependent on the leg (sound vs. prosthetic) and the characteristics of the prosthesis used (2). This case study aimed at determining the effect of prosthesis stiffness on spring-mass behavior of the sound and prosthetic leg in a unilateral transtibial amputee runner.
METHODS: One male below knee amputee runner participated in this study. He used a newly developed running blade (Hopper, Hopper SAS, France) that allowed stiffness adjustment thanks to a mechanism at the stump-blade junction. Two blade stiffness conditions were compared (HIGH = 21.6 kN/m, LOW = 18.2 kN/m) while running at 11 and 13 km/h on a 15-m pathway. Measurements included ground reaction forces with 3 force plates embedded in the pathway. Centre of mass vertical displacement was derived from force data as described previously (2). 10 steps (5 per leg) were collected for each speed and blade stiffness. The vertical stiffness (Kvert) was calculated for both the sound and prosthetic leg using the equation Kvert = Fpeak/Δy with Fpeak the maximal vertical ground reaction force and Δy the maximal vertical displacement of the center of mass during ground contact. As data from only one runner were analyzed, the trends between conditions are presented using means and 95% confidence intervals (CI).
RESULTS: At 11 km/h, similar Kvert were observed in the sound and prosthetic leg for the LOW condition (47.2 CI=3.3 vs. 43.1 CI=2.6 N/body weight/m, respectively), whereas Kvert was higher in the sound leg for the HIGH condition (66.5 CI=9.8 vs. 45.7 CI=1.5 N/body weight/m). This difference in the sound leg was mainly due to a decreased Δy in the HIGH condition.
Similar results were observed at 13 km/h. Kvert in the LOW condition was unchanged between sound and prosthetic leg (54.2 CI=2.5 vs. 49.3 CI=3.7 N/body weight/m, respectively), but was higher in the sound leg for HIGH (61.1 CI=6.3 vs. 48.5 CI=2.7 vs. N/body weight/m). This difference in the sound leg was also due to a decreased Δy in the HIGH condition.
CONCLUSION: The higher Kvert in the sound limb is in line with a previous study in unilateral transtibial amputee runners (3), but was observed only in the highest running blade stiffness condition in the present study. In other words, the blade stiffness had an influence on the vertical stiffness in the sound leg only. This could be due to compensatory mechanisms in the joint stiffnesses of the sound leg as proposed previously (3). These results show that blade stiffness can serve as an adjustment variable for unilateral transtibial amputee runners.
REFERENCES
1) Blickhan, J Biomech, 1989.
2) Wilson et al., Prosth Orth Int, 2009.
3) Hobara et al., J Biomech, 2013.

**OVERALL ATHLETE WELL-BEING STATES IN JAPANESE ELITE ATHLETES VIA A NATIONAL SURVEY**

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INTRODUCTION: It appears that the optimization of athlete well-being has received considerable attention in academic and practical fields of high performance sport. The International Olympic Committee has promoted the importance of athlete well-being particularly focused on mental health (Reardon et al., 2019). Nevertheless, the literature is limited to understand the case of Japanese athletes. Therefore, the aim of this study was to conduct a fact-finding national survey of athlete well-being in Japan.
METHODS: First, a total of 100 Japanese university student-athletes (43 male, 57 female) from 17 Olympic and 7 Paralympic sports completed an online survey as a pilot study. The validity, reliability, and feasibility of the national survey were verified in the pilot study. Consequently, the validated survey was applied to Japanese elite athletes who competed at the Tokyo 2020 Olympic and Paralympic Games. The respondents were 92 Japanese elite athletes (42 male, 50 female), aged 16 to 64 years (30.8±9.4). The state of the respondents' well-being in the past 3 years was calculated on a 5-point scale (1 = very good, 2 = somewhat good, 3 = not so good, 4 = not good at all, 5 = not sure) to account for the influence of the COVID-19 widespread in 2020 in Japan.
RESULTS: Test-retest reliability of the national survey was found to be good (r = 0.7 ± 0.3) (Hopkins, 2000). The results of the national survey indicated that the overall states of athlete well-being in the Japanese elite athletes were perceived as relatively good in terms of physical, mental, educational, organizational, social, and financial aspects (Wylleman, 2019). Interestingly, there were 78 respondents (84.8%) who had someone they could talk to when they felt anxious or distressed, while 55% of the university student-athletes indicated the availability of someone whom they could approach in the pilot study. Parents (48.7%) were the most common people to talk to about their concerns and problems of well-being, followed by friends (44.9%), teammates (47.4%), and coaches (38.5%). However, many Japanese elite athletes (84.8%) mentioned that they had never received or used athlete well-being support from the national sport federations and the government due to lack of information and accessibility to the services etc. The respondents agreed that the national sport federations and the government should implement measures to enhance and support athlete well-being including consultation services, athlete education, and coach education.
CONCLUSION: Taken together, we could recommend to develop an evidence-based national system to enhance and support athlete well-being in Japan and to provide related programmes (consultation services and education etc) so as to support athlete well-being in a better way than currently available.

## Oral presentations

### OP-SH14 Youth development

**CHANGES IN THE PERCEIVED MOTIVATIONAL CLIMATE AS PREDICTORS OF ATHLETES' GOAL-DIRECTED EFFORT DURING A SEASON: MEDIATIONAL ROLE OF GOAL MOTIVES**

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*UNIVERSITY OF VALENCIA*

Introduction
Self-Concordance Model (Sheldon & Elliot, 1999) emphasizes the importance of motives that underlie the goals pursued (and whether these motives are autonomous or controlled) to the effort exerted to achieve one's goals. Self Determination Theory framework points to the importance of the motivational climate that coaches create to athletes' goal regulation (Ryan & Deci, 2017). According to Duda's (2013)

multidimensional and theoretically-integrated conceptualization of the motivational climate, more or less empowering (task-involving, autonomy supportive, and socially supportive) and disempowering (ego-involving and controlling) motivational climates hold differential implications for the processes underlying goal pursuit.
Past work grounded in SDT and SCM has been primarily cross-sectional and/or didn't take into consideration the higher order empowering/disempowering climate dimensions (Martínez-González et al., 2021). Adopting a longitudinal design, the purpose of this research was to test if changes in perceived empowering and disempowering climates predicted changes in the goal-directed effort during the season through changes in autonomous and controlled goal motives.
Methods
Participants were 112 Spanish male and female athletes aged between 18 and 34 years (M = 20.90; SD = 2.79). All of them participated in university team sports and completed a package of questionnaires assessing variables of interest at the beginning and at the middle of the sport season.
Results
Path analysis showed that changes in perceptions of an empowering motivational climate positively predicted changes in autonomous goal motives, which in turn led to positive changes in goal-directed effort. Changes in the perceive disempowering climate did not predict changes in goal-directed effort through controlled nor autonomous goal motives.
Discussion
These findings are in concordance with SCM, SDT and past research, and support the positive implications of perceived empowering climates in relation to athletes' pursuit of adaptive goals when examined over time.
References
Duda, J. L. (2013). The conceptual and empirical foundations of Empowering CoachingTM: setting the stage for the PAPA project. Int. J. Sport Exerc. Psychol., 11, 311–318.
Martínez-González, N., Atienza, F., Tomás, I., & Balaguer, I. (2021). Perceived coach-created motivational climates as predictors of athletes goal reengagement: the mediational role of goal motives. Front. Psychol., 12:740060
Ryan, R. M., & Deci, E. L. (2017). Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness. Guilford Publications.
Sheldon, K. M., & Elliot, A. J. (1999). Goal striving, need satisfaction, and longitudinal well-being: the self-concordance model. J. Persona. Soc. Psychol. 76, 482–497.

### IMPLEMENTING A POSITIVE YOUTH DEVELOPMENT PROGRAM TO FOSTER DECISION-MAKING IN FEMALE YOUTH VOLLEYBALL

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Introduction
Decision-making is a skill that implies success in both the sports context and the daily life of people, involving four conceptions: emotional, volitional, motivational and cognitive; it is composed of three dimensions: confidence in own abilities, concern about improving decision-making and ability to overcome difficult situations in competition. Decision-making is one of the skills addressed in Positive Youth Development (PYD) programs, which are proliferating in the last decade, and specially the Teaching Personal and Social Responsibility Model (TPSR) and the Sport Education Model (SE). The aim of this study is to analyze the effect of the application of a hybrid TPSR+SE PYD program on decision-making in female youth volleyball players.
Method
A convergent mixed-method design was employed, combining phenomenological design (qualitative) and pretest-posttest design (quantitative). 15 girls (age=8.93±0.80) from a volleyball team in a subsidized school in Seville took part in the study. Qualitative data assessed players' and coach's insight of decision-making enhancement through semi-structured interviews (players) and field notes (coach); data was analyzed using NVivo 12 software. Quantitative data assessed two factors of decision-making (perceived decisional competence and commitment in decisional learning) obtained through CETD questionnaire; non-parametric tests were applied using SPSS 26.0 software. Integration of qualitative and quantitative data was carried out using a joint display.
Results
Qualitative data analysis showed positive results in the majority of the group within perceived decisional competence and commitment in decisional learning. Quantitative data analysis reported higher values in posttest when compared to pretest in both factors, although they were not significant ($p > .5$). Integration showed discrepancies between qualitative and quantitative results in both perceived decisional competence and commitment in decisional learning, with only a few congruent observations derived from some participants' interviews.
Discussion
Results showed an improvement in perceived decisional competence (more and enhanced decision-making in conflict resolution, achieving goals and sport-specific decisions) and commitment in decisional learning (autonomous goal setting and choosing the best decisions to achieve those goals) in the majority of the group; however, the lack of significance in the quantitative analysis caused discrepancies in data integration. Due to the limitation in the sample size and the possibility of suffering a satisficing process fulfilling the questionnaires due to lack of comprehension and motivation and context influence, there is more confidence in qualitative results. Considering those findings, the application of a hybridized PYD program in female youth volleyball players seems to improve decision-making skills. However, more studies are needed that use larger samples to strengthen these results.

### THE BODY CONFIDENT SPORT GUIDELINES AND THE ATHLETIC DISORDERED EATING (ADE) SCALE – AN INDIVIDUAL AND ORGANISATIONAL APPROACH TO PREVENTING DISORDERED EATING AND IMPROVING BODY IMAGE IN CURRENT AND F

BUCKLEY, G.

*BODY CONFIDENT COLLECTIVE*

Sport has an incredible capacity to improve an individual's body image, yet eating disorders remain significantly higher in current and former athletes than the general population. Eating disorder prevention work has long been seen as a potential compromise to an athlete's performance, however since the thorough developments in the Female Athlete Triad and Relative Energy Deficiency in Sport (RED-S) we can now comprehend and understand that a nourished athlete is a performing athlete. Sports science has prioritised quantitative measures of success and physiological performance, but recent scientific developments have highlighted that the relationship an athlete has with

their body can influence whether an athlete engages or quits their sport, and whether they develop confidence, self-efficacy, self-esteem and psychological wellbeing long after their sport has ceased.
This presentation introduces two new tools to the sports science and psychology field; the Athletic Disordered Eating (ADE) Scale and the Body Confident Sport Guidelines (BCSG). The ADE Scale was developed through exploratory mixed methods design using qualitative interviews, classic test theory and item response theory and is a 17-item scale that assesses current and former athletes for disordered eating and body image concern. The project found that 60% of current and former athletes have disordered eating and demonstrated a significant need for preventative support at both the individual and organisational level. The other findings of the exploratory sequential project have been translated into the BCSGs to generate 5 tangible and practice guidelines to shape culture positively so that sport is a place of body confidence, body safety and body celebration, rather than a risk factor for body dissatisfaction and eating disorder development.
The guidelines are intended to provide a benchmark of expectations to champion body confident sport and are for uptake amongst athletes, coaches, parents, supporters, sporting clubs, sports administrators and sports media. The five guidelines have been developed to address all determinants of body confidence: whether that be environmental, cultural, behavioural or social. These guidelines are intended to prevent and protect athletes from psychological and physical harm and to encourage safety, diversity and inclusion. The five guidelines include: (1) empathetic and informed body communication, (2) decentring weight and body composition importance, (3) promotion of food first principles, (4) flexible uniforms and equipment, and (5) creating safe environments.
These guidelines have been launched internationally and are currently being taken up by innumerable major sporting organisations and just as importantly at a grassroots and club level. This presentation will highlight the evidence backing the guidelines and additionally initiate important conversation about how research translation can be transformed into tangible outcomes that shape and

**THE DUAL COMMITMENT OF STUDENT ATHLETES IN LOWER SECONDARY SCHOOLS IN FINLAND**

ROMAR, J.E., KÄLLBERG, C., HUUHKA, V., KUOKKANEN, J.
*ÅBO AKADEMI UNIVERSITY*

The Finnish dual career (DC) policy can be described as state sponsored, including a centralized network of upper-secondary-level (ages 16–19 years) and tertiary-level (i.e., higher education) educational institutions that enable athletes to acquire a degree while competing in sports. The absence of national standards has hindered the provision of optimal developmental grounds for talented young athletes in lower secondary education. Consequently, the Finnish Olympic Committee introduced a lower secondary sports schools pilot project (LSSSPP) that started on a trial basis at 19 public lower secondary schools (ages 13–15 years) in 2017 and expanded in 2020 as a nationwide model open to all interested schools across the country. The national project aimed to find solutions that allowed student athletes opportunities for practice and flexibility in school-related issues in Grades 7–9.
Utilizing rich qualitative data derived from individual interviews with student athletes from grade eight (n = 15), teachers (n = 4), principals (n = 2), and nonparticipant observations (n = 7) at five schools in conjunction with the LSSSPP, the present study examined how young student athletes succeed in school and sports and in combining these two. The data was analysed using collaborative qualitative data analysis to find themes describing these student athletes. The main findings indicated that most student athletes had high ambitions and showed strong orientations in their school approaches. For some student athletes, the student and athlete roles conflicted, and they prioritized sports over educational success. A similar variation in student athletes' sport commitments was found: from having a goal to become a professional athlete to pursuing sport as a leisure activity. Student athletes in this study were in the beginning of their DC, and they needed to be recognized as a heterogeneous group with individual pathways. In all, the findings indicated the demanding nature of the dual commitment of student athletes in lower secondary sport schools. As earlier research findings mainly come from upper secondary and university students, the study responds to the Finnish Olympic committee´s need to evaluate the LSSSPP to improve DC support functions at these specialized educational institutions.
Keywords: student athlete, dual career, sport and education, qualitative methods

**THE MEANING AND SIGNIFICANCE OF NON-CLUB TALENT DEVELOPMENT ENVIRONMENTS FROM THE PERSPECTIVE OF ELITE FOOTBALL PLAYERS**

SÖDERSTRÖM, T.
*UMEÅ UNIVERSITY*

Adult football success in Sweden can, besides the training in the club, be advanced through the Swedish football associations regional (U15-17) and national (U15-U21/23) team systems or through elite sport schools at the upper secondary school. These systematic talent development environments are of central interest in this study. Research on talent development environments has had a focus on football academies and environmental success factors (e.g., Cooper, 2021; Larsen et al, 2013). However, to date, research undertaken has not in any greater extent taken into consideration non-club environments and athletes views on how useful those environments have been for their development into elite football players. Thus, in this paper the aim is to explore the meaning and significance of non-club talent development environments by scrutinizing elite football players experiences of participating in such environments and their importance for their development as football players.
The material in this study is based on interviews with 13 male and 12 female present and former elite football players between 22-35 years of age. The results showed that being selected at age 15 as one of 16 players in one of the 24 district squads (a two-year process) is, for both women and men, mostly a question of being confirmed and has little or no importance with respect to their football development. The analysis of players experiences of upper secondary elite sport schools (2-3 trainings/week) revealed a more mixed picture. Half of the men and women considered it, although they trained more hours, of little importance for their development. However, those players who have participated in elite sport schools organized by an elite club highlighted to a greater extent the importance of the school environment. The players perceived the national team activities (foremost U15-U19) as professional and serious, but since most players club environment had the same or better quality it had little significance for their development as a football player. Overall, the analysis shows that the importance of non-club environments for developing as a football player are dependent on the players background and present level (e.g., elite vs. grassroot, youth vs. senior team). In conclusion, the players stories suggest that the value of non-club talent development environments appears to be of minor importance for their path towards elite football. The essential environment for the players is the club environment.
References
Larsen, C. H., Alfermann, D., Henriksen, K., & Christensen, M. K. (2013). Successful talent development in soccer: The characteristic of the environment. Sport, Exercise and Performance Psychology, 2 (3), 190-206.

Cooper, A. (2021). An investigation into the factors affecting player development within each phase of the academy pathway in english football academies, Soccer & Society, 22(5), 429-441.

# 09:30 - 10:45

## Invited symposia

### IS-PN04 Rethinking lactate – from metabolic 'poison' to critical metabolic signal?

#### LACTATE IN CONTEMPORARY EXERCISE SCIENCE: A PHOENIX RISEN

BROOKS, G.

*UNIVERSITY OF CALIFORNIA*

For much of the twentieth century, lactate was considered a dead-end metabolite or 'poison' causing fatigue. This idea, floated by Nobel-prize winning scientists, went unchallenged for nearly 100 years. Indeed, it is still common for some scientists to describe the main biological role of lactate as causing fatigue. Prof. Brooks was the first to challenge this paradigm and his pioneering research revolutionised thinking. Rather than being a fatigue-causing metabolite, Prof. Brooks provided the first evidence that lactate is a major metabolic intermediate that moves between cells and has important biological roles in energy substrate utilisation, cell signalling, and adaptation. Prof. Brooks will therefore open this symposium with an historical overview of how understanding of lactate and its role in exercise physiology and medicine has changed dramatically in the last three decades. He will tell the definitive story of lactate and highlight how its role in physiology has changed dramatically in the last three decades. He will describe how this "metabolic poison" is now known to shuttle between tissues and cells (i.e., the "lactate shuttle"), where it has a multitude of diverse roles such as wound healing, cancer biology, insulin secretion, management of sepsis, learning and memory, and treatment of traumatic brain injury. Hence, in contemporary biology, the role of lactate in metabolism needs to be understood and viewed as a 'phoenix risen' in contrast to the early 20th century view of lactate as a dead-end metabolite that causes fatigue.

#### LACTATE EXCHANGE BETWEEN TISSUES AND THE EFFECTS OF TRAINING

THOMAS, C.

*INSEP*

During heavy exercise, the rapid increase in the energy demand of contracting skeletal muscles is associated with an increase in glycolysis and the subsequent production and accumulation of lactate and protons. The lactate that accumulates in muscle can also be exchanged between tissues, where it serves as an important link between energy metabolism in different tissues. In the 1970s, a saturation phenomenon was observed for lactate transport from exercising human skeletal muscle to the blood compartment; it was subsequently reported that muscle lactate uptake also displayed a saturation effect. A monocarboxylate transporter (MCT) family, which mediates the 1:1 transmembrane cotransport of lactate and protons via a facilitated diffusion mechanism was first identified in red blood cells in the early 70 s by Halestrap and Denton, and later in skeletal frog muscle and cardiac myocytes. The MCT family currently comprises 14 members. MCT distribution is ubiquitous, but intracellular distribution varies among the different cell types (e.g., plasma membrane, mitochondrial membrane, peroxisome), although this distribution is not universally accepted. Lactate/proton cotransport is bidirectional, which means that these transporters facilitate lactate flux, relative to lactate concentration and the proton gradient, either into or out of the skeletal muscle, according to the cell-to-cell "lactate shuttle" first described by Prof. Brooks. This cell-to-cell lactate shuttle provides the basic framework for the understanding of lactate metabolism and exchange. Without the MCTs, lactate could not be as rapidly exchanged between tissue compartments, under conditions ranging from postprandial to sustained exercise.
In skeletal muscle, the most important and well-described isoforms are MCT1 and MCT4. During the last two decades, interest has focused on the effects of a single session of exercise and regular exercise training on the muscle content of these two isoforms. Despite limited research, it appears that both MCT1 and MCT4 belong to a class of proteins that can be rapidly altered by a single session of exercise. Further studies are needed to investigate the underlying mechanisms and to clarify the role of transcriptional regulation on the expression of these proteins in response to exercise. Such research has important implications for the design of an acute exercise stimulus to maximally increase MCT content. The content of MCT1 and MCT4 in humans can also be affected by chronic activity levels, as indicated by the results of both cross-sectional and longitudinal studies. The type of training appears to be of little importance, as few studies have not observed an increase in MCT content or lactate transport capacity following training. However, further research is still required to determine the optimal intensity and duration of a training session to promote improvements in both MCT content and lactate transport capacity, although high-intensity exercise app.

#### A NEW BIOLOGICAL ROLE FOR LACTATE AS A CRITICAL METABOLIC SIGNAL?

BISHOP, D.

*VICTORIA UNIVERSITY*

Lactate is an abundant metabolite produced through glycolysis in many cell types, including skeletal muscle, cancer cells, immune cells, and the brain. While this lactate was traditionally considered a dead-end metabolite, new findings have challenged the way scientists think about lactate. Recent evidence, using both qPCR and RNA-seq, indicates that lactate accumulation is associated with the upregulation of genes associated with metabolism, DNA repair, and inflammation. As transcription is controlled by sequence-specific transcription factors (proteins) that interact with DNA in the nucleus, this has led us to hypothesise that the molecular mechanisms by which lactate increases transcription might relate to increased DNA binding of transcription factors. In support of this, Prof. Brooks has reported that the addition of lactate to myotubes leads to an increased DNA binding of ROS-responsive transcription factors. An alternative and/or complimentary hypothesis is that lactate may also regulate gene transcription in skeletal muscle cells via chromatin modifications. Incubating cells with lactate has been shown to produce a less compact chromatin structure, which should facilitate access of transcription factors to DNA.

Some of our own research suggests this may be via reduced activity of HDAC proteins, which leads to less histone deacetylation and a more relaxed, transcriptionally permissive chromatin (in contrast, greater HDAC activity produces a more condensed, transcriptionally repressed chromatin conformation). Chromatin compactness (and hence gene expression) is also regulated in part through the chemical labelling of histones - highly alkaline proteins found in cell nuclei that package and order the DNA. The addition of chemical tags, such as acetyl and phosphate groups, reduces the positive charge of histones and disrupts electrostatic interactions between DNA and histones – leading to chromatin relaxation. A recent article in Nature reported that lactylation is a previously unknown histone modification that results in the covalent attachment of a lactate-derived lactyl group to lysine residues in the tails of histone proteins. It was also observed that an increase in lactylated histones correlated with increased gene expression in macrophages (immune cells). Thus, results from disparate studies, in different experimental models, converge to establish the hypothesis that increasing the lactate concentration decreases HDAC activity and modifies and relaxes chromatin, which facilitates the transcription of many genes. This emerging understanding of a new role for lactate is of fundamental biological importance as lactate is generated in both physiological (e.g., during exercise) and disease (e.g., cancer) contexts. In this talk, Prof. Bishop will describe pioneering work by Prof. Brooks, and newer evidence from multiple labs, different experimental models, and his own unpublished data, that lactate accumulation is associated with the upregu

# Invited symposia

## IS-BM02 Opportunities to study new features of neuromuscular physiology and mechanics by imaging…

### STANDARD FRAME RATE ULTRASOUND IMAGING CAN REVEAL DIFFERENCES BETWEEN HEALTHY MOTOR UNITS AND THOSE UNDERGOING NEURODEGENERATIVE CHANGE

HODSON-TOLE, E.

*MANCHESTER METROPOLITAN UNIVERSITY*

Motor unit (MU) remodelling and loss result from various causes, including ageing and neurodegenerative diseases such as Motor Neurone Disease (MND). An indicator of such ongoing neurogenic changes is spontaneous, intermittent, involuntary excitation and contraction of single MUs, termed fasciculation. Fasciculations are typically detected during clinical examination using intramuscular electromyography and are a diagnostic indicator for MND. They are however also visible in standard frame rate, b-mode ultrasound image sequences, where they are seen as transient, localised muscle tissue displacements. Driven by a need for sensitive biomarkers of MND disease progression, there has been increasing interest in using non-invasive ultrasound imaging and high-density surface electromyography to both diagnose and monitor changes in motor unit behaviours and characteristics related to MND. Such markers may also have application to investigating ageing-related changes to MUs to improve understanding of force decline and loss of physical ability.
Standard frame rate ultrasound imaging is widely accessible and commonly used in medical settings and physiology/biomechanical research settings. Its application to studying MU physical properties is however in its infancy and not widely exploited. In this presentation I will therefore review recently proposed quantitative image analysis approaches that provide automated, objective measures of fasciculation occurrence and MU characteristics in standard frame rate (~80 fps) b-mode ultrasound image sequences. Comparisons between computer vision-based feature tracking and learning-based foreground detection approaches will be provided. Additionally, an overview of some physical motor unit properties that can be quantified using these techniques, such as spatial (location, area) and temporal characteristics. In the second part of the presentation a comparison of physical and electromechanical properties between MUs in healthy and MND-affected muscles will be provided, based on data collected using high-density electromyography and standard frame rate B-mode ultrasound imaging. The talk will conclude by reviewing some of the challenges still to be addressed for new biomarkers of neurodegeneration to be established, and will also consider how useful these markers and standard frame rate ultrasound may be in understanding changes in MU properties associated with ageing

### ELECTRICAL AND PHYSICAL MOTOR UNIT PROPERTIES REVEALED WITH SIMULTANEOUS HIGH-DENSITY ELECTROMYOGRAPHY AND ULTRASOUND IMAGING

BOTTER, A.

*XXXX*

During a muscle contraction, myofibrils translate the neural excitation arising from spinal motoneurons into tensile forces, which are transmitted to tendons and finally, to the skeleton. Current technology allows to study this cascade of events non-invasively and from different perspectives. Surface EMG provides information about the degree of neural excitation issued to the muscle both at global level and, when detected with multiple electrodes (high-density EMG, HD-EMG), at single motor unit level. Ultrasound (US) imaging, conversely, is applied to study muscle properties both from anatomic (e.g. tissue architecture and texture) and functional (e.g. muscle contraction patterns, tissue elasticity and muscle anisotropy) perspectives. Although both techniques underwent significant advancements in the last ten years, individually they provide a partial description of the complex electromechanical phenomena leading to muscle force production. When combined, therefore, EMG and US have the potential to provide a more detailed and complete description of the events underpinning the generation of muscle force.
In this talk I will briefly introduce the challenges related to the combined acquisition of EMG and US, the way they have been addressed and the applications to the study of global muscle properties. Afterwards, I will present a method to study the electrical and physical (i.e. mechanical and anatomical) characteristics of single MUs by combining HD-EMG and US image sequences detected at high frame rate (2500 fps). The method uses individual MU firings obtained through HD-EMG decomposition to identify the corresponding region of muscle tissue displacement in the US tissue velocity sequences. The time evolution of the tissue velocity in the identified region is regarded as the MU tissue displacement velocity. The method was tested in simulated conditions and applied to experimental signals to study the local association between the amplitude distribution of single MU action potentials and the identified displacement area. We were able to identify the location of simulated MUs in the muscle cross-section with an error lower than 2mm and to reconstruct the temporal profiles of the simulated MU displacement velocities with cross correlation coefficients higher than 0.85. Multiple regression analysis of 180 experimental MUs detected during isometric contractions of the biceps brachii revealed a significant association between the identified location of MU displacement areas and the centroid of the transversal EMG amplitude distribution.

The proposed approach has the potential to enable non-invasive assessment of the electrical, anatomical, and mechanical properties of single MUs in voluntary contractions. Information obtained from this multi-modal approach, such as MU firing properties, location and territory, is required to better investigate fundamental aspects of MU and muscle function, as well as changes resulting from neurodegenerative disease.

### USING ULTRAFAST ULTRASOUND IMAGING FOR THE IDENTIFICATION OF FIRING PATTERN AND LOCATION OF SINGLE MOTOR UNITS IN VOLUNTARY CONTRACTIONS

GRÖNLUND, C.

*UMEÅ UNIVERSITY*

The central nervous system controls human locomotion by successive recruitment of motor units (MUs) in the skeletal muscles. The MU comprises a motoneuron and a bundle of innervated muscle fibers within a localized territory. Today, the function of MUs is measured and analyzed by electromyographical (EMG) methods. It provides the basis for MU analysis in diagnosing neuromuscular diseases, exercise physiology and sports, and rehabilitation medicine. The EMG records the muscle fibers' repeated electrical depolarizations following a firing pattern transmitted from the spinal cord via the motor neuron. The so-called excitation–contraction mechanism links the electrical depolarization to the thickening and shortening of the fibers (mechanical twitch). Therefore, recording and analyzing mechanical twitches may provide an alternative way to study MUs.
Non-invasive ultrasound imaging allows mechanical information from a large field of view in soft tissues such as the muscles. In skeletal muscle applications, ultrasound has mainly been used for structural imaging. For example, in diagnostics of neuromuscular disease, the quantification of muscle function in exercise physiology and sports, detection of contraction onset. High-resolution ultrafast ultrasound imaging, with a high frame rate (>1000 images per second), has been successfully applied on imaging the MUs' mechanical twitches during externally controlled electro-stimulations. However, electrical stimulation provides no information about (neural) firing pattern. Voluntary contractions are required to access this information. Our group recently proposed methods to extract the mechanical twitches of contracting MUs in ultrasound image sequences under voluntary contractions.
In this talk, we will present how spatiotemporal and deep learning methods can be used to detect firing pattern and position of single MUs in high frame rate ultrasound image sequences of voluntary contractions. We will start with discussing the need for ultrafast imaging systems as compared to clinical ultrasound systems, and that there may be work-arounds to achieve MU identification using low frame rate systems such as clinical commercial US systems. Next, we present some work on estimating the contractile properties of the individual MU twitches during voluntary contractions. Finally, we discuss the influence of the myofascial coupling and a need for authentic simulation models of the intra-muscular contraction patterns arising from the contraction of the fibres of the active MUs. This will be important to facilitate further advances of this new research field of neuromuscular imaging.

## Oral presentations

### OP-LAG03 Physical activity promotion

### FACTORS ASSOCIATED TO PHYSICAL ACTIVITY IN USERS OF NATIONAL PROGRAM OF HEALTHY HABITS AND LIFESTYLES "HEVS" OF THE MINISTRY OF SPORT IN COLOMBIA

CASTRO, C.1, GÁLVEZ, A.1, MENDOZA, D.1, TRIANA-REINA, H.R.1, RUIZ, N.2, LEANDRO, R.2, DÍAZ DEL CASTILLO, A.2, SAENZ, N.2, SERRATO, J.2, OREJARENA, J.2

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INTRODUCTION: Obesity is considered a public health problem in the world; it is estimated that by 2025 one fifth of the population will be overweight, represented as being overweight or obese (1). In the population, the consumption of sugary drinks and processed foods has increased and physical activity has decreased, which increases excess weight (2). To counteract the above, both globally and in Colombia, good practices are carried out to promote of healthy habits and lifestyles, based on this, has created a national program led by the Colombian Ministry of Sports in conjunction with Municipal and Department of Sports entities dedicated to the healthy habits and life styles called "HEVS". This program encourages regular physical activity practices, healthy eating and smoke-free environments and performs research activities. HEVS is conducting a research to identify the performance of physical activity and associated factors across the country and those involved in the HEVS Program. METHODS: The research scope consisted of 75.086 people over 18 years of age, users of the HEVS Program who provide information at the time thy joined the program related to their physical condition such as weight, height and other lifestyle statistics. Individuals comprise 33 departments and 11 municipalities. For the statistical analysis, a hierarchical logistic regression model was carried out. The dependent variable was compliance with the physical activity recommendations (0 = does not comply, less than 150 minutes and 1 = complies, equal to or greater than 150 minutes per week). RESULTS:The users had a mean age of 44.04 ± 15.75 years, and 87.7% were women. 92.5% of users do not comply with the physical activity recommendations and exercised less than 150 minutes a week. This corresponds to 49.489 people who answered this variable. The remaining 7.5% (4.026 people) comply with the recommendation. Users grupos regulares de actividad física (realizados 3 veces por semana) reported a greater probability of complying with the recommendations (OR=2.72; 95% CI=2.36 to 3.13) que los usuarios inscritos en grupos realizados 2 veces por semana. Moreover, users in the Caribbean region, the Coffee Region, and Antioquia presented a probability greater than 2 of complying with the recommendations, compared to those who live in the Amazon, Eastern Plains or Casanare. Men were more likely than women (OR=1.2; 95% CI=1.06 to 1.4) to follow the recommendations, and consuming more than 5 or more servings between fruits and vegetables was also associated with more than 150 minutes per week of physical activity (p≤0.01). However, the variable of high blood glucose was not related to compliance with the recommendations. CONCLUSIONS:The practice of physical activity from 150 minutes a week or more is associated with the intake of more than 5 or more servings between fruits and vegetables and gender, being higher in men than in women. REFERENCES:1. Galecio 2. Ferrantea 3. Coldeportes.

## CONSTRUCTION OF A MUNICIPAL PUBLIC POLICY FOR SPORT AND PHYSICAL ACTIVITY: A SIGNIFICANT COLOMBIAN EXPERIENCE

ARIAS, A., ORDOÑEZ, N., GÓMEZ, J., CARRILLO, L., SÁNCHEZ, D., COLORADO, A., RIVERA, L., OBANDO, L., MERCHÁN, N., SEGURA, L.

*UNIVERSIDAD DE CIENCIAS APLICADAS Y AMBIENTALES UDCA / INSTITUTO MUNICIPAL DE RECREACIÓN Y DEPORTE DE CHÍA.*

Introduction
The public policy for sports and physical activity of the municipality of Chía in Colombia was built with the participation of public and private actors, guided by the Municipal Institute of Recreation and Sports of Chía and the Colombian Network Association of Schools of Sport, Physical Education and Recreation [1]. This significant experience, from the perspective of qualitative research, becomes a reference for the organizations of the sector, which must guide long-term planning processes with the active participation of the community [3].
Method
The public policy in its formulation phase was developed in five stages with a qualitative methodology: formation of working groups for interest groups (beneficiaries, representatives of organizations, dignitaries and experts), identification of problems and needs, selection of solution alternatives, definition of guidelines, discussion with stakeholders on the technical document [2]. The construction of the public policy was developed through a semi-structured interview addressed to the focus groups, validating the process with the feedback of the results.
Results
546 people participated in the process. 52.10% women and 47.90% men. 50.7% from the urban area and 20.5% from the rural area. The public policy was structured around 5 axes (coverage with equity and quality, professional suitability, culture of organizational self-management, sports infrastructure and implementation, and institutional development), which materialized in a strategic plan and an operational plan 2021 - 2032.
Discussion
The way how the public policy was built, allowed to establish guidelines, which facilitated the establishment of goals and indicators for the sector in the municipality, with the purpose of improving the quality of life of the inhabitants through the practice of sports and physical activity [4]. With this space for citizen participation, social, political and economic reality of the sector is evidenced, and contributes to the concerted design of strategic lines, to focus the action of the State at all levels, taking into account its articulation with the Sustainable Development Goals 2030 [1].
[1] Ordoñez Saavedra, N., Carrillo Barbosa, L., Arias, A., Gómez, J., Sánchez, D., Rivera, L., Obando, L., Colorado, A. y Merchán, N. (2020). Política Pública para el Deporte y la Actividad Física del Municipio de Chía, 2020 – 2031. Chía, Colombia: IMRD de Chía.
[2] Melo, J., y Santander, J. (2013). Introducción a las políticas públicas: conceptos y herramientas desde la relación entre el Estado y ciudadanía. Bogotá, Colombia: Editorial IEMP.
[3] Departamento Nacional de Planeación, DNP. plan nacional de desarrollo. desarrollo.aspx,%20recuperado%20octubre%202020
[4] Dirección de Coldeportes. (2018). Política pública nacional para el desarrollo del deporte, la recreación, la actividad física y el aprovechamiento del tiempo libre, hacia un territorio de paz 2018 – 2028. COLDEPORTES

## INCIDENCE OF INSTITUTIONAL DESIGN, IN THE STATE OF GOVERNANCE OF NATIONAL SPORTS ORGANIZATIONS.

GÓMEZ, J., ARIAS, A., ORDOÑEZ, N., RAMOS, J., GUERRERO, O.

*ECCI UNIVERSITY*

INTRODUCTION: Governance is the form of government that guarantees the fundamental right to practice sport [2]. On this premise, Play the Game developed research in 15 countries. With the study completed in 2021, the National Sport Governance Observer (NSGO) index was determined, generating the following question: What is the incidence of institutional design, in the state of governance of national sports organizations (NSOs)?
METHODS: The NSGO instrument was used, composed of 4 dimensions (Transparency, democratic processes, internal control and social responsibility), 47 principles and 274 indicators. This instrument was applied by researchers to 8 NSOs from the 15 countries [1].
RESULTS: The NSGO index for the 15 countries is 40%. The NSGO index by country is: United States 53%, Canada 41%, Colombia 45%, Bosnia and Herzegovina 51%, Bulgaria 41%, Georgia 21%, Iceland 37%, Lithuania 44%, Portugal 39%, Serbia 59%, Slovenia 30%, Spain 46%, Ukraine 38%, India 27%, and Indonesia 28%. Regarding the institutional design in each country, it was found that there are two systems, one open and the other mixed; the first, typical of developed countries, such as the United States; the second, related to developing countries, Colombia case.
CONCLUSION: In the open system, inclusive policies are developed, articulating public and private education with sports programs or activities, providing opportunities in the recruitment of athletes, sports training, and participation in sports events [3]. The mixed system is mainly delimited by laws, which establish a hierarchical order for public and private sports organizations [4]. It is evident that the institutional design affects the state of the governance of the NSOs. It is also clear that open or mixed national systems adapt their private organizational structure to what is established by international sports federations and the International Olympic Committee. This situation does not occur in the national public sphere, because there is no high influence of international government agencies.

## LOWER COST OF TRANSPORT COINCIDES WITH SELF-SELECTED WALKING SPEED IN PREGNANT INDIVIDUALS

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INTRODUCTION: Pregnancy has important structural and physiological changes related to the growth of the baby [1]. These changes can alter metabolic and biomechanical parameters of pregnant individuals (PI) [2]. Changes in the body centre of mass (CM), body dimensions, and weight can influence postural aspects as well as gait pattern [3]. Thus, changes may occur in different variables such as cost of transport (C) (unit J.kg-1.m-1) [4], ventilatory efficiency, and walking speed. Aim: to compare C, VE/VCO2, self-selected walking speed (SSWS) on treadmill and on a track, at different walking speeds, of PI and a control group (CG).
METHODS: PI: n=24: n=8 in 1st trimester (T1), 12-13 wks; n=8 in 2nd trim. (T2), 26-27 wks; n=8 in 3rd trim. (T3), 35-36 wks; CG: n=8 healthy non-PI. C is energetic cost to travel a given distance. Ventilatory efficiency evaluated by the ventilatory equivalent for carbon dioxide (VE/VCO2). VO2 uptake was collected during trials of 5 min at 5 walking speeds, in randomized order (SSWS, ±40%, ±20% of SSWS) on the treadmill [5]. The SSWS was initially assessed on a track, and then tested on the treadmill. ANOVA for repeated measures was used to

compare C and VE/VCO2 for walking speed and groups. One-way ANOVA was used to compare SSWS on the track and on the treadmill. Multiple comparisons were possibly made with Tukey's post-hoc analysis (α=0.05).
RESULTS: Values of C were higher in PI compared to CG for all Ts (p=0.005; differences between Ts p=0.001). VE/VCO2 also showed higher values for PI (among Ts p<0.0001) compared to CG (p<0.0001). Differences in the SSWS (T1 0.83±0.14; T2 0.82±0.18; T3 0.85±0.18; CG 1.01±0.14 m.s-1) on the treadmill and on the track were found for all T (p<0.0001), and between PI and CG (p<0.0001).
CONCLUSION: C always showed the characteristics of "U" shape described previously [4], with higher metabolic economy at SSWS. Interestingly, VE/VCO2 showed higher values in T2 compared to T1, T3 and CG. VE/VCO2 is known to be affected by increased chemoreceptor numbers, peripheral ergoreceptor response, dead space ventilation, and muscle mass involved in exercise [2]. The feeling of greater respiratory difficulty with the increase in walking speed and due to the smaller excursion of the diaphragm by the increased abdominal volume. Our results showed that the greatest respiratory comfort (lower VE/VCO2) occurred at the highest speed performed (above SSWS). The choice of SSWS seems to be related to a greater metabolic economy and not to respiratory comfort.
After all physiological changes in T1 and T2 of pregnancy [1], T3 resulted to a certain adaptation. Lower metabolic economy is probably due to the physical alterations such as increase in body mass, displacement of the CM which could have altered the pendulum mechanism, generating displacement with less mechanical efficiency [5].
-Supported by ANII (Uy).
REFERENCES
1.Mottola, BrJSporMed 2019
2.Kohlhepp, Anaesth 2018
3.Forczek, GaitPost 2018
4.Cavagna, JPhysiol 1976
5.Bona, ClinBiomech 2017

## Invited symposia

### IS-AP05 Crossing boundaries in talent development: implications at the micro, meso and macro level

#### CROSSING BOUNDARIES BY THE ATHLETE

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In order to deliver maximum performance, talented athletes repeatedly push their boundaries. Not seldom, this leads to crossing their physical and mental boundaries resulting in injuries, which can have a negative impact on their physical and mental well-being, as well as a decrease in performance development. Skills related to 'self-regulation of learning and training' are related to prevention of injury and also to successful rehabilitation. Athletes who self-regulate well, take responsibility for their own development and score better on adherence to their rehabilitation once they get injured. Successful athletes are able to apply this skill in various situations and domains: not only when they are injured but also during regular sports training and competition. In addition, they use it for school work and in combining sport and school, thereby crossing boundaries between domains. This holds for individual and team sports, male and female athletes.

#### CROSSING BOUNDARIES BETWEEN SPORTS FROM A DEVELOPMENTAL AND PERFORMANCE PERSPECTIVE

LENOIR, M.
*UNIVERSITY OF GHENT*

Traditional research on talent identification and development has primarily focused on individual characteristics matching the required performance characteristics in a particular sport. More recently, researchers have increasingly crossed boundaries between sports, resulting in more profound insights in differences as well as similarities in profiles in young and promising sports talents. The aim of this contribution is to explore the benefits of such information for a healthy development of sport participants as well as for training of the young promising athlete. A scientifically based overview is given of a) how 'different' sports can contribute to a general healthy development of the young athlete (diversification), and b) how 'similar' sports can be applied to train key characteristics in young athletes in a specialization pathway.

#### CROSSING BOUNDARIES BETWEEN DOMAINS: WHAT CAN SPORTS LEARN FROM THE CONTEXT OF SCHOOLS?

FABER, I.
*CARL VON OSSIETZKY UNIVERSITY OLDENBURG*

Talent programs have become an integral part of the sports context in Western society. These programs aim to recognize young talented athletes and support them in their development to the top. Unfortunately, in practice it is not easy to find rough diamonds and to counter disappointing results. Moreover, the sports context is a dynamic and constantly changing environment. That is why sports associations are always looking for innovative methods within their talent programs.
It is not only in the sports context that progress is being made with regard to talent programs. Particularly in education, more attention has been paid to the excellent student in recent years and various programs/approaches have been developed. There too, strategies are being sought to better recognize talented young people and to provide them with the best possible guidance in their development process. These programs/approaches have been developed in the educational context and independently of the sports context. Cross-domain peeking at the neighbours in education have pointed out new knowledge, ideas and insights for the sports context.

## Oral presentations

### OP-PN20 Hydration

#### CHALLENGING PROLONGED REHYDRATION CONCEPTS: AD-LIBITUM FLUID INTAKE, RESULTING IN CONSUMPTION OF >200% FLUID LOSS POST-EXERCISE, WAS INSUFFICIENT TO ACHIEVE EUHYDRATION 20 H AFTER INTERMITTENT RUNNING

FUNNELL, M., JUETT, L., FERRARA, R., MEARS, S., JAMES, L.

*LOUGHBOROUGH UNIVERSITY*

INTRODUCTION: The majority of rehydration research has focused on the composition, volume, and timing of rehydration drinks consumed in a prescribed manner in a short post-exercise period (0-6 h). Little is known about rehydration kinetics over longer time frames more typical of times between exercise sessions in athletes (6-24 h). This study documented 20 h rehydration from intermittent running while concealing the primary aim of the study.
METHODS: Twenty-eight male intermittent games players (age 25 ± 3 y; predicted V̇O2max 54 ± 3 mL·kg-1·min-1; training sessions·week-1 6 ± 3) were pair-matched to an exercise (EX) or rest (RE) group. Body mass, urine and blood samples were collected at 08:00, pre-intervention (09:30), post-intervention (12:00), 3 h post-intervention and 08:00 the next day, to determine hydration status. The intervention was a 110-min intermittent running session in EX (modified Loughborough Intermittent Shuttle Test) and a 110-min rest in RE, with water allowed ad-libitum in both. Subjects completed a weighed diet record and urine collection for the 24 h period.
RESULTS: Changes typical of hypohydration were apparent in EX following the intervention (body mass: EX -2.0 ± 0.5 %; RE -0.2 ± 0.3 %; serum osmolality: EX 293 ± 4 mOsm·kg·kgH2O-1; RE 287 ± 6 mOsm·kgH2O-1; P≤0.022). Water intake during the intervention (EX 704 ± 286 mL, RE 343 ± 230 mL) and in the 3 h post-intervention (EX 1081 ± 460 mL, RE 662 ± 230 mL) was greater (P≤0.004) in EX, with no difference thereafter (P=0.923), with 209 ± 97 % fluid loss in EX consumed post-exercise. Total 24 h urine output was lower in EX (EX 1697 ± 824 mL, RE 2370 ± 842 mL; P=0.039). Body mass was reduced (-0.6 ± 0.5 %; P=0.030) and urine osmolality elevated (844 ± 197 mOsm·kgH2O-1 vs 698 ± 200 mOsm·kgH2O-1; P=0.004) the following day in EX, but not RE. Sweat sodium losses were 1861 ± 647 mg during exercise in EX, but 24 h sodium intake was not different between groups (P=0.801). Total 24 h urine sodium losses were reduced in EX (EX 1557 ± 834 mg, RE 2606 ± 828 mg; P=0.003), but not enough to account for sweat losses, meaning 24 h sodium balance was lower in EX (EX -383 ± 1178 mg, RE 524 ± 726 mg; P=0.022).
CONCLUSION: Ad-libitum water intake during 110 min intermittent running produced hypohydration of ~2% body mass, and despite free access to fluids meaning ~209% of fluid loss was consumed post-exercise, a small degree of hypohydration remained 20 h post-exercise (reduced body mass and elevated urine osmolality). This might be explained by the negative sodium balance in EX over the 24 h lessening fluid retention. Although small and unlikely to impair exercise performance in isolation, any hypohydration present before a subsequent training session means significant hypohydration is more likely in that session or that more significant deficits might more easily accrue with repeated exercise.

#### SEVERE FLUID RESTRICTION FOR 24 H INCREASES A BIOMARKER OF KIDNEY INJURY IN MALES

JUETT, L.A., FUNNELL, M.P., JAMES, L.J., MEARS, S.A.

*LOUGHBOROUGH UNIVERSITY*

INTRODUCTION: Hypohydration induced by exercise exacerbates biomarkers of renal tubular injury, such as urinary kidney injury molecule-1 (uKIM-1) (1). However, the isolated effects of hypohydration (in the absence of heat stress and/or exercise) on biomarkers of renal tubular injury are not well-understood. Fluid restriction/inadequate fluid intake is common in athletes who 'make weight' in weight-category sports, as well as in settings where there is reduced availability of fluids and/ or toilet facilities. The present study investigated the effects of 24 h severe fluid restriction on biomarkers of renal tubular injury, including uKIM-1 and urinary neutrophil gelatinase-associated lipocalin (uNGAL).
METHODS: Fifteen males (age: 27 ± 5 y; BMI: 24.1 ± 3.8 kg/m2) completed two trials in a randomised order, involving either severe fluid restriction (limiting water consumption to 100 mL; HYP) or maintaining euhydration (40 mL/kg body mass water; EU) for 24 h whilst consuming a dry food diet. At baseline and 24 h post-baseline, nude body mass, blood samples and urine samples (additional urine sample at 12 h) were collected. To account for changes in urine concentration affecting urinary biomarkers of renal injury, uKIM-1 and uNGAL concentrations were corrected for urine osmolality. Data are presented as mean ± standard deviation.
RESULTS: At 24 h post-baseline, severe fluid restriction resulted in increased body mass loss (HYP: -1.52 ± 0.34%, EU: -0.24 ± 0.40%), plasma volume loss, urine osmolality, and serum osmolality (HYP: 297 ± 4 mOsm/kg, EU: 289 ± 2 mOsm/kg) compared to EU (P < 0.005). Fluid restriction increased osmolality-corrected uKIM-1 concentrations by 92 and 21% at 12 h post-baseline (HYP: 1.097 ± 0.587 ng/mOsm, EU: 0.570 ± 0.408 ng/mOsm; P < 0.001) and 24 h post-baseline (HYP: 1.932 ± 1.173 ng/mOsm, EU: 1.599 ± 1.012 ng/mOsm; P = 0.01), respectively, compared to EU. There were no trial by time interaction effects for osmolality-corrected uNGAL (P = 0.781), serum creatinine (P = 0.826) or serum uric acid (P = 0.097).
CONCLUSION: Severe fluid restriction for 24 h increased renal injury, compared to when euhydration was maintained with water ingestion. The difference between trials with regards to osmolality-corrected uKIM-1, yet lack of differences in osmolality-corrected uNGAL concentrations, suggest that the location of renal injury was the proximal tubules. The increased proximal tubular injury was likely mediated by serum hyperosmolality and subsequent increases in circulating vasopressin. The long-term consequences of an acute increase in a biomarker of proximal tubular injury and/ or repeated increases require further research.
References:
1. Juett LA, Midwood KL, Funnell MP, James LJ, Mears SA. Hypohydration produced by high-intensity intermittent running increases biomarkers of renal injury in males. Eur J Appl Physiol. 2021. 121(12): 3485-3497.

### WHOLE-BODY AND MUSCLE-LOCALIZED BIOELECTRICAL IMPEDANCE VECTOR MIGRATION OVER A GIRO D'ITALIA PRO RACE

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INTRODUCTION: Giro d'Italia is one of the most demanding multistage races included in the professional cycling Tour, in which it is difficult to intervene systematically in these group of cyclists to assess the adaptations to such intense competitions. Bioelectrical impedance vector analysis (BIVA) is a non-invasive and safe technique for assessing hydration and body composition changes [1]. The purpose of this study was to apply BIVA to assess possible hydration changes evoked over the 3 weeks of Giro d'Italia in a group of elite rink hockey players.
METHODS: 9 elite cyclists completed whole-body and muscle-localized BIVA (quadriceps, hamstrings and calves) assessments at three different checkpoints: one day before the start of Giro d'Italia 2013 (PRE), on the first resting day (MID), and on the final day of the race (POST). A tetra-polar phase-sensitive BIA at 50 kHz was used to measure height-adjusted resistance, height-adjusted reactance and phase angle. Hotelling's T2 test determined differences in the complex vector through the 95% confidence intervals. Haemoglobin, haematocrit, plasma volume and osmolality were also assessed in all three checkpoints as a hydration biomarkers. All the procedures were in accordance to the Declaration of Helsinki.
RESULTS: Whole-body BIVA reported a non-significant shortening vector migration in PRE-MID and a significant lengthening vector migration in MID-POST. In PRE-POST, there was a significant lengthening of the vector. Regarding muscle-localized BIVA, no significant vector migrations were reported neither in quadriceps nor in hamstrings. As far as calves' vector migration, there was a significant shortening of the vector in PRE-MID and a significant lengthening of the vector in MID-POST. Across PRE-POST the mean calves' vector experienced a significant shortening.
Haemoglobin and haematocrit significantly decreased in PRE-MID and significantly increased in MID-POST, but below baseline values. The dynamic of plasma volume was opposite: it significantly increases in PRE-MID and decreases in MID-POST. Considering the entire 3-week race, plasma volume values increased significantly. Osmolality increased significantly from the start to the end of the competition.
CONCLUSION: Haematological markers showed that major hydration changes were experienced in the second half of the race, a fact that was confirmed by the kinetic of whole-body and calves' vector migration. Whole-body BIVA lengthening vector indicated a global dehydration, but a possible fluid accumulation in the calves could have occurred, not like in quadriceps or hamstrings since there were none changes. Results indicate that BIVA is sensitive to assess hydration adaptations in relation to hydration biomarkers changes induced by a strenuous race.
1. Lukaski HC, Piccoli A. Bioelectrical impedance vector analysis for assessment of hydration in physiological states and clinical conditions. In: Handbook of Anthropometry: Physical Measures of Human Form in Health and Disease. 2012. p. 287–305.

### TIMING OF CARBOHYDRATE AND PROTEIN INTAKE AND HYDRATION STATUS OF GERMAN JUNIOR FOOTBALL PLAYERS

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INTRODUCTION: Recently, the UEFA expert group highlighted that nutritional support plays a key factor for junior football players and will help to optimise growth, health, performance, recovery, training adaptations and body composition (Colllins et al. 2020). Although, young players may have different nutritional needs from those of adults the expert group stated that carbohydrate (CHO) and protein (PRO) needs are similar to those of senior players and Urine specific gravity (USG) can be a useful indicator of hydration status suggesting euhydration of USG <1.020. Data on nutritional status in junior football players are still rare, therefore this observational study focus, whether academy players follow the UEFA nutrition guidelines on training and match days.
METHODS: In total, 55 male junior football players (15 ± 0,8 yrs; 176 ± 8 cm; 63,9 ± 8,6 kg) from 3 academy teams (Under 17, 16 & 15 yrs) of a German professional football club were asked to weigh and record their food and beverages consumed on five consecutive days as well as their activities. These included training days (TD1 - TD3), pre-match day (MD-1) and a match day (MD). MD Kick-Off time was between 11am-1pm. Dietary protocols were analysed based on the German food database (BLS 3.1) using Ebispro Software. On each morning, urine samples were collected and analysed for urine specific gravity (USG).
RESULTS: On TDs mean PRO 1.7 ± 0.7 g/kg/d and CHO 4.7 ± 2.1 g/kg/d intake was within the recommended guidelines. In 21% of all TDs PRO intake was <1g/kg and for CHO <3 g/kg (22%) respectively. Mean MD-1/MD PRO intake (1.6 ± 0.7 g/kg/d) and CHO intake (4.4 ± 2.0 g/kg/d) was similar to TDs. However, 78% of the players are below the recommended CHO intake (6-8g/kg/d) on MD-1. On MD pre-Match CHO Intake (<4 hrs before Kick Off) was 1.5 ± 0.8 g/kg. Depending on the team and Kick-Off time 20% - 38% of the players consumed CHO <1 g/kg. Mean total water intake (TWI) on TDs was 4.0 ± 1.8. L (63 ± 29 mL/kg) and 3.8 ± 1.9 L (60 ± 30 mL/kg) on MD-1/MD. Mean morning USG on TDs was 1.022 ± 0.008 (30% <1.020 and 32% >1.025), on MD-1 1.023 ± 0.008 (26% <1.020 and 38% >1.025) and on MD 1.023 ± 0.006 (32% <1.020 and 41% >1.025).
CONCLUSION: In the present study, PRO and CHO intake of German Junior Football Players were within the recommended guidelines on training days, but not for CHO on MD-1 and MD. A relatively high number of players have had a low CHO intake and a morning USG >1.025 before Kick-Off on MD, assuming that they were not well prepared for competition. These data suggest that young academic football players need more information regarding a sport specific diet and timing of nutrient intake during trainings days, but specifically on match day.
Collins J, Maughan RJ, Gleeson M, et al., UEFA expert group statement on nutrition in elite football. Br J Sports Med 2021; 55:416–442

## OP-PN27 Supplements I

### A NOVEL NUTRITIONAL BLEND IMPROVES SUBJECTIVE & OBJECTIVE MEASURES OF SLEEP IN MALE AND FEMALE PARTICIPANTS: A RANDOMISED COUNTERBALANCED, REPEATED MEASURES CROSSOVER, DOUBLE BLIND DECEPTION STUDY

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INTRODUCTION: Nocturnal sleep is a fundamental process in aiding the recovery of several key psycho-physiological functions, yet a large majority of the global population experience some form of sleep disturbance [1, 2]. To that end, the nutritional regulation of sleep is of interest, with studies employing a range of active ingredients purported to enhance sleep qualities [3]. However, to determine the true efficacy of any intervention on measures of sleep, participants should be sufficiently blinded to monitoring of their sleeping patterns [4]. Therefore, the aim of this study was to examine the effects of a novel nutritional blend on subjective and objective assessments of sleep, whilst blinding participants to this as primary outcome measure.
METHODS: The study was a randomised, counterbalanced, repeated measures crossover, double blind deception design. Male and female participants (n = 16; age: 24 ± 3; body mass: 69.8 ± 11.6 kg; stature: 170.8 ± 9.1 cm) completed a three day free living familiarisation period, employed to establish baseline measurements for specific subjective (core consensus sleep diary & Karolinska sleepiness scale) and objective (actigraphy) nocturnal sleeping patterns, daily energy/macronutrient intakes (weighed inventory & remote food photography method), physical activity (actigraphy), and light (Lux sensor) exposure profiles, which were then replicated during the main intervention and placebo trials. Additionally, participants provided daily urine samples for assessment of targeted and untargeted metabolomes, analysed via hydrophilic liquid interaction chromatography (HILIC). Statistical comparison between the main trials was conducted via parametric paired samples t-test or non-parametric Wilcoxon tests for normally or non-normally distributed data, respectively.
RESULTS: The intervention trial resulted in a 24 min reduction in sleep onset latency ($p = 0.002$), 22 min increase in total sleep time ($p = 0.01$) and a 2.4% increase in sleep efficiency ($p = 0.03$) compared to the placebo trial. Additionally, there was a reduction in morning sleepiness ($p = 0.02$) between the intervention and placebo trials. 75% of participants remained blinded to sleep assessment as a primary outcome within the main trials and when unblinded, 56% subjectively indicated improved sleep during the intervention trial. HILIC analysis highlighted several significantly elevated metabolomes during the intervention trial inclusive of 6-Sulfatoxymelatonin and D-Serine.
CONCLUSION: Data demonstrate that within male and female participants during free living conditions, nocturnal sleep can be enhanced using a novel nutritional blend, by shortening time to fall asleep and extending time asleep, resulting in overall greater sleep efficiency. These improvements may be caused by the inclusion of the sleep enhancing ingredients tryptophan and glycine, which lead to the upregulation of key metabolites involved in the neurophysiological modulation of sleep/wake cycles.

### EXAMINATION OF AMORPHOUS CALCIUM CARBONATE ON THE INFLAMMATORY AND MUSCLE DAMAGE RESPONSE IN EXPERIENCED RESISTANCE TRAINED INDIVIDUALS.

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INTRODUCTION: Calcium is a micronutrient that has an important role in both bone health and skeletal muscle function. Calcium supplementation is often used to achieve adequate calcium intake. Several studies have concluded that calcium supplementation is effective at enhancing bone strength, but may be more efficacious when it is combined with vitamin D. When provided by itself, the efficacy of calcium alone has been inconclusive. Part of this may be related to its formulation. The calcium found in most dietary supplements is from either carbonate and citrate salts derived from various sources including oyster shells, coral calcium, dolomite minerals, and other synthetic material and has limited absorbability. Calcium carbonate is one of the most abundant minerals in nature, having six known polymorphs. The least stable polymorph is the amorphous form, which has the greatest absorption capability. The instability of the amorphous calcium carbonate provides a highly bioavailable calcium source that enables a fast and effective transport of the mineral across the intestinal epithelium calcium carbonate. In consideration of the greater absorption capability of the amorphous calcium carbonate (ACC), and the limited research on young, active participants, the purpose of this study was to examine the effect of 3-weeks of amorphous calcium carbonate (ACC) supplementation (2000mg per day) on the recovery response to resistance exercise in trained men.
METHODS: Participants were randomly divided into a supplement (ACC; n=15) or placebo (PL; n=15) group. Following the supplementation protocol (T3) participants performed 6-sets of 10-repetitions per set in both the bench press (BP) and incline BP exercises, using 80% of their maximal strength. Participants returned 24- (T4) and 48-hours (T5) post-T3 performing 6-sets of the BP exercise only using the same loading pattern as T3.
RESULTS: Significant decreases in the number of repetitions performed ($p<0.001$), peak power ($p<0.001$) and mean power ($p=0.009$) were noted over time, but no significant interactions were observed ($p>0.05$). Magnitude-based inference analysis (MBI) indicated that the change in repetitions was possibly beneficial for ACC at T4 and likely beneficial at T5. No significant interactions were noted for general soreness ($p=0.452$), but a trend towards an interaction was observed in upper body soreness ($p=0.089$). Confidence intervals for mean percent change scores indicated significant differences between the groups at T4 and T5. MBI analysis indicated that ACC was very likely or likely to be beneficial at T4 and T5, respectively. No significant interactions were noted for interleukin (IL)-6, IL-10, tumor necrosis factor-α or creatine kinase-muscle.
CONCLUSION: ACC supplementation may have a potential beneficial effect in attenuating the decline in performance, possibly due to the carbonate component. The benefits associated with the attenuated soreness response requires further investigation.

### TART CHERRY SUPPLEMENT ENHANCES SKELETAL MUSCLE GLUTATHIONE PEROXIDASE EXPRESSION AND FUNCTIONAL RECOVERY AFTER MUSCLE DAMAGE

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*QUEX INSTITUTE*

INTRODUCTION: Montmorency cherry concentrate (MCC) supplementation enhances functional recovery from exercise. However, to date, only indirect blood biomarkers provide evidence supporting the mechanistic hypotheses of antioxidant and anti-inflammatory effects. This study is the first to investigate functional recovery from exercise alongside molecular changes within the exercised muscle following MCC supplementation.
METHODS: Ten healthy males (age: 23.4±5.4 y, weight: 78.0±21.9 kg, height: 1.78±6.90 m) completed two maximal unilateral eccentric knee extension trials following MCC (20.167 mg/mL polyphenolics and 7.211 mg/mL total anthocyanins) or placebo (PLA) supplementation for 7 d prior to and 48 h following exercise. Knee extension maximum voluntary isometric contractions (MVC) was assessed before (PRE), immediately (POST), 24 and 48 h after exercise; and normalised to PRE (100%). Venous blood and vastus lateralis muscle samples were collected at each time point. Plasma phenolic acids were quantified via HRAM mass spectrometry. Intramuscular mRNA expression of SOD1 and 3, GPX1, 3, 4 and 7, Catalase, and Nrf2 were quantified and expressed as fold change from PLA baseline. Relative intramuscular protein expression of SOD1, Catalase and GPX3 were quantified via immunoblotting. All data are presented as mean±SD.
RESULTS: MCC supplementation enhanced recovery of normalized MVC compared to placebo (POST PLA 59.5±18.0% vs MCC 76.5±13.9%; 24h PLA 69.8±15.9% vs MCC 80.5±15.3%, supplement effect p=0.024). After 7d supplementation plasma hydroxybenzoic (PLA 10.27±0.85 vs MCC 11.76±2.71 mmol/L, supplement effect p=0.028), hippuric (PLA 2.14±1.13 vs MCC 6.45±3.93 mmol/L, supplement effect p=0.002) and vanillic acid (PLA 16.55±8.08 vs MCC 40.47±36.83 mmol/L, supplement effect p=0.003) concentrations were higher in MCC vs PLA group. MCC elevated muscle antioxidant gene expression: SOD3 (POST: PLA 1.84±1.94 vs MCC 4.60±3.91; 24 h: PLA 5.51±8.33 vs MCC 4.28±4.87; supplement effect p=0.038), GPX1 (POST: PLA 4.09±6.95 vs MCC 4.90±6.69; 24 h: PLA 2.36±3.58 vs MCC 3.91±7.59; interaction effect p=0.017), GPX3 (POST: PLA 2.02±2.84 vs MCC 3.52±5.81; 24 h: PLA 2.91±3.71 vs MCC 7.39±8.72; supplement effect p<0.001), GPX4 (POST: PLA 11.12±30.71 vs MCC 34.01±95.85; 24 h: PLA 6.35±16.61 vs MCC 25.52±72.12; supplement effect p=0.011), and GPX7 (POST: PLA 0.63±0.54 vs MCC 2.42±3.70; 24 h: PLA 0.68±1.22 vs MCC 1.67±2.16; supplement effect p=0.001). In addition, muscle GPX3 protein expression (POST: PLA 0.64±0.82 AU vs MCC 2.60±2.32 AU; 24 h: PLA 0.72±0.50 AU vs MCC 1.88±1.55 AU; supplement effect p=0.004), but not SOD1 or catalase, was higher after MCC vs PLA.
CONCLUSION: This study showed for the first time that MCC supplementation significantly increased expression of antioxidant genes and proteins in human skeletal muscle, in parallel with a significant increase in plasma [phenolic acids]. This study also confirmed previous findings that MCC supplementation improved functional muscle recovery from muscle damage.

### EFFECT OF CANNABIDIOL (CBD) SUPPLEMENTATION ON RECOVERY AN PERFORMANCE AFTER INTENSIVE RESISTANCE TRAINING

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INTRODUCTION: The consumption of cannabidiol (CBD) to support recovery and enhance performance has become popular among athletes. Potential anti-inflammatory and anti-oxidative properties of CBD are supposed to result in pro-regenerative effects after strength training. Therefore, we have conducted three intervention studies to investigate the effects of CBD treatment on performance and muscle recovery after resistance training.
METHODS: Three independent randomized, double-blind, placebo-controlled trials were conducted in cross-over designs. The effects of a single CBD (60mg in aquarious solution) application after intensive strength training was investigated in study 1 in advanced (n=16) and in study 2 in highly advanced resistance-trained athletes (n=8). Effects on lower body performance and muscle damage proxies (MDP) were quantified. In study 3. advanced (n=8) and highly advanced (n=10) resistance-trained athletes were treated daily with two different CBD products (60mg CBD in aquarious solution or oil/day) during a 7-day lasting intensive training week. In addition to lower body performance and MDP, bench press performance here anti-inflammatory, and anti-oxidative effects were investigated.
RESULTS: In highly advanced athletes a single CBD application reduced creatine kinase concentrations (CK) 24h after the training bout (CBD:). This was not confirmed for less advanced athletes. A small but significant effect of CBD was observed on CK (p<0.05) and myoglobin (MYO)(p<0.05) concentrations after 72h.These results are in line with previous interventions, which detected a small effect on muscle soreness via visual analog scale 24h and 72h post-exercise in well-trained athletes. Only advanced athletes showed small effect of CBD on squat performance after 72h (p<0.05). In study3 a significant increase in CK and MYO-concentration was observed in all athletes after the intense training week. In advance athletes, a significant reduction of Myo (p<0.05) and CK (p =0.07) serum concentrations could be detected in the CBD oil group. After the training week a significant decrease in countermovement jump (CMJ) in advanced (p<0.05) as well in highly advanced athletes in squat performance (p<0.05) were detected. No significant effect of CBD on these performance parameters was identified, however trends can be assumed.
CONCLUSION: The results indicate faint but significant effects of a single CBD application after strength training on MDP. Interestingly the effects correlate to the performance levels of the athletes. Similar trends could be observed after repeated treatment. Clinical parameters for liver toxicity were not affected by 7-day treatment with 60mg CBD /day. Interestingly some of these parameters respond to the intensive training which could be antagonized by CBD. In all three studies the effect of CBD administration on strength performance is inconsistent. Potential effects are faint and it may be speculated that we can distinguish between responders and non-responds. This needs to be investigated in future studies. In our training setting we also do not found evidence for anti-inflammatory or antioxidant effects of CBD.

### A COMPARISON OF ADVERTISED VERSUS ACTUAL CANNABIDIOL (CBD) CONTENT OF OILS, AQUEOUS TINCTURES, E-LIQUIDS AND DRINKS PURCHASED IN THE UK.

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INTRODUCTION: Cannabidiol (CBD) is a phytocannabinoid uniquely available to consumers in many nations in over-the-counter products. CBD-containing products are used by both recreational exercisers and professional athletes for several purported benefits (e.g. enhance exercise-recovery, pain relief, improve sleep and reduce anxiety). Whilst analyses of CBD-containing products have identified discrepancies between advertised and actual CBD content, there is limited information regarding whether different types of CBD-containing products

vary in this regard. Such differences would have important implications for informing consumer choices. Therefore, this study assessed CBD concentrations in a range of product types.
METHODS: 63 products were purchased online within the UK from 40 brands (13 aqueous tinctures, 29 oils, 10 e-liquids and 11 drinks) and analysed for CBD concentration in a blinded fashion. Cannabinoids were extracted using isopropyl alcohol and methanol and CBD concentrations were quantified in aqueous tinctures, oils and e-liquids by high performance liquid chromatography and in drinks by gas chromatography-mass spectrometry. Percentage deviations from advertised concentrations were rank-transformed and product types compared using one-way ANOVA for unequal variance, followed by post-hoc Holm-Bonferroni corrected t-tests. Relationships between variables were examined using Spearman's ranks or Pearson's correlations.
RESULTS: Only 5/29 oils had measured concentrations within 10% of advertised (8% of all products). All other products fell >10% below advertised, except one oil that was 50% greater than advertised. Median (±interquartile range) deviation from advertised concentrations was -51.4±41.4% for aqueous tinctures, -19.0±14.5% for oils, -29.2±10.2% for e-liquids, and -65.6±36.5%, for drinks, and was less for oils vs all other product types (P<.01), less for e-liquids vs aqueous tinctures (P=.04) and drinks (P<.01), but not different between aqueous tinctures and drinks (P=.19). There was no linear relationship between product price (normalised to advertised CBD concentration) and relative discrepancy between measured and advertised CBD concentration for any product type (R<.26, P>.05).
CONCLUSION: Oils deviated least from advertised concentrations, but overall results reinforce concerns over product quality, whereby most athletes and exercisers using CBD are likely obtaining less than their target dose. As CBD doses in over-the-counter products are already lower (e.g. ~50 mg) than proven clinical doses (≥300 mg), the discrepancies highlighted in this study may contribute to the lack of perceived benefit experienced by a third of athletes using CBD, and may indicate a need for improved regulation of CBD products. Potential issues associated with consumer CBD products should be conveyed to athletes and exercisers. Deviations were independent of product price but may indicate poor manufacturing standards, or that CBD is susceptible to degradation in consumer products.

## Oral presentations

### OP-PN21 Ageing II

#### ELASTIC BAND RESISTANCE EXERCISE INCREASES MYOFIBRILLAR PROTEIN SYNTHESIS IN YOUNGER BUT NOT OLDER ADULTS, LARGELY INDEPENDENT OF ACUTE INTRACELLULAR SIGNALING

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INTRODUCTION: Resistance exercise training (RET) attenuates age-related declines in muscle mass and strength (sarcopenia). Compared with typical machine-based RET, however, the efficacy of cost-effective, accessible elastic band RET (EB-RET) for muscle adaptive remodelling lacks supporting mechanistic evidence. EB-RET may, therefore, offer a promising and accessible RET strategy in the absence of traditional facilities.
METHODS: In a parallel study design, 8 young (YM; 24 ± 4 yrs) and 8 older (OM; 68 ± 6 yrs) males consumed an oral stable isotope tracer (D2O) combined with serial vastus lateralis muscle biopsies to measure integrated myofibrillar protein synthesis (iMyoPS) and regulatory signalling over ~48hrs prior to (habitual) and following an acute bout of EB-RET (6 x 12 repetitions at ~70% of one-repetition maximum). Daily saliva samples were obtained to monitor body water isotope enrichment via TC/EA-IRMS. Deuterated alanine incorporation into myofibrillar protein was determined via gas chromatography-pyrolysis-isotope ratio mass spectroscopy. Subsequently, the iMyoPS rates were calculated as the percentage per day [2H]-alanine via the precursor-product equation. Intracellular protein expression and phosphorylation status were determined by immunoblot. A two-way repeated-measures ANOVA was performed to detect group, time, and interaction effects. A statistical significance of $p< 0.05$ was recognised. Data are presented as mean ± SEM unless otherwise stated, with individual data points presented.
RESULTS: Habitual iMyoPS did not differ between YM and OM (1.62 ± 0.21 vs 1.43 ± 0.47%·day-1, respectively; P=0.128). There was a significant increase in iMyoPS after EB-RET in YM (2.23 ± 0.69%day-1; P=0.02), but not OM (1.75 ± 0.54%day-1; P=0.30). The Δ change in iMyoPS (%day-1) was greater in YM (0.61 ± 0.62%/day-1) vs. OM (0.32 ± 0.58%/day-1) (effect size = 0.5) but was not significantly different between groups. EB-RET increased the phosphorylation of key anabolic signalling proteins similarly in YM and OM at 1h post-exercise, including p-IRS-1Ser636/639 (YM: ~106%, OM: ~79%), p-AktSer473 (YM: ~181%, OM: ~124%), p-4EBP-1Thr37/46 (YM: ~48%, OM: ~59%), p-P70S6KThr389 (YM: ~550%, OM: ~424%) and p-RPS6Ser240/244 (YM: ~1030%, OM: ~1005%) (all P<0.05). There were no differences between YM and OM in protein expression of amino acid transporters/sensors (LAT-1, SNAT-2 & Sestrin-2) or proteolytic markers (MuRF1, Atrogin-1, Caspase-3, all P>0.05) following EB-RET.
CONCLUSION: EB-RET increased rates of iMyoPS in YM but not OM. Alterations in mTORC1 signal phosphorylation after EB-RET revealed only marginally impaired responses in OM compared with YM. Therefore, the capacity for EB-RET to support muscle mass accrual may be impaired in older age, and the manipulation of exercise variables (e.g., load, volume, time-under-tension) may be necessary to optimise muscle adaptive remodelling to EB-RET in OM.

#### GREATER MUSCLE VOLUME AND LOAD-INDUCED MYOFIBRILLAR PROTEIN SYNTHESIS, BUT POORER MUSCLE QUALITY IN OBESE VS. LEAN OLDER ADULTS

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INTRODUCTION: The presence of obesity in older age may be accompanied by equivalent or even greater levels of muscle mass compared with lean age-matched individuals, despite a paradoxically impaired postprandial muscle anabolic response to amino acid provision. However, the metabolic basis through which obesity appears to protect absolute levels of muscle mass in older age are unclear, but may relate to augmented muscle anabolism during weight-bearing activity. Similarly, beyond absolute muscle mass, muscle quality is an important predictor of numerous health outcomes in older age, including function, and may be adversely affected by the presence of obesity.

METHODS: We determined the muscle anabolic response to weight-bearing activity and indices of muscle morphology, quality and function in 15 older-obese (OO; Body fat: 35.0 ± 2.9%), 10 older-lean (OL; 20.0 ± 2.8%) and 10 young-lean (YL; 13.0 ± 5.2%) adults. Rates of habitual and weight bearing-induced integrated myofibrillar protein synthesis (iMyoPS) were assessed 48h prior to and following a 45-min bout of brisk treadmill walking (~55% V̇O2max), using an oral stable isotope tracer (D2O) and serial muscle biopsy, plasma and saliva samples. iMyoPS rates were determined via gas chromatography-pyrolysis-isotope ratio mass spectroscopy. Acute intramuscular anabolic signaling was also determined post-exercise. Indices of muscle mass, quality, function, morphology and the abundance, species and sub-cellular location of intramyocellular lipids (IMCL) were determined via 3T MRI, electromyography, dynamometry, ELISA, immunofluorescence and transmission electron microscopy. Diet and physical activity were monitored/controlled throughout.
RESULTS: Relative to habitual activity, step count was higher on the day of the 45-min treadmill task in OO and OL but not YL. No differences in habitual iMyoPS were observed between groups. However, the 48h change in weight bearing-induced iMyoPS rates was greater in OO compared with YL and OL. Quadriceps muscle volume was lower in OL but not OO compared with YL. Markers of IMCL were higher/worsened, and muscle function lower, in OO compared with YL and OL, indicative of impaired muscle quality.
CONCLUSION: In summary, iMyoPS rates were elevated above 48h habitual values following intensity-matched weight-bearing activity in OO compared with YL and OL, which may explain the observed greater muscle mass in obese vs. lean age-matched individuals, likely driven by physical activity levels. Despite this, indices of muscle quality were markedly lower in OO. Indeed, whilst muscle quality was reduced in OL, this reduction was exacerbated by the presence of obesity, which might be modulated by alterations in contractile protein content and the abundance, species and/or sub-cellular location of lipids. However, the effects of obesity on muscle protein turnover across the lifespan remains to be fully elucidated, particularly in the 'oldest old' and in severely/morbidly obese individuals.

**SKELETAL MUSCLE MASS MAINTENANCE DURING A TRANSATLANTIC OCEAN ROWING RACE.**

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INTRODUCTION: Ultra-endurance transatlantic rowing represents a unique scenario of controlled and sustained elevated total energy expenditure (TEE) and intake (EI) for ~7 weeks in males and females of varying ages. Due to the nature of rowing, some muscle groups are in constant use whereas others are relatively inactive. The aim of the present study was to characterise changes in muscle thickness and architecture across a transatlantic rowing race, and to provide insight as to whether any sex or age differences exist.
METHODS: Fifty-six competitors (m=35, f=21; age 39±11 y, range 24-67 y; time at sea 46.3±6.7 d) in the 2020 and 2021 Talisker Whisky Atlantic Challenge rowed 12-18 h per day for 3000 miles. Thickness (Tm) of relatively active (vastus lateralis, vastus intermedius, biceps brachaii and rectus abdominus) and inactive (gastrocnemius, soleus, triceps) muscles were measured pre (<7 d) and post (<24 h) row using ultrasound, with fascicle length (Lf) and pennation angle (PA) also measure in gastrocnemius. Body mass was measured at the same time. TEE was assessed in the final week of the row using the 2H218O doubly labelled water technique; EI and dietary macronutrient composition was analysed from recall of all daily ration packs over this period.Two-way ANOVAs were used to determine sex differences in all parameters. Data are presented as mean±SD.
RESULTS: There was no change in Tm of vastus lateralis (-3.8±21%, P=0.07), vastus intermedius (-3.7±19%, P=0.20), biceps brachaii (-1.6±11%, P=0.20), or rectus abdominus (1.9±23%, P=0.98), whereas there was a decrease in Tm of gastrocnemius (-14.3±13%, P<0.001), soleus (-8±10%, P<0.001), and triceps (-11±11% P<0.001) in both males and females post row. Rate of atrophy in gastrocnemius was lower in older than younger men (0.16±0.2 v 0.45±0.2 %.day-1, respectively; P<0.05), but greater in older than younger females (0.68±0.4 v 0.27±0.2 %.day-1, respectively; P<0.05).There was no difference between males and females in increase in gastrocnemius Lf (3.0±11.6% v 3.8±18.0%, respectively; P=0.42) and decrease in PA (-17.4±17.7% v -13.4±24.2%, respectively; P=0.5). Males and females had a similar reduction in body mass (10.6±3.6%; P<0.0001) throughout the row. TEE/RMR was similar for males and females (2.5±0.5 v 2.8±0.5, P=0.1) as was EI/RMR (2.3±0.4 v 2.4±0.3, P=0.7). Males and females had similar CHO (43±5%, 5.7 g.kg-1, P=0.80) and fat (42±3%, 2.4 g.kg-1, P=0.35) intake, but protein intake was higher in males than females (16±2%, 2.0±0.4 vs.12±2%, 1.5±0.5 g.kg-1, respectively; P<0.01).
CONCLUSION: During prolonged rowing, despite being in a sustained negative energy balance and resultant considerable body mass loss, active muscles maintained mass. Despite dietary protein intake remaining high, inactive muscles still atrophied considerably, an effect that appeared to be diminished in older males but enhanced in older females. Physical activity appears to be a major determinant of muscle mass maintenance under conditions of extreme endurance.

**MECHANICAL EFFICIENCY AND FEMALE AGEING**

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INTRODUCTION: Ageing supposes an impaired maximum fat oxidation point (MFO), accompanied of a shifting down and leftward of oxidation rates curves (1). This behavior seems related to reduced muscle power at higher intensities (2), what may be associated with dropped levels of exercise efficiency with the increase of intensity in older adults. This is a limiting factor for daily living activities (3). Due to paucity of literature on efficiency with ageing, this study analyses differences on efficiency and economy up to the second ventilatory threshold comparing two age-groups of over-60 female.
METHODS: Twenty-four women performed a submaximal graded cycling test (10W every 3-min 15-s) with gas analysis by indirect calorimetry (ethics committee H105715353921). Two groups were set, considering a younger group (<65yr; 63.25±1.54y, n= 12) and an older one (>65yr; 71±4.88y, n=12). MFO was calculated, together with delta and gross efficiencies (DE% & GE%), and exercise economy (EC). Since GE% is the ratio between the external work developed and its cost, mechanical power output and metabolic power input (both in kcal·min) were determined using the mean of VO2 and RER values in the last 60s of each stage. Meanwhile, DE% was determined by the slope between metabolic power input and mechanical power output. Finally, EC (expressed in Kj·L-1) was calculated as the ratio between mean power output in the last 60s and mean steady-state oxygen uptake of each stage in the test.
RESULTS: We found differences on economy, both at the MFO intensity (<65yr; 62.64 ± 18.93 Kj·L-1 and >65yr; 43.26 ± 11.35 Kj·L-1; ECMFO p=0.01) and peak (<65yr 103.55 ± 55.13 Kj·L-1 and >65yr 59.73 ± 20.27 Kj·L-1; ECPeak p=0.02). Conversely, there were no differences on gross efficiency (p=0.17), nor regarding the delta efficiency (p=0.93).
CONCLUSION: EC confirmed age differences, pointing to higher efficiency in the younger old females. However, we failed to found age differences in any parameter of metabolic efficiency. Recently Blasco-Lafarga et al. (2) found an inverse correlation between GE% and the point of maximal carbohydrates oxidation in >60y women, so being more efficient by reducing carbohydrate oxidation would allow older

women to cope with increasing intensity whatever the age-group. Notwithstanding, efficiency maybe be related to the influence of many other factors like the cardiorespiratory, neuromuscular or biomechanical efficiencies (4). Noteworthy, future studies should look more closely to some parameters such as cadence, given that lower cadences would have greater economy compared to higher cadences (5), and we did not control for it. Larger samples are also needed.

References:
1. Monferrer-Marín et al. Sports Med Open (2022)
2. Blasco-Lafarga et al. Front Phy (2022); 0:657.
3. Broskey et al. Physiol Rep (2015): 3(6)
4. Barnes et al. Sports Med Open: (2015); 1(1)
5. Catañeda-Bararro et al. Int J Environ Res Public Health; (2020) (13):4893.

## Oral presentations

### OP-AP19 Cycling I

#### A LONGITUDINAL STUDY ON THE INTERCHANGEABLE USE OF WHOLE-BODY AND LOCAL EXERCISE THRESHOLDS IN CYCLING

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INTRODUCTION: This study longitudinally examined the interchangeable use of critical power (CP), the maximal lactate steady state (MLSS) and the respiratory compensation point (RCP) (i.e., whole-body thresholds), and breakpoints in muscle deoxygenation (m[HHb]BP) and muscle activity (iEMGBP) (i.e., local thresholds).
METHODS: Twenty-one participants were tested on two timepoints (T1 and T2) with a 4-week period (study 1: 10 women, age=27±3yr, V̇O2peak=43.2±7.3mL·min-1.kg-1) or a 12-week period (study 2: 11 men, age=25±4yr, V̇O2peak=47.7±5.9mL·min-1.kg-1) in between. The test battery included one ramp incremental test (to determine RCP, m[HHb]BP and iEMGBP) and a series of (sub)maximal constant load tests (to determine CP and MLSS). All thresholds were expressed as oxygen uptake (V̇O2) and equivalent power output (PO) for comparison.
RESULTS: None of the thresholds were significantly different in study 1 (V̇O2:P=0.143, PO:P=0.281), but differences between whole-body and local thresholds were observed in study 2 (V̇O2:P<0.001, PO:P=0.024). Whole-body thresholds showed better 4-week test-retest reliability (TEM=88-125mL·min-1 or 6-10W, ICC=0.94-0.98) than local thresholds (TEM=189-195mL·min-1 or 15-18W, ICC=0.58-0.89). All five thresholds were strongly associated at T1 and T2 (r=0.75-0.99), but their changes from T1 to T2 were mostly uncorrelated (r =-0.41-0.83).
CONCLUSION: Whole-body thresholds (CP/MLSS/RCP) showed a close and consistent coherence taking into account a 3-6%-bandwidth of typical variation. In contrast, local thresholds (m[HHb]BP/iEMGBP) were characterized by higher variability and did not consistently coincide with the whole-body thresholds. Also, we found that most thresholds evolved independently of each other over time. Together, these results do not justify the interchangeable use of whole-body and local exercise thresholds in practice.

#### EFFECT OF PEDALLING CADENCE DURING ECCENTRIC CYCLING ON MUSCULAR ACTIVATION AND PERCEIVED EXERTION

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INTRODUCTION: For a given power output, changing the cycling pedalling rate alters factors such as perceived exertion, oxygen consumption or muscular activation (1). While this observation holds for traditional (i.e., concentric) cycling, no data are available for eccentric cycling (ECC), despite the fact that this exercise modality has been extensively studied in the last decade, especially in the rehabilitation field (2). Notably, the effects of ECC cycling cadence on muscular activity and perception of effort remain unknown.
METHODS: In the current investigation, twelve participants completed four sessions one week apart: 1) determination of maximal concentric aerobic power (MAP); 2) familiarization with ECC cycling at five cadences (30, 45, 60, 75, and 90 rpm); 3) and 4), ECC cycling exercise consisting of 5 min at the five different cadences at either 40 or 60% MAP. Perceived exertion (PE) was reported and the mean electromyography (EMG) root mean square was calculated over the last 30 s of exercise for the vastus lateralis and rectus femoris muscles. The optimal cadence for each parameter, minimising either PE (PECAD-OPT) or EMG (EMGCAD-OPT) was estimated using second-order polynomial regressions.
RESULTS: At both power outputs, PE and EMG showed an effect of cadence ($P < 0.001$) and followed a U-shaped curve ($R^2 > 0.77$ and 0.83, respectively). Estimated PECAD-OPT (63 ± 13 rpm for 40% MAP and 62 ± 8 rpm for 60% MAP) and EMGCAD-OPT (61 ± 8 rpm for 40% MAP and 65 ± 9 rpm for 60% MAP) did not significantly change with power output ($P > 0,69$). For both power outputs, PECAD-OPT and EMGCAD-OPT were not significantly different ($P > 0.35$).
CONCLUSION: To our knowledge, this study is the first to describe the effects of cadence on both EMG and PE, for ECC cycling at different power outputs. Both PE and EMG were affected by cadence and showed maximal values for extreme cadences, while the lowest values appeared at intermediate cadences. As lower ECC cadences require greater force production on the pedals, these likely involve the recruitment of additional motor units (3), as evidenced by an increased EMG. In addition, a greater motor command would be related to higher PE (4). Conversely, high ECC cadences may require a suboptimal muscle coordination pattern that would increase EMG (and thus PE) compared with intermediate cadences (5). Additional research is required to examine the short- and long-term effects of using low versus high ECC cadences following fatiguing exercises and training programs.

1. (1) Ansley & Cangley, (2009). European Journal of Sport Science, 9(2), 61-85.
2. (2) Inostroza et al., (2022). Eur J Appl Physiol 122, 489–502
3. (3) Henneman, et al. (1965). Journal of Neurophysiology, 28, 599-620.
4. (4) De Morree et al., (2012). Psychophysiology, 49(9), 1242-1253.
5. (5) Sarre, & Lepers (2007). Journal of Electromyography and Kinesiology, 17(5), 617–621

**INTER- AND INTRA-INDIVIDUAL RELIABILITY OF A 30-MINUTE RPE CLAMP CYCLING EXERCISE**

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INTRODUCTION: Exercise protocols at a fixed rating of perceived effort (RPE) are useful for exploring the psychophysiological influences on exercise performance. However, studies that have employed these "RPE clamps" have arbitrarily selected RPE values without considering physiological state and intensity domains at a given RPE. Therefore, incorporating a validated and justified approach which aligns RPE intensities with established physiological boundaries seems beneficial. Yet, no research has assessed if such a protocol is reliable at both the inter- and intra-individual level.
METHODS: Eight recreationally trained, active cyclists completed eight laboratory visits. Within the first two visits, participants underwent identical cycling ramped incremental tests to identify gas exchange threshold (GET). A linear regression model plotted RPE responses during this ramped test alongside gas parameters to establish individual RPE responses corresponding to GET (RPEGET) and 15% above GET (RPE+15%GET). The next six experimental visits involved participants completing three randomised trials at each intensity. Performance (power output), physiological (gas parameters, heart rate, blood lactate), and psychological (affect, self-efficacy) measures were obtained throughout and averaged across five- and thirty-minute intervals. Data from these RPE-clamped trials were assessed for reliability using intraclass correlation coefficients (ICC), coefficients of variation (CoV) and 95% confidence intervals (95% CI). Repeated measures ANOVAs and paired samples t tests assessed differences over time and between conditions.
RESULTS: Power output and all gas parameters showed excellent levels of test-retest reliability (ICC = >.900) across both intensities. Power output, gas parameters and heart rate demonstrated good intra-individual reliability (mean CoV = <5 %) in both conditions. Narrower 95% CI were observed in the RPE+15%GET condition (range = 1.1 – 5.2 %) compared to the RPEGET condition (range = 2.0 – 8.4 %). Plots of time-lapsed physiological data during the 30-minute RPE clamp exercise showed that blood lactate, V̇O2 and V̇O2.kg-1 were closely aligned with power output changes in both conditions. Psychometric data showed significant differences (P = <.05) at all time intervals between conditions.
CONCLUSION: Recreationally trained, active cyclists can reliably replicate RPE clamp exercise when RPE is aligned to physiological thresholds. Evidence suggests that exercise at higher RPE values (RPE+15%GET) may be more reliable than lower RPE values (RPEGET). Moreover, it appears that sensations emanating from the muscle (e.g., blood lactate) and oxygen demand (V̇O2) are the main regulators of exercise performance at a fixed RPE. However, to further substantiate this finding, future research could probe the underlying decision-making processes that determine exercise intensity during fixed RPE exercise to corroborate psychophysiological data.

**PERFORMANCE CHARACTERISTICS OF TOP5 VERSUS NOT-TOP5 RACES IN FEMALE PROFESSIONAL CYCLING**

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INTRODUCTION: Maximal mean power output (MMP) is commonly used to describe the demands and performances of races within professional male cycling. Within the female professional cyclist domain, however, there is limited knowledge regarding MMPs in races.1-4 Therefore, this study aims to describe MMPs within female professional cycling races whilst investigating differences between TOP5 and NOT-TOP5 races.
METHODS: Race data (n=1324) were collected from 14 professional female cyclists between 2013-2019. Races were categorized as TOP5 or NOT-TOP5. MMPs were consequently determined over a range of different timeframes (5sec to 60min). To provide these MMPs with additional context, two factors were determined: when these MMPs were attained in a race (based on duration and kJ spent [kJspent·kg-1]) and these MMPs relative to the cyclist's season's best MMP (MMP%best). All performance indicators from TOP5 races are compared to NOT-TOP5 through a multilevel random intercept model using Tukey's method for pairwise comparisons in R (Statistical computing, Vienna, Austria). Random effect variability was modelled using a random intercept for each individual participant. The level of significance was set at P <0.05.
RESULTS: Short-duration power outputs (≤1min) were higher in TOP5 races compared to NOT-TOP5 races. In addition, the timing (both duration and kJspent·kg-1) of all MMPs was later and after more workload in the race in TOP5 compared to NOT-TOP5 races. In contrast, no difference in MMP%best was noted between TOP5 and NOT-TOP5 races.
CONCLUSION: TOP5 races in female cycling are presented with higher short duration MMPs (≤1min) when compared to NOT-TOP5 races and cyclists were able to reach a higher % of their seasonal best MMP when they were able to finish TOP5. In addition, these MMPs are performed later and after more kJspent·kg-1 in TOP5 vs NOT-TOP5 races, which confirms the importance of "fatigue resistance" in professional (female) cycling.
References
1. Menaspa P et al. Int J Sports Physiol Perform. 2017;12(10):1293-1296.
2. van Erp T et al. Int J Sports Physiol Perform. 2020;15(4):534-540.
3. Sanders D et al. Int J Sports Physiol Perform. 2019;14(3):296-302.
4. Ebert TR et al. Eur J Appl Physiol. 2005;95(5-6):529-36.

## Oral presentations

### OP-AP11 Sprinting Performance

**EFFECTS OF VELOCITY BASED RESISTED SPRINT TRAINING ON PERFORMANCE IN SOCCER PLAYERS.– A PILOT STUDY.**

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INTRODUCTION: The effects of resisted sprint training (RST) on performance are currently a question of discussion in scientific literature. Traditionally, not reducing the athlete's velocity by more than 10% from unresisted sprinting have been recommended. [9] However, some authors have recommended the use of sled loads heavier than 20% BM for enhancing the initial acceleration phase, where velocity is low

and resistive forces are high, and lighter loads (ie, <10% BM) for improving the maximal velocity phase, where velocity is higher and resistive forces are lower. [10] The aim of this study was to compare the training effects of resisted sprint with 3 different external loads that reduced sprint mean velocity by 10, 25 and 40% on 20-m sprint, change of direction and jump performance in Soccer players.
METHODS: Eighteen amateur soccer players performed 2 unresisted and resisted 20-m sprint with 10, 30, 50 and 70% body mass recording sprint time (Photocell timing gates Witty; Microgate). Percentage mean velocity loss (%VL) compared to unloaded condition were used to allocate players into 3 groups: Low load resisted sprint training group (G10%VL, n = 6), medium load resisted sprint training group (G25%VL, n= 5) and high load resisted sprint training group (G40%VL, n = 3). Pretraining and posttraining assessments included 20-m sprint time, countermovement jump and change of direction time. All groups were trained twice a week for 6 wk and completed the same training program, but with different loads (10% vs 25 vs 40% VL). Data were analyzed using a 3 (group) × 2 (time) factorial analysis of variance with Bonferroni post hoc comparisons. Statistical significance was established at the P < .05 level.
RESULTS: No significant "time × group" interactions were observed. For sprint performance, only G10%VL showed significant (P = .017) decreases. Regarding CMJ, only G10%VL and G25%VL showed significant (P = .011 and .018 respectively) improvements. Any group showed significant improvements in COD time.
CONCLUSION: In soccer players, no significant differences in sprint, countermovement jump and change of direction performances were detected after 6 weeks of different resisted sprint training programs. Future studies should, therefore, be devoted to how sprint training should be individualized to maximize performance.

**RELIABILITY OF AN ISOTONIC SPRINT DEVICE IN RECREATIONALLY TRAINED PARTICIPANTS**

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INTRODUCTION: An increasing number of coaches have employed isotonic sprint devices to provide an external resistance while sprinting. The device has been demonstrated to help improve sprint performance [1], however from a scientific perspective it is currently unclear if such a device provides external load in a reliable manner. This is important as the magnitude of load dictates adaptation, therefore it is crucial to understand if this load prescription is reliable within and between sessions, in order to be used with confidence [2]. The main purpose of this study was to determine the reliability of an isotonic sprint device in recreationally trained individuals. More specifically, the question was: does it result in changes of split times at the same load over multiple runs, and between sessions?
METHODS: Thirteen recreationally active participants (age, 21 ± 1.61 years; height (cm), 180.08 ± 2.88cm; weight (kg), 84.27 ± 10.87 kg) were recruited and required to complete 2 testing days, 5-7 days apart. Three maximal 20m sprints, with an isotonic resistance device (Exer-Genie, Thousand Oaks, CA, USA), at three resistance levels (2oz, 5oz & 8oz) on a sprint track were undertaken, in a randomized order on two separate testing days (18 sprints in total). The device was attached to the participant by a waist harness which connected on to the rope (36m) via a safety clip. The device itself was attached to the railing of the sprint track via an anchor strap (91.44cm) and safety clip. Sprint time was assessed using photocells, which were set up at 5-meter intervals. Intrasession (comparison of the 3 sprints of the second session) and intersession (comparison of the average of the 3 sprints across days) reliability of sprint time for 5m, 10m, 15m & 20m at all resistance levels, were assessed by intrasession correlation coefficient (ICC) and coefficients of variation (%CV) and associated 90% confidence intervals (CI). The scale of magnitude for effect statistics used were rated as trivial (<0.1), small (0.1-0.29), moderate (0.3-0.49), large (0.5-0.69), very large (0.7-0.89) or nearly perfect (0.9-0.99) [3].
RESULTS: The device showed moderate intersession reliability for 2oz & 5oz and large reliability for 8oz across all distances (ICC 0.18 – 0.77), (%CV 5.6 – 12.9). Intrasession reliability was moderate to nearly perfect across the distances for the resistance level of 2oz (ICC 0.35 - 0.91), (%CV 3.1 - 14.6%). At 5oz reliability ranged from large to nearly perfect across the distances, (ICC 0.58 - 0.95), (%CV 2.9 - 10.7%). At 8oz reliability ranged from very large to nearly perfect across the distances, (ICC 0.80 - 0.97), (%CV 3.9 - 8.4%).
CONCLUSION: To conclude, isotonic resistance appears to be a reliable method to provide a desired training stimulus to athletes engaging in sprinting activities and therefore could be considered as part of a training programme for those wishing to enhance their performance.
1. Bremec (2018), 2. Koo et al. (2016), 3. Hopkins (2002)

**RAMP ORDER FROM SKIP TO SPRINT**

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INTRODUCTION: Isolation drills are often utilised to decompose and aid the learning and refine key aspects of sprinting technique1. Popular drills include A-skips; calf dribble (CD), straight leg skip (SLS); bounding (BD) and submaximal percentage effort sprints2. However, there is limited knowledge on how these drills in isolation transfer to overall sprinting performance and how the intensity of each drill varies. The aim of this study was to determine if any relationships exist between submaximal running drills and maximal sprinting (MS) and to develop a continuum of submaximal running drills based on average velocity.
METHODS: Twenty-five physically active individuals (17 male, 8 female, 22.6±5.4 years, 175.2±7.7 cm, 75.2±11.6 kg) performed three repetitions of 20m, with a split at 15-20m MS and submaximal running drills: A-skips, CD, SLS, BD; 80% sprint; and 90% sprint over three consecutive weeks using electronic timing gates (Draper, Utah, USA), with the first week used for familiarisation purposes. Average velocity of the 15-20m split is presented as mean±SD. Pearson's r and R2 were used to observe if any relationships existed between MS and running drills, a series of RMANOVA with Bonferroni post-hoc analysis were performed to compare between drills. Significance was set at $p<0.05$.
RESULTS: A-skip (3.21±0.86 s) and CD (4.24±0.94 s) were moderately correlated with MS ($r=0.303$ $p=0.048$ & $r=0.465$ $p=0.002$). A large correlation was observed between SLS (4.43±0.93 s) and MS ($r=0.553$ $p<0.001$). A very large correlations was observed between MS (7.20±0.91 s) and BD (5.41±0.88 s, $r=0.722$ $p<0.001$). Large and moderate correlations were observed between MS and 80% sprint (5.75±0.88 s, $r=0.594$ $p<0.001$), and 90% sprint (5.73±1.01 s $r=0.487$, $p<0.001$). Non-significant ($p>0.05$) differences were observed between 80- and 90% sprint, between 90% sprint and BD and between SLS and CD. All other pairwise comparisons were significant ($p<0.021$).
CONCLUSION: Despite popularity2, A-skips accounted for 9.2% of the variance in sprinting performance, whereas bounding was able to explain 52.1% of sprinting performance. The remaining drills were able to explain between 21.6-35.3% of sprinting performance. A-skips had the slowest average velocity, closely followed by the SLS, CD and BD. Sprinting at 80- and 90% effort had almost identical velocities, with 80% being greater than 90%, highlighting a lack of speed regulation4. Although the skips and drills closely mimic aspects of sprinting technique, they lack similar muscle activation levels and magnitude and orientation of ground reaction forces in MS3. The results of the present study could be utilised in prescribing training or warm up activities, with a RAMP based or control-chaos progression based on intensity.

References
1. Cissik, JM, StrengthCondJ, 2004.
2. Whelan, N., Kenny, IC., Harrison, AJ. IntJSportsSciCoach, 2006.
3. Johnson, ST, et al., J.Sport Rehabil. 2005.
4. Darrall-Jones, et al., JSCR. 2021.

**EFFECTS OF RESISTED AND MAXIMUM VELOCITY SPRINT TRAINING ON THE ACCELERATION PERFORMANCE OF TEAM SPORT ATHLETES**

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INTRODUCTION: Sprint speed is considered an essential performance attribute for field-based invasion team sport (FITS) athletes, and is associated with the successful completion of key attacking and defensive performance indicators [1]. A large volume of short distance sprints (10-20m) within FITS's [2] highlights the importance of developing acceleration performance. While a number of methods are used to improve this phase, resisted sprint training (RST) applies an external resistance to the sprinting movement and is frequently utilised to develop acceleration specific speed due to its ability to influence key acceleration determinants such as horizontal force production [3]. Alternatively, research indicates a moderate to strong relationship between an athlete's maximum velocity (MV) and their ability to accelerate [4], thus suggesting that players with a higher MV may hold an advantage over players with a lower MV when performing shorter sprints. Therefore, the aim of this study was to investigate and compare the impact of RST and maximum velocity sprint training (MVST) on the acceleration performance of FITS athletes.
METHODS: Elite level, male Gaelic football players were randomly assigned to RST (n=8) or MVST (n=7). Both groups underwent force-velocity profiling, with the RST group utilising sled sprints at 50% velocity decrement and the MVST group performing flying sprints (12-20m) with a preceding 25m submaximal build-up phase. Participants completed 7 training sessions across 4 weeks. Sprint, vertical and horizontal jump performance were measured at baseline and after 4 weeks.
RESULTS: Significant increases in 0-5m, 0-10m, 0-15m and 0-20m were found following RST only. However, results showed significant differences in baseline speed parameters between the RST and MVST groups. When controlling for baseline sprint performance, there were no significant differences between RST and MVST groups post intervention over 0-5m, 0-10m, 0-15m and 0-20m distances or at maximum velocity (Vmax). Finally, vertical and horizontal jump performance did not significantly change after 4 weeks.
CONCLUSION: Marked increases in acceleration performance can be attained by FITS athletes with just 7 RST sessions over a 4-week period. Failure to detect significant change following MVST may be due to the length of the intervention, number of sessions or baseline values of the training group, as those with the lowest initial values of a physiological system have the greatest capacity for improvement in response to training. Further work is required to determine the effectiveness of RST and MVST in FITS athletes under controlled conditions.

References
1. Cunningham, D.J., et al., PloS one, 2018. 13(9): p. e0202811.
2. Malone, S., et al., Journal of Strength and Conditioning Research, 2016. 30(8): p. 2292-2298.
3. Morin, J.-B., et al., International Journal of Sports Physiology and Performance, 2017. 12(6): p. 840-844.
4. Clark, K.P., et al., Journal of Strength and Conditioning Research, 2019. 33(6).

## Oral presentations

### OP-MH07 Injury and Team Sports

**MULTI-SEASON INJURY SURVEILLANCE IN RUGBY UNION: ADDRESSING THE CHALLENGES OF DATA COLLECTION.**

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INTRODUCTION: Rugby Union has a relatively high injury rate in line with field-based full-contact sports. The injury rates are well studied in single seasons. The next progression of understanding would come from multi-season studies of injury rates. Multi-season studies must consider the effect of varying data collection practices over time. Changes across seasons can influence the comparability of data. We aimed to examine how modifications to data collection procedures influenced data quality and overall injury outcomes (injury incidence rates and injury severity) from surveillance over a 6-year period in Australian professional rugby.
METHODS: Game sustained time-loss injuries were included in this study. The data were reported by all five Australian franchises in Super Rugby (2016-2021) using a common collection tool. Match exposure hours and injury incidence rate per 1000 player-game-hours are presented, alongside descriptions of key changes to data collection procedures. Main changes in the data collection procedures included the facilitation of support resources to the teams, discussions with the field practitioners on the objectives of the system and refining of the variables to collect. Injury severity was calculated as the number of days the player was unable to participate in the competition or/and training.
RESULTS: There were 368 game sustained injuries in 195 players from 8229 player-game-hours. The match sustained injury incidence was 44.7 injuries per 1000 game hours, with a median severity of 31 (IQR±58) days missed per injury. The differences in injury incidence rates by season were notable with 12.8 injuries per 1000h in 2016, and 52.1 injuries per 1000h in 2018. This is credited to the increased engagement of the teams with the system as a result of the support resources and involvement of the field practitioners with the system, and the refinement of the variables collected.
There was also a notable change in the median severity of injury in 2016 [median 66 (IQR±174) days] and 2018 [median 31 (IQR±48) days]. This is attributed to improved processing of injuries that are deemed to be recovered.
CONCLUSION: Questions should be asked if the differences in severity and incidence across seasons are reasonable or if they are attributable to changes in the data collection processes. Modifications in the data collection procedures influence the outcomes of the system. The growth of engagement and improved processing of the collection system increased the incidence of the game injuries but decreased the

severity. The data in later years show a decrease in variability in incidence and severity. But only major changes across seasons influenced the comparability of the data.
Good output data is needed to correctly inform organisational decisions, and this is dependent on the quality of the input data.

**INFLUENCE OF EXECUTIVE COGNITIVE PERFORMANCE ON INJURY RISK IN PROFESSIONAL FOOTBALL PLAYERS**

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INTRODUCTION: Systematic evidence suggests that team sport athletes with lower baseline cognitive performance are at higher risk of sustaining non-contact injuries (Avedesian et al. 2022). While previous studies have focused primarily on rather lower cognitive functions (e.g., reaction time and visual perception) (Avedesian et al., 2022), the aim of this study was to investigate the potential influence of executive performance measures (e.g., cognitive flexibility, working memory) on the risk of sustaining a non-contact injury in elite football players.
METHODS: Seventy-nine professional male football players (4 teams of first Slovenian league, age: 24.4±4.5 years; BMI: 21.3 Kg/m2) participated in our prospective case-control study. Computerized (PsyToolkit) and pen-and-paper tests (Trail-Making-Test) were used to compare baseline cognitive performance (visual screening, simple and choice reaction time, working memory, cognitive flexibility,) between players who experienced at least one non-contact injury (n=29) and those who remained uninjured (n=35, con-trols) during the one-year follow-up period. Variance analyses were applied to investigate potential differences between groups.
RESULTS: The majority of non-contact injuries affected the lower extremity (79.3%), with thigh (56.7%) and knee (28.2%) being the most common injury sites. Both groups differed significantly in terms of age (25.7 vs. 23.3; $p = 0.04$) but not for BMI ($p = 0.458$). Analysis of covariance (age as covariate) showed a signifi-cantly faster visual screening performance for the non-contact injury group compared to the controls (14.6 vs 17.8 sec, $p=0.019$). No significant between-group differences were found for the other cogni-tive measures assessed ($p > 0.05$).
CONCLUSION: Our findings seem to contradict previous evidence. Better visual screening skills may predispose higher in-game performance increasing the odds of being a regular player. The longer playing exposure times might have made them more vulnerable to injuries than players with less playing time. However, this interpretation is speculative based on our data. To further elucidate how the occurrence of non-contact injuries relates to executive cognitive performance in professional football, the assessment of playing status (e.g., regular or substitute player), position and exposure time is crucial.
REFERENCES:
1. Avedesian, J. M., Forbes, W., Covassin, T., & Dufek, J. S. (2022). Influence of Cognitive Performance on Musculoskeletal Injury Risk: A Systematic Review. Am J Sports Med, 50(2), 554-562. doi:10.1177/0363546521998081

**A SYSTEMATIC REVIEW OF INJURY INCITING ACTIVITIES IN MALE AND FEMALE FOOTBALL PLAYERS**

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INTRODUCTION: A comprehensive examination of the sport-specific activities performed at the time of injury is important to hypothesise injury mechanisms, develop prevention strategies, improve management, and inform future investigations. The aim of this systematic review is to summarise the current literature describing the activities performed at the time of injury in football (soccer).
METHODS: A systematic search was carried out in PubMed, Web of Science, SPORTDiscus, and OpenGrey. Studies were included if participants were football players aged > 13 years old and the activities performed at the time of specific injuries (e.g., ACL, hamstring injuries) were reported together with the total number of injuries. Risk of Bias was assessed using an adapted version of checklists developed for prevalence studies. The activities reported by the studies were grouped to account for inconsistent reporting, and the proportion of each activity performed at the time of injury was calculated. Data were not meta-analysed due to high heterogeneity of methods and classification criteria. The review was performed following the PRISMA 2020 guidelines and the protocol was registered at the Open Science Framework (https://doi.org/10.17605/OSF.IO/U96KV).
RESULTS: In total, 29 studies were included in this systematic review. ACL injures were analysed by 12 studies, ankle/foot and knee injuries were analysed by 5 studies, thigh injuries were analysed by 4 studies, hip/groin injuries were analysed by 3 studies and hamstring injuries were analysed by 2 studies. Two studies analysed more than one type of injury. Running and kicking were the predominant activities leading to thigh and hamstring injuries. Changing direction and kicking were the predominant activities leading to hip and groin injuries and duels were the predominant activities leading to ankle injuries. Results for ACL and knee injuries were inconsistent among the included studies. High or medium risk of bias was observed in 80% of studies for injury definition and in 95% of studies for the measurement of inciting activities.
CONCLUSION: High intensity running and kicking activities seem to be the main activities leading to thigh and groin injuries, which is in accordance with what has previously been hypothesised [1, 2]. Duels seem to be the most frequent activity leading to ankle injuries which is in contrast with the literature available for other sports [3]. Results for other injuries were inconsistent between the studies. Most of the studies included in the review did not implement an appropriate definition of injury and/or a validated or standardised classification system for the inciting activities, therefore these results need to be interpreted carefully. It is paramount that future studies implement standardised injury definitions and standardised systems to classify the inciting activities in order to have consistent data that can be compared among studies.
1. Charnock et al. (2009) 2. Huygaerts et al. (2020) 3. Doherty et al. (2014)

**SURVEY OF THE CURRENT PRACTICES OF GERMAN FOOTBALL ACADEMIES TOWARDS BIOLOGICAL MATURITY AND TRAINING LOAD AND CLUB BELIEVE ON EVIDENCE-BASED PRACTICE**

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INTRODUCTION: Despite the structural development of youth academies and the ongoing professionalism there appears to be the necessity of further investigations into their operational behavior. Injury surveillance studies of maturing football players emphasize the im-

portance to implement load monitoring into a youth football academy and to modify and adapt the imposed demands during sensitive growth phases [1]. Therefore, it has become increasingly common for practitioners in the Premier League to utilize non-invasive equations to estimate maturity status and timing for talent development [2]. Therefore, this study aims at (1) providing an overview of the practices towards load and maturity monitoring in German football academies and (2) examining the club belief towards the benefit of evidence-based practice (EBP).
METHODS: An online survey was conducted, consisting of multiple choice and Likert scale questions, which was distributed towards all 56 licensed German youth academies with full survey completion of 71% (n = 40). The survey was built on maturity and training load themes previously surveyed [2] and considering current research results towards maturity and training load assessment and application. The average response to five Likert Scale questions was used to describe the club belief on the importance of EBP.
RESULTS: The result indicates that the sport science staff were mostly responsible for data collection and analysis (84%) regarding monitoring load and maturity. 87% of respondents agreed that considering biological maturation and load monitoring is important for the overall development and injury prevention of youth football players whereas a formal assessment of maturity was implemented by 48% (n = 19) and load monitoring practices by 58% (n = 23) of the respondents. Of the 19 practitioners of maturity assessment, six (31%) perform regular adjustments in their football training and ten (52%) adjust their strength and conditioning training considering the maturity status. Regular application for maturity matched official competitions as bio-banded tournaments does not take place (n = 0). Further results indicate lower attribution of importance to the benefit of evidence-based practices in lower leagues (Bundesliga n = 12, 3,05 ± 1,87; 2. Bundesliga n = 15, 3,2 ± 2,87; 3. Liga n = 7, 1,75 ± 0,78, Regionalliga n = 6, 1,28 ± 0,81).
CONCLUSION: Practitioners in German football youth academies assign high significance to the assessment of biological maturation and load monitoring for a sustainable youth player development. Nevertheless, there is only a limited application and consideration for various training content. Despite the rise of bio-banded soccer tournaments by the Premier League, such a regularly implementation has not been found in Germany so far.
REFERENCES:
1. Towlson et al., Journal of sport and health science, 2021
2. Salter et al., International Journal of Sports Physiology and Performance, 2021

### TACKLER AND BALL-CARRIER INJURY MECHANISMS DURING MODERATE AND SEVERE INJURIES (≥8 DAYS LOST) IN ELITE RUGBY UNION

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INTRODUCTION: Tackle injuries have the highest injury incidence, may cause the greatest number of days lost (severity) and carry a high injury burden. Moderate and severe injuries may have financial, psychological and team performance implications. Video analysis is a useful tool to understand injury mechanism during competition. This information can be used to develop effective injury prevention strategies. Therefore, the purpose of this study was to analyse tackler and ball-carrier injury mechanisms during moderate and severe contact injuries in professional rugby union from 2014 to 2018.
METHODS: Injury surveillance was conducted during The Currie Cup (South Africa's annual premier domestic competition) between 2014 and 2018 as part of the SA Rugby Injury and Illness Surveillance and Prevention Project (SARIISPP). Using the SARIISPP injury surveillance data, video footage of injuries with a 'moderate' and 'severe' severity (≥8days' time loss) were identified. Player-matched and team-matched non-injury events were also identified as controls. A total of 579 total injuries occurred over the four-year period, with 237 injuries recorded as 'moderate' and 'severe' (≥8 days' time lost). One-hundred and eight (n=108) of these injuries were clearly identifiable on the video footage. Of the 108 injuries, 87 injuries were tackle-related. A total of 965 non-injury tackles were analysed as controls. Injured and non-injured tacklers and ball-carriers were coded for pre-contact, contact, post-contact, and contextual variables. Multinomial logistic regression was used to determine the relative risk ratio (RR) for an injury or non-injury outcome based on the observed characteristics.
RESULTS: Ball-carriers were less likely to be injured when they made contact at 'high' intensity compared to 'medium' intensity (own control RR = 0.14, 95% CI, 0.05 – 0.38, $p < 0.05$; team control RR = 0.14, 95% CI, 0.05 – 0.39, $p < 0.05$). Tacklers had a higher risk of injury when their body position before contact was 'medium' (own control RR = 3.02 [95% CI, 1.18 – 7.74], $p < 0.05$; team control RR = 2.52 [95% CI, 1.04 – 6.13]; $p = 0.041$) or 'upright' (own control RR = 4.56, 95% CI, 1.31 – 15.90, $p < 0.05$; team control RR = 3.40, 95% CI, 1.01 –11.43; $p < 0.05$) compared to a 'low' body position. Tacklers were less likely to be injured when they approached the ball-carrier at a 'fast' speed (own control RR = 0.21 [95% CI, 0.06 – 0.75], $p < 0.05$; team control RR = 0.27 [95% CI, 0.08 – 0.93]; $p < 0.05$), and contacted the ball-carrier at the arm (own control RR = 0.15 [95% CI, 0.04 – 0.52], $p < 0.05$; team control RR = 0.22 [95% CI, 0.06 – 0.75]; $p < 0.05$) or hip (own control RR = 0.11 [95% CI, 0.02 – 0.53], $p < 0.05$; team control RR = 0.18 [95% CI, 0.04 – 0.81]; $p < 0.05$).
CONCLUSION: Our results suggest that attempts to reduce speed into contact and contact intensity may not be worthwhile injury prevention strategies. Rather, rugby stakeholders should focus injury prevention efforts on player tackle technique and conditioning.

## Oral presentations

### OP-BM19 Youth II

### PROFILING OF AGE-RELATED DEVELOPMENT OF METABOLIC PERFORMANCE DETERMINANTS IN ELITE YOUTH SOCCER PLAYERS: CONVENTIONAL STATISTICS AND CONTRIBUTIONS OF MACHINE LEARNING

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INTRODUCTION: Performance diagnostic is an indispensable process for optimizing individual training programs and monitoring an athlete's development in all sports disciplines. Due to the high impact of biological maturation on performance development of young athletes, systematic and continuous physiological monitoring is even more important in this population than in senior athletes (Barker & Armstrong, 2010). However, data on physiological performance determinants and their time-course changes in young elite athletes is

limited and rather complemented with data from untrained children and adolescents. Thus, this cross-sectional study aimed to explore physiological characteristics regarding endurance performance and the longitudinal development of elite youth soccer players based on chronological age and age groups.
METHODS: 221 male elite youth soccer players (17.0±2.9 yrs) performed an incremental step test till exhaustion (start at 2.8 m/s +0.4 m/s every 5 min), to determine physiological determinants of endurance performance such as running velocity at lactate thresholds (vLT1 & vLT2), maximal oxygen uptake (VO2max), oxygen cost of running (CR), and total distance covered (DTot). For each athlete, 1-10 tests were carried out in a period of 4 years (number of tests: U15 = 72, U16 = 136, U17 = 204, U19 = 201, U23 = 188). The data were organized in a "data warehouse" and used for conventional statistics and machine learning, such as clustering and decision trees.
RESULTS: There was no significant difference between age groups (mean±SD) regarding VO2max (ml/kg/min; U15 = 55.5±3.8, U16 = 55.1±4.4, U17 = 54.6±4.0, U19 = 55.3±4.5, U23 = 53.7±4.1). In contrast, the key indicator of overall treadmill performance (i.e. DTot; m) increased with age: U15 = 4598±855, U16 = 5089±868, U17 = 5241±911, U19 = 5667±890, U23 = 5836±888. At the same time, improved CR (ml/kg/m) with increasing age was found: U15 = 0.241±0.019, U16 = 0.232±0.022, U17 = 0.224±0.017, U19 = 0.216±0.015, U23 = 0.208±0.014. A similar development pattern in these variables was also observed in the intra-individual analyses.
Due to the large number of experimentally available variables an important consideration is the strategy of "dimension reduction" to gain a better understanding of complex key indicators. For this purpose, factor-analyses with varimax-rotation have been used. Two major factors with an explained variance of 68% were extracted, which can be associated with dominant aerobic (52%) and anaerobic energy supply (16%).
CONCLUSION: Our results indicated an age-related improvement in CR without a change in VO2max resulting in improved endurance performance. Although the positive impact of growth and maturation cannot be ruled out (Ariens et al., 1997), the decreased metabolic demand of running (CR) per se can be associated with performance development in elite youth soccer players. Metabolic profiling and player grouping using machine-learning can help to better understand and improve an athlete's performance development.

**HIGH MUSCULAR FITNESS LEVEL MAY POSITIVELY AFFECT BONE STRENGTH AND BODY COMPOSITION IN CHILDREN WITH OVERWEIGHT AND OBESITY**

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*UNIVERSITY OF ZARAGOZA*

INTRODUCTION: Obesity has become a major global health challenge because of its increased prevalence. Bone mineral content (BMC) is higher in obese children than in normal weight peers because body adiposity represents a mechanical load, but the fractures of the lower limb are much more frequent in obese children due to the excessive mechanical loading due to excessive adipose tissue and hormonal negative effects (Rinonapoli et al. 2021). Higher muscular fitness (MF) may attenuate the adverse hormonal effect of childhood obesity on bone mass (Gil-Cosano et al. 2020). The aim of this study was to compare bone health and the body composition between overweight and obese children with different (MF) level.
METHODS: A total of 59 children with overweight and obesity were included in this study. (MF) was measured by a countermovement jump (CMJ), handgrip and maximal isometric strength of knee extension. Participants were divided into four groups depending on their (MF) level as follow: 16 children with high MF (HMF) in both isometric (knee and handgrip) and CMJ (10.7±0.6 y, 8 males), 18 with high performance in isometric strength (HIS) (10.2±0.9 y, 10 males), 15 with high performance in CMJ (HCMJ) (9.7±0.9 y, 10 males) and 10 with low (MF) (LMF) (9.5±0.6 y, 4 males). A k-means cluster analysis was conducted to create these (MF) levels from handgrip and CMJ test. Body composition values were measured by DXA to obtain BMC, bone mineral density (BMD), fat mass (FM), lean mass (LM) and their indexes. Bone strength values were measured at the 8%, 38% and 66% sites of the length of the non-dominant tibia by peripheral quantitative computed tomography (Stratec XCT-2000 L pQCT scanner). Multivariate analysis of covariance test was applied to analyze bone strength differences between overweight and obese children who had different (MF), using maturity offset, height and weight as covariates.
RESULTS: Results show that HMF had better body composition.Despite having more FM than LMF, it had lower fat mass index (FMI) and lower fat mass index z-score. In addition, HMF had significantly lower FM and FMI than HIS and higher LM and lean mass index (LMI). HIS showed higher LMI than the worst performing group, and HCMJ showed higher LM and LMI than LMF.
On the other hand, the bone health variables are in the same direction. HMF showed higher bone mineral content and bone mineral density than LMF. In addition, LMF showed a significantly lower fracture load in X-axis and polar strength strain index compared to HMF and HIS. HCMJ showed a lower fracture load in X-axis also compared to HMF. Finally, LMF showed a smaller cortical area compared to HMF and HIS, and a smaller trabecular area compared to HMF and HCMJ.
CONCLUSION: MF plays a major role in bone health and body composition in overweight and obese children. It is key that the development of this muscle fitness is both absolute isometric strength and dynamic strength in which ones own body weight has to be moved.

**WALKING ONTOGENESIS IN TYPICAL DEVELOPING PRESCHOOL CHILDREN: WAVEFORM KINEMATIC ANALYSIS**

RYGELOVÁ, M., UCHYTIL, J., MALUS, J., ESTEVAN, I., JANURA, M.

*UNIVERSITY OF OSTRAVA*

INTRODUCTION: The development of walking in preschool children is a variable process that mainly affects the maturation of the central nervous system, but also gender, age, and anthropometric characteristics (1). Results of studies often differ on the age of children and their walking maturity, which resembles the adult walking pattern (2). There are several stages that may be considered important milestones in walking development. Various authors commonly agree on the age range of 4 to 8 years (3,4). Thereafter, the walking patterns of children begin to resemble an adult walking pattern most closely. During child development, kinematic parameters are constantly changing and are often cross-sectionally described by discrete variables (5). However, there are several longitudinal studies that may have been conducted on older children (6). To date, it has not been accurately described at which phases of the step cycle the greatest changes occur and how these changes manifest themselves in ontogeny during longitudinal tracking. This study aimed at investigating ontogenetic differences in kinematics walking during the stance phase of gait in typically developing preschool children.
METHODS: Six (3 boys and 3 girls) preschool typically developing children participated in the longitudinal study (age: 4.47 ± 0.89 years, height: 105.82 ± 6.94 cm, and mass: 17.3 ± 2.36 kg). The children participated in three measurements (1 per 12 months). Children walked on a 10m walkway marked with cones. Kinematic data were collected for 8 barefoot trials at a self-selected speed. Statistical parameter

mapping (SPM) was used for foot, ankle, and knee curves. SPM independent sample t-test determined significant differences between age group categories. The significance level was set at p<0.05.
RESULTS: SPM analysis of foot angle curve showed significant differences between 3-4 years children (p<0.001) from 0-96,5% step phase (SP), at comparison 3-5 years old (p=0.037) from 9% to 17,5% SP, (p=0.033) from 24,5% to 34% SP and between 4-5 years old (p<0.001) from 13% to 90% SP. Ankle angle differences were found between 3-4 years (p<0.001) during 100% SP, between 3-5 years (p=0.045) from 0% to 6,5% SP, (p<0.001) from 23,5% to 66% SP, (p=0.037) from 89,5% to 100% SP and between 4-5 years was no significant found. There were no significant differences between 3-4 at knee angle. For other two group age 3-5 and 4-5 were differences (p<0.001) during 100% SP and 4-5 years (p<0.001) from 44% to 84% SP respectively.
CONCLUSION: The greatest changes occur between 3-4 years of age in the type of stride and the ankle angle joint during the stance phase. From 4 years of age, significant differences also occur in the knee joint angle. The results suggest that gait maturation occurs gradually from distal to proximal segments.
REFERENCES:
1. Froehle et al. (2013) 2. Sutherland et al. (1980) 3. Lythgo et al. (2011) 4. Hallemans et al. (2004) 5. Samson et al. (2011) 6. Stansfield et al. (2001)

**THE RELIABILITY OF A HIP EXTENSION SPEED-TEST IN TEAMGYM GYMNASTS AND ITS CORRELATION WITH SELF-REPORTED SKILL LEVEL**

NEISS PALLISDAL, A.
*UNIVERSITY COLLEGE ABSALON*

INTRODUCTION: Teamgym gymnasts commonly consider fast hip extension as an essential movement in trampet and vault disciplines. However, how hip extension speed influences the skill level has yet to be investigated. Therefore, we investigated how hip extension speed correlates with self-reported skill level on the trampet and vault disciplines. Likewise, we investigated the reliability of the proposed hip extension speed-test setup.
METHODS: This cross-sectional reliability study included 120 gymnasts aged 13-29 years old (male n=47; female n=73). Anthropometric measurements, self-reported skill level in the disciplines trampette and vault and hip extension speed test was conducted for all participants to investigate correlations between hip extension speed and self-reported skill level. Sixty-seven participants were tested a second time a week later to establish the reliability of the hip extension speed-test.
RESULTS: The Intertester reliability for the hip extension test was considered good ICC=0,8 (CI95% 0,676 - 0,876).
Further, we found a strong correlation between the hip extension speed test and trampet skill level (Spearman's rho=-0,633, CI95% -0,732 - -0,508)(p<0,01) as well as the hip extension speed and vault (Spearman's rho=-0,633, CI95% -0,732 - -0,508)(p<0,01). When adjusting for anthropometrics of the height:leg length-ratio no significant influence was observed on the relationship.
CONCLUSION: The hip extension speed test shows good reliability and can easily be conducted in teamgym gymnasts. We observed strong correlations between the hip extension speed test and self-reported skill level, indicating that hip extension speed is a significant variable when performing trampet and vault disciplines. Targeting greater hip extension speed might be essential to increase skill level in these disciplines.

## Oral presentations

### OP-SH05 Equality and diversity

**EQUALITY IN THE PHYSICAL EDUCATION IN SWEDEN DURING TWO DECADES**

JANSSON, A., MATTSSON, T.
*MALMÖ UNIVERSITY*

INTRODUCTION: Education equality is a central goal in well-fair states around the world. In Sweden, the school and the subject physical education (PE) should be equal and compensate for students' different backgrounds, e.g. socioeconomic, - and migration background. Although equality is a central goal, little is known about how equality in PE has changed during the last decades (Jansson et al., 2021). One approach to study equality is to analyze how grades for biological siblings correlate – this captures all aspects that siblings share, among others, socioeconomic, - and migration background. Although this approach is well established in educational research, there are no studies in PE-research (Jansson et al., 2021). As a result, there is limited knowledge about the extent to which students' backgrounds have affected their grades in PE. Therefore, the aim of this study is to analyze how equality in PE in Sweden has changed over the last two decades.
Method: The method is based on quantitative analyzes of students' (N = 5,848,642) grades in PE, between the years 1999-2019. The method is based on analyzing correlations between siblings' grades, using variance decomposition. More precisely, analyzing the correlation between full siblings, born within a three-year window, and their annually standardized grades in PE. In addition to socioeconomic, - and migration background, the measure takes into account all the aspects that full siblings share, such as: upbringing, genetic factors, living conditions, parenting and regional factors.
Results: In relation to the total variation in students' grades in PE, the proportion explained by variation between siblings has increased between the years 1999-2019. That is, the results indicate that the importance of students' family background, over the past two decades, has become more important for students' grades in PE. Furthermore, the largest increase in sibling correlation is found within the group of students born abroad.
Discussion: The results indicate that equality in PE in Sweden has deteriorated. This can be explained by that, between 1999 and 2019, (i) the student group has become more heterogeneous, i.e., it has become more difficult to compensate for students' different backgrounds; (ii) PE has become worse at compensating for students with different backgrounds, e.g. lower socioeconomic background.
Reference: Jansson, A., Sundblad, G. B., Lundvall, S., Bjärsholm, D., & Norberg, J. (2021). Students' perceived learning in physical education: variations across students' gender and migration background in Sweden. Sport, Education and Society, (1)1-13. Doi.org/10.1080/13573322.2021.1878129

Topic: Physical Education and Pedagogics.

## GENDER AND ECONOMICAL STATUS MAKE A DIFFERENCE AT PERCEIVED SOCIAL SKILLS DURING PHYSICAL EDUCATION LESSONS IN CHINA RURAL AREA

PRIMO, L.1, GONZÁLEZ, J.2, YANG, Y.3, LOPEZ DE SUBIJANA, C.1

*1 UNIVERSIDAD POLITÉCNICA DE MADRID, SPAIN 2 UNIVERSIDAD DE GRANADA, SPAIN 3 BEIJING SPORT UNIVERSITY, CHINA*

Introduction

All human societies value prosocial actions, and the expression of prosocial behavior is an integral aspect of all social animals. Such behaviors are essential to developing and maintaining harmonius relationships. A more prosocial behavior-specific approach has important real-world implications for intervention development and policymaking (Padilla-Walker & Carlo, 2015). Physical Education (PE) classes are a great opportunity to develop not only physiologically, but also psychosocially (Mischenko et al., 2020), and life skills in sport is in its infancy suggests that life skills transfer to to other life contexts may occur either explicitly or implicitly (Turnnidge, Côté, & Hancock, 2014). This study analyzed the relationships between social skills, Physical Education and motivational perceptions in a sample of disadvantaged Chinese students under the postulates of the Self-Determination Theory (SDT). so this study aims to investigate the relationship between students social skills and the three variables: motivation towards PE, perceived support (PS; parents, teachers and peers) and basic needs satisfaction (BNS).

Methods

Two hundred seven students enrolled in a camp organized by an NGO in Chengdu province (15.9 ± 1.7 years; 72.6% female and 25.5% male) completed the Chinese versions of the SDT-related and social skills questionnaires: LCQ, AFS, PLOC and MESSY (Chou, 1996; Goudas et al., 1994; Matson et al., 1983; Reeve & Sickenius, 1994; Williams & Deci, 1997; Yang et al., 2019; Zhou et al., 2017; Zhou et al., 2019).

ResultsThe results revealed a significant direct correlation between all the variables studied ($p<.01$). Perceived autonomy support from PE teacher was higher among female and those students that were practicing teams sport their PE lessons ($p<.05$). Basic needs satisfaction (autonomy, competence and attribution) were higher among those students that practice any sport out of school self-organized ($p<.05$). Intrinsic motivation was higher at male, those students practicing team sports at PE lessons and those practicing any sport out of school self-organized ($p<.05$).Social skills were perceived higher among male students and among those students which parents earned more than 50.000 RMB as family income ($p<.05$). The regression model to predict social skills based on PS, BNS and motivation towards PE was significant ($F(3,204) = 25.6$; $p<.001$; $R2=.27$; Cohen's $f2 = 0.37$). PS ($\beta$ =.024-.128; $p=.004$) and PE motivation ($\beta$ =.045-.120; $p<.001$) were positively associated with social skills.

Discussion

In line with previous studies (do Nascimento-Junior et al., 2021), the present study established a relationship between motivation towards PE, PS and social skills. However, according to these results, BNS does not seem to be associated with social skills.

Funding

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## THE DEVELOPMENT OF SPORTSMANSHIP IN THE SOCCER SOCIO-SPORTS SCHOOLS OF THE REAL MADRID FOUNDATION

GIMENEZ, F.

*UNIVERSITY OF HUELVA*

The development of sportsmanship in the Soccer Socio-Sports Schools of the Real Madrid Foundation
Real Madrid Foundation, Spain
Giménez, F. J. , Ortega, G. , Robles, J. , Alarcón, F. , Ortega, E. , Silla, A. , & Abad, M. T.

Introduction

The practice of sports during the school stage must have a clear educational orientation that contributes to the comprehensive education of young people. In this sense, the Real Madrid Foundation (FRM) has been designing a sports model for years in which the promotion of values is its most important backbone. Therefore, the objective of this study was to know how the sport model of the FRM influences the personal and social factors of sportsmanship, and to know if there are differences according to the sex or the categories of the athletes.

Methodology

The study involved 1139 players belonging to the Sociodeportivas de Soccer Schools of the FRM of the Community of Madrid, aged between 8 and 15 years (M= 10. 57; SD= 2. 00). The sample consisted of 1110 boys (97. 5%) and 29 girls (2. 5%). Regarding the different categories and modes of soccer, 753 (66. 1%) belonged to the categories youngest (n=409) and alevin (n=344), football mode 7, while 386 (33. 9%) belonged to the categories children (n=269) and cadet (n=117), football mode 11.

The Multidimensional Scale of Orientation towards Sports was used (Lamoneda, Huertas, Córdoba and García, 2014). This questionnaire consists of 21 items and is subdivided into two dimensions: personal and social factors. Each item is answered on the basis of a Likert scale of 5 answer alternatives that express the degree of agreement or disagreement with each of the different questions where. Internal consistency analyses (Cronbach's alpha) yielded values of . 844 for the entire scale. Regarding alpha by dimension, the following data were observed: personal factors . 749 and social factors . 779.

Results

Regarding the differences of sex, it was observed that the girls presented higher values in the variables related to the one of sportsmanship, however, no significant differences were detected. The data also showed that the smaller athletes had higher values in both dimensions (personal and social), although only significant differences were found in the social factors, with a small effect size. Finally, considering the time spent in sports at the Social Sports Schools of the Real Madrid Foundation, no significant differences were observed in the variables related to sportsmanship.

Conclusions

Football training through sports models such as the FRM has a positive influence on the development of sportsmanship (both the personal and the social factor) among young players.

References

Lamoneda, J., Huertas, F. J, Córdoba, L J., & García A.V. (2014). Adaptación de la Escala Multidimensional de Orientaciones hacia la Deportividad al contexto del fútbol alevín. Cuadernos de Psicología del Deporte, 14(2), 71-80.

# Oral presentations

## OP-SH15 Talent development

### A QUALITATIVE INVESTIGATION OF EXPERTS' PRACTICE AND COACHING STRATEGIES TO PROMOTE SOCCER-SPECIFIC COMPETENCIES IN PLAYERS ON A TALENT PATHWAY

BERGMANN, F.1, WACHSMUTH, S.1, O'CONNOR, D.1,2, LARKIN, P.3,4, DUGANDZIC, D.5, HÖNER, H.1

*1 EBERHARD KARLS UNIVERSITY TÜBINGEN, GERMANY; 2 UNIVERSITY OF SYDNEY, AUSTRALIA; 3 UNIVERSITY OF MELBOURNE, AUSTRALIA; 4 MARIBYRNONG SPORTS ACADEMY MELBOURNE, AUSTRALIA; 5 GERMAN FOOTBALL ASSOCIATION*

Introduction
The development of soccer-specific competencies in aspiring players is a major challenge for coaches working in a talent development context. In support of coaches' efforts, research examining the effectiveness of practice and coaching approaches is valuable to enrich practical knowledge. However, methodological weaknesses and a sparse focus on talent development in past research restrict practical implications thereof [1]. To further improve the empirical knowledge base, the present study aims to investigate the practice and coaching strategies of experts to facilitate soccer-specific competencies in early-adolescent players.
Method
Twelve semi-structured interviews with international A- and PRO-licensed coaches and coach educators/developers were conducted. The interviews focused on supportive characteristics of the learning environment and practice tasks as well as strategies to optimally address specified soccer-specific competencies. In this respect, the experts were also asked to provide a rationale for their methodological decisions. A reflexive thematic analysis was conducted to identify thematic patterns across the data [2].
Results
Preliminary results reveal the experts consider a safe learning environment that encourages players to collect multifaceted experiences in the game as crucial for learning (theme I). According to the interviewees, coaches should try to develop practice tasks that pursue specific practice goals and stimulate players' problem-solving (theme II). Specifically, simplified game situations that guide players to certain actions were considered conducive for learning. The experts further suggested the learning process may be supported through implicit coaching strategies (e.g., modifications of the rules) as well as periods of explicit reflection to improve players understanding of the game (theme III). Though to a lower extent, individualized technically focused drill practices were considered supportive to address movement-related characteristics of techniques and to improve the players self-efficacy to apply the skills in the game (theme IV).
Conclusion
Overall, the experts recommended strategies that encourage players' exploration of functional solutions to presented problems. Hereby, the need for various practice and coaching "tools" is considered crucial to allow individualized support. Thus, strategies that were associated with different theoretical frameworks to skill acquisition are considered complementary to promote soccer-specific competencies, depending on the practice goals and the talents' needs.
References
[1] Bergmann, F., Gray, R., Wachsmuth, S., & Höner, O. (2021). Perceptual-Motor and Perceptual-Cognitive Skill Acquisition in Soccer: A Systematic Review on the Influence of Practice Design and Coaching Behavior. Frontiers in Psychology, 12: 772201 https://doi.org/10.3389/fpsyg.2021.772201
[2] Braun, V., & Clarke, V. (2022). Thematic Analysis. A practical guide. Sage.

### THE RELATIONSHIP BETWEEN TECHNICAL SKILLS, PERCEIVED TACTICAL SKILLS AND SELF-REGULATORY SKILLS IN YOUTH ELITE TENNIS PLAYERS

KOLMAN, N.

*UNIVERSITY OF GRONINGEN*

INTRODUCTION: Technical skills have been demonstrated crucial for tennis performance. Ball speed and accuracy are usually considered the two most important components of technique in tennis (Landlinger et al., 2012). These components are not only crucial for current tennis performance, but also vital for future tennis success in youth tennis players. Tactical skills and the perceptions thereof have been suggested to influence these skills, and self-regulatory skills may be beneficial for technical skills in various tactical situations (Kolman et al.,2019; Kolman et al., submitted). However, the relationship between technical skills in a tennis-specific situation and perceived tactical skills has not been investigated yet, and also the association with self-regulatory skills is unknown. Therefore, the purpose of this study is to explore the relationship between technical skills in various tactical situations, perceived tactical skills and self-regulatory skills among 21 youth elite tennis players (13 males, 8 females; age range 12-18 years).
METHODS: Using the Dutch Technical-Tactical Tennis Test (D4T), the Perceived Tactical Skills Scale in Tennis (PTSST) and the Self-Regulated Learning for Sport Practice (SRL-SP), this study aims to determine (i) whether there is a correlation between technical skills (i.e. ball speed, accuracy, percentage errors and spin rate) and perceived tactical skills, (ii) whether there is a correlation between technical skills in various tactical situations (offensive, defensive and neutral) and game situations (fixed and variable) and any of the four subscales of the PTSST (Anticipation and positioning, Game intelligence and adaptability, Decision-making and Recognizing game situations) (iii) which of the five domains of self-regulatory skills (Planning, Checking, Evaluating/Reflecting, Self-Efficacy for Challenges and Effort) is correlated with technical skills or perceived tactical skills and (iiii) whether technical skills, perceived tactical skills and self-regulatory skills differ according to gender or age category.
RESULTS: Preliminary results show a negative relationship between percentage errors and perceived tactical skills, decision-making and recognizing game situations. There is a positive relationship between perceived skills in recognizing game situations and accuracy in variable game situations. Preliminary results also show a positive relationship between perceived tactical skills and self-regulatory skills and the underlying subscale planning
CONCLUSION: These preliminary findings provide players, coaches and other professionals with insight into the relationship between technical skills, perceived tactical skills and self-regulatory skills. This can have important implications for talent development and optimizing performance in youth tennis players.

**PACING BEHAVIOUR DEVELOPMENT OF SWIMMERS: A LONGITUDINAL ANALYSIS OF THE 200M FREESTYLE.**

MENTING, S.G.P., POST, A.K., NIJENHUIS, B.S., KONING, R., VISSCHER, C., HETTINGA, F.J., ELFERINK-GEMSER, M.T.

*UNIVERSITY MEDICAL CENTER GRONINGEN*

INTRODUCTION: Due to the low efficacy of the swimming movement and relatively high resistance of water, pacing is crucial for swimming performance [1]. Cross-sectional studies show that in the 200m freestyle event, adolescent swimmers tend to start too fast, as an even pacing behaviour has been proposed to yield the best performance and is preferred by elite adult swimmers [1,2]. Studies in speed skating have indicated that during adolescence, pacing behaviour develops to better fit the task demands and that an early development of pacing behaviour relates to a higher performance level in adulthood [3]. It is therefore hypothesised that the pacing behaviour of 200m freestyle swimmers will develop towards a more even pacing behaviour during adolescence, and adolescent swimmers of a higher performance level already exhibit a more even pacing behaviour.
METHODS: Total race time and 50m split times were gathered of male (m) and female (f) swimmers' season best 200m freestyle performances between 2000 and 2021 (n=16645, 6848 female; 4.1±1.3 observations per swimmer). Included swimmers had a minimum of three season best times (SBT) between 12-18 years old and were categorized by comparing their best SBT to the prevailing world record: competitive (<116%) or recreational (116-125%). Using the lmer4 package in R, longitudinal multilevel models, in which repeated measures (level 1) were nested within individual swimmers (level 2), were used to analyse the effect of age and performance level on the normalized velocity in each 50m section ($p<0.05$).
RESULTS: Comparing 12 and 18 years old swimmers, the models predicted older swimmers to go relatively slower in the initial 50m (m: -1.22%, f: -1.12%), faster in the 50-100m (m: 1.20%, f: 0.77%) and 100-150m sections (m: 1.31%, f: 1.12%), and slower in the final section (m: -1.56%, f: -1.02%). Compared to the recreational swimmers, the competitive swimmers were relatively slower in the initial section (m: -1.20%, f: -1.01%) and faster in the 100-150m (m: 0.64%, f: 0.56%) and 150-200m sections (m: 0.38%, f: 0.11%). In the 50-100m section, competitive males were slower (-0.04%) and competitive females were faster (0.16%) than their recreational peers.
CONCLUSION: With age, adolescent swimmers hold back at the start of the race to achieve a higher velocity in the middle sections, overall achieving a more even pacing behaviour. Higher performing adolescent swimmers already exhibit a more even pacing behaviour compared to lower-performing swimmers. The current study used a rigid longitudinal design and large sample size to provide robust evidence that pacing behaviour of swimmers develops during adolescence and that pacing behaviour is linked to performance during adolescence. Coaches could use the data provided in the current study as benchmarks to monitor their swimmers' pacing behaviour development, guiding junior swimmers on the road towards elite performance.

1. De Koning et al (2011)
2. Menting et al (2019)
3. Wiersma et al (2017)

**AN EXPLORATION OF THE NORWEGIAN ACADEMY CLASSIFICATION MODEL FOR TALENT DEVELOPMENT IN FOOTBALL**

NILSEN, A., KJÆRLAND, G., MOE, V.F.

*WESTERN NORWAY UNIVERSITY OF APPLIED SCIENCES*

Introduction
Top football is provided with constantly changing requirements, which has led to an increased professionalization of younger players. National plans for payer development have been revised or created to meet these conditions. A major change in Norwegian football came in 2017 with the Academy Classification Model (ACM), a new national plan introduced and developed by the Norwegian Top Football, the interest organization of the clubs in the two top divisions in Norway. The model aims to improve football by developing more quality players within the top clubs. Research on player development is vast; however, few studies include an analysis of national plans.
This study aims to explore the ACM documents through a pedagogical lens, and in specific using sports pedagogical models as a framework. Such models consist of special characteristics to ensure learning outcomes. For example, the model must prescribe some specific `non-negotiable` features that make it distinctive. It must leave enough space for local adaption, which is vital to successful sustainable practice, and the content should be based on an explicit knowledge base and values. Research has also pointed at the need for more studies regarding ethics and values within the domain of talent development, which include looking at national documents at the macro-level.
The research question illuminated; What are the value and knowledge base of the ACM, the basic characteristics, and the strategies needed to develop talented football players?
Method
A document analysis was conducted by closely reading seven texts connected to the ACM, containing the models background and the requirements for different classification levels. A hermeneutic approach was used to analyze the texts, and to ensure trustworthiness, all authors participated in the analysis work.
Results and discussion
The ACM represents tools and transparent standards for working with player development. In specific, the model consists of eleven areas, each area containing objective goals and criteria to be benchmarked. Of the eleven areas, three are threshold areas on which every club is assessed. There is no room for compromise in these areas, which can be linked to the non-negotiable features of the sports model framework. The remaining areas also release points, and how many the clubs get in total determines the classification level and the incentives provided. Despite the models detailed characteristics, there is room for local adaptation for player development, which is vital to succeeding within a sports model framework. The knowledge base and values are not explicit in the ACM apart from a few exceptions.
This study can contribute to policymaking, especially regarding designing documents aimed at young players. Using a sports pedagogical framework is also a new approach to analyzing these documents, which seems beneficial when also including value questions.

# 11:00 - 12:15

## Invited symposia

### IS-PN05 Determination and regulation of blood volume with an emphasis on exercise, doping and gender.

#### DETERMINATION AND REGULATION OF BLOOD VOLUME

LUNDBY, C.

*UNIVERSITY OF LILLEHAMMER*

New data suggest that well established differences in blood volume between female and male largely disappear if blood volume is expressed per lean body mass. In a similar manner the aging population does not differ from the younger population if blood volume is expressed per lean body mass. In support that lean body mass is a strong predictor for blood volume, elite endurance athletes also have only slightly higher blood volumes/ lean body mass when compared to untrained but healthy individuals. Although blood volume is rather constant in humans, both acute and chronic changes occur with environment, behaviour, and disease. New findings will be presented showing rather remarkable adjustment strategies.

#### BLOOD VOLUME ADAPTATIONS AND LIMITATIONS TO EXERCISE: GENDER FOCUS

MONTERO, D.

*INSTITUTE OF CARDIOVASCULAR SCIENCE AND MEDICINE*

Endurance training provides the most effective stimuli to enhance cardiac reserve and aerobic capacity in humans. Yet, as far as we know, women do not adapt to the same extent and quality to a given dose of training compared with men. Notably, the eccentric enlargement of the heart is generally blunted in women, which seems to primary limit their maximal cardiac filling and output in the systemic circulation. Based on recent findings, in this presentation we will propose a novel hypothesis linking blood volume, central/peripheral cardiovascular variables and body composition. Potential integrative mechanisms and direct implications for the design of effective training programs in women will be discussed.

#### INFLUENCE OF GENDER IN ANTI-DOPING WORK RELATED TO BLOOD MANIPULATION

FAISS, R.

*UNIVERSITY OF LAUSANNE*

Current anti-doping work includes the athlete biological passport in which individual changes in blood parameters are monitored longitudinally. These may be altered by alterations in plasma volume (PV) unrelated to doping practice. PV variations and haematological variations in conjunction with hormonal changes in active women taking oral contraceptive pill (OCP) are largely unknown. Data will be discussed from recent studies where measured PV variations using a validated carbon monoxide rebreathing method and are correlated to changes in haematological biomarkers (e.g., hemoglobin concentration ([Hb]), reticulocytes concentration, Transferrin (sTFN), ferritin (FERR), albumin (ALB), calcium (Ca), creatinine (CRE), total protein (TP), and low-density lipoprotein (LDL) in women taking OCP over a duration of 8 weeks. Data will be presented in context of other non-doping activities that may affect plasma and red blood cell volume and thereby potentially influence the ABP.

## Invited symposia

### IS-MH05 Skeletal Muscle Power: A Critical Determinant of Physical Function In Older Adults

#### EFFECTS OF SEX HORMONES ON SKELETAL MUSCLE POWER AND PHYSICAL FUNCTION

SIPILA, S.

*UNIVERSITY OF JYVÄSKYLÄ*

Human ageing is accompanied with deterioration in endocrine functions the most notable and well characterized of which being the decrease in the production of sex hormones. Current research literature suggests that low sex hormone concentration may be among the key mechanism for age-associated muscle loss, loss in fast muscle function (power), and accumulation of fat in skeletal muscle. In the present talk, the role of sex hormones, estrogens and testosterone, in causing the aging-related loss of muscle mass and function will be discussed.

#### MUSCLE POWER: AGE TRAJECTORIES AND APPLICATION OF COUNTERMEASURES IN THE CLINICAL SETTING

ALCAZAR, J.

*UNIVERSITY OF CASTILLA-LA MANCHA*

Muscle power increases progressively during the childhood and remain at peak levels during the early adulthood. However, age-related decreases in muscle power are already evident in middle-aged adults and are progressively accentuated in older adults. Due to muscle power is the product of force and velocity, physiological traits related with both capabilities are involved in the age-related loss of muscle power (i.e. slowing of action potentials transmission, specific atrophy of type II fibers, infiltration of connective and fat tissue within skeletal muscles, loss of muscle mass, changes in tendon stiffness, etc.). However, age-related declines in muscle power are more evident during fast vs. slow muscle actions, which may be caused by the greater severity of changes observed with age in some of these physiological

determinants. Notably, muscle power is one of the first capabilities declining with age, making the loss of muscle power an important hallmark of aging. The loss of muscle power with age is also one of the main determinants of impaired functional ability in older people. Specifically, relative muscle power (i.e., normalized to body mass) has been found to be more strongly associated to physical performance in older people in comparison with absolute muscle power, handgrip strength and sarcopenia. This would be due to most of the activities of daily living being weight bearing tasks (e.g., walking, chair rising or stair climbing). Nevertheless, the lack of feasible tests and normative data for older people has prevented the widespread testing of muscle power in older people in the past. Recently, a feasible test to evaluate relative lower-limb muscle power in older people has been validated: the sit-to-stand muscle power test. In addition, normative data, cut-off points and an operational algorithm to diagnose low relative muscle power in older people has been provided. Importantly, older people having low relative muscle power presented a higher risk of mobility limitations, frailty, disability, hospitalization, and all-cause mortality. Fortunately, power-oriented resistance training performed throughout a relative wide range of loads has been provided as an effective treatment to revert low muscle power in older people. With the advent of increasingly aging societies, and with main healthy aging goal of maintaining functional ability, the monitoring and treatment of low relative muscle power with aging should be a public health priority. Finally, and with this purpose, a free-cost smartphone app (PowerFrail App®) that integrates the sit-to-stand muscle power test is available.

**LOSS OF MUSCLE POWER AND PHYSICAL FUNCTION AT OLDER AGE: DISUSE OR AGING?**

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The age-related loss of muscle power and physical function is associated with lower quality of life, frailty, and sarcopenia, and can increase risk of falling, fractures and hospitalization; however, it is not yet clear to which extent the deterioration can be attributed to an inherent biological ageing process and/or sedentary lifestyle. Notably, even brief periods of hospitalization, immobilization and bed rest result in rapid loss of muscle power and muscle mass at all ages, although there seems to be age-related differences. Thus, the effects of many years of a sedentary lifestyle may confound our understanding and expectations of the properties of a muscle for a given chronological age.

## Oral presentations

### OP-BM04 Hamstring and testing

**A COMPARISON BETWEEN DISCRETE AND ANGLE-SPECIFIC HAMSTRING QUADRICEP RATIOS IN ELITE FOOTBALL PLAYERS**

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INTRODUCTION: Conventional and functional knee strength ratios, defined using peak joint moment of the flexors and extensors, are used in practice to estimate injury risk (Baroni et al., 2020). Despite literature commonly reporting these values there remains uncertainty regarding their functional value (Kellis et al., 2022). It has been suggested that using a time-series metric from angle-specific joint moments might be more successful at identifying injury risk (Read et al., 2022). Therefore, the aim of this study was to compare discrete strength ratios commonly used in practice with angle-specific ratios to determine the differences between the two measures.
METHODS: Twenty-eight footballers were recruited from the same English Premier League club (age: 22±4 y; stature: 1.81±0.07 m; body mass: 75.2±6.8 kg). Isokinetic testing was conducted for the knee flexors and extensors in a concentric motion at two angular velocities (60°/s and 240°/s) and in an eccentric motion (for the knee flexors only) at one angular velocity (30°/s) using an isokinetic dynamometer (Biodex Medical Systems). Conventional, discrete H:Q ratio's (c HQR-D) were calculated as the ratio between peak joint moment in the flexors and extensors at 60°/s. Functional, discrete H:Q ratio's (f HQR-D) were calculated as the peak joint moment in the flexors during the eccentric condition (30°/s) and the extensors at 240°/s. Angle-specific ratios (cHQR-AS and fHQR-AS) were computed as the ratio between flexor and extensor joint moments for all angles where both muscle groups were in the isokinetic range. Mean absolute residuals were then computed to compare between discrete and angle specific ratios.
RESULTS: Peak joint moment for flexors and extensors at 60°/s was 129.4±21.6 and 240.9±35.6 Nm, respectively (cHQR-D = 0.54±0.07). Eccentric peak joint moment for the flexors was 165.9±34.6 Nm, and concentric peak moment for the extensors at 240°/s was 145.3±18.4 Nm (fHQR-D = 1.15±0.21). Throughout the isokinetic range, average cHQR-AS ranged from 0.41-0.98 with a mean absolute residual of 0.11±0.11 versus cHQR-D. In comparison, the average fHQR-AS ranged from 0.98-1.33 with a larger mean absolute residual of 0.26±0.14 versus fHQR-D.
CONCLUSION: Neither conventional nor functional discrete ratios were fully representative of angle-specific ratios throughout the isokinetic range. However, the average residual for the conventional ratio was lower than the functional ratio, despite a greater range of values for cHQR-AS. Suggesting that discrete conventional ratios are more representative of angle-specific ratios over a greater range of joint angles, compared to discrete functional ratios. Furthermore, discrete functional ratios are not representative of angle specific functional ratios, which could mask athletes who may have fHQR deficits and may be at risk of injury.
References
Baroni, BM et al. (2020). J Strength Cond Res, 34, 281-293.
Kellis, E et al. (2022). J Sport Health Sci.
Read, PJ et al. (2022). J Sports Sci, 1-7.

### MUSCLE ELASTICITY, STRENGTH AND FLEXIBILITY IN HIGH ELITE ATHLETE WITH HAMSTRING STRAIN INJURY HISTORY

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INTRODUCTION: Hamstring strain injury (HSI) is recognized to impair isometric strength and range of motion (ROM) during a passive straight leg raise (SLR)(1). While such deficits have been reported in various sports, little is known regarding injury-induced impairments in elite athletes. Moreover, SLR amplitude is a global measurement and does not provide information about the localized adaptations close to the injury locations. Therefore, the aim of this study is to determine the effect of HSI history on strength, flexibility and local muscle elasticity in high elite athletes.
METHODS: Among the fifty-one elite athletes (participating in the Olympic, World and European competitions in athletics, rugby seven and bobsleigh) that completed a survey on their injury history, fourteen participants (age: 25.0±5.3 years, height: 178.5±10.7 cm, weight: 79.7±17.8kg) reported HSI on one side, more than 30 days prior to the testing. Maximal ROM during a SLR test, maximal knee flexor force during Nordic hamstring exercise (NHE), peak torque during 60°.s-1 isokinetic eccentric knee flexion (ECC), peak torque during isometric contraction (MVC) were evaluated for knee flexors and hip extensors. Muscle elasticity was assessed using shear-wave elastography on the biceps femoris (BF), semitendinosus (ST) and semimembranosus (SM).
RESULTS: No significant differences were observed between previous HSI side and non-injured (NI) side in any of the variables. The mean and standard deviation for HSI side and NI side were respectively 7.8±1.9 vs 8.0±1.1 N.kg-1 (674±235 vs 637±188N) for NHE (p=0.83), 2.3±0.5 vs 2.3±0.7 N.m.kg-1 (123±87 vs 144±92 N.m) for the ECC torque of knee flexors (p=0.35), 1.7±0.5 vs 1.9±0.7 N.m.kg-1 (172±69 vs 184±72 N.m) for the MVC of hip extensors (p=0.37), 2.2±0.6 vs. 2.4±0.5 N.m.kg-1 (132±59 vs 148±78 N.m) for the MVC of knee flexors (p=0.94). ROM on SLR was 93±11 vs 91±10° for HSI side and NI side respectively. For muscle elasticity, for HSI side and NI side results were respectively, 17.4±6.0 vs 18.2±6.9 for BF (p=0.66), 19.6±5.2 vs 18.9±5.1 for SM (p=0.61) and 17.7±6.2 vs 15.3±4.6 KPa for ST (p=0.07).
CONCLUSION: Descriptive data of this study provides reference values for elite athletes from sprint-based sports. HSI history does not seem to be associated with deficit in strength or flexibility in elite athletes. These findings differ from some previous studies and may reflect the positive adaptations to thorough rehabilitation implemented for athletes involved in Olympic quest. The lack of difference in bilateral muscle elasticity infirm the hypothesis that post-injury collagen inclusion in injured muscle would increase muscle stiffness.
(1) Maniar et al., Br J Sports Med, 2016

### 3D FASCICLE ARRANGEMENT OF THE BICEPS FEMORIS INDICATE THE NEED TO TAKE CURVATURE AND BENDING OF FASCICLES INTO CONSIDERATION WHEN ASSESSING THE ARCHITECTURAL PARAMETERS

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INTRODUCTION: The muscle architecture-function relationship is an important determinant in health and disease. Parameters of muscle architecture such as fascicle length (FL) have been conventionally measured with 2-dimensional ultrasound (2DUS). However, in muscles with longer fascicles, as the biceps femoris long head (BFlh), 2DUS can give rise to substantial errors. Three-dimensional ultrasound (3DUS) may solve these issues, but needs to be validated. This study aims to assess the BFlh architecture by a 3DUS approach and (2) to investigate if muscle FL can be assessed using a 2D analysis.
METHODS: 11 healthy adults between 18 to 30 years old participated. Due to poor visualization of the fascicles or the aponeurosis, we present data from only three subjects (1 female, 2 males). Before the measurements, the subject performed a contraction at 50% of MVC to ensure maximal shortening of the fascicles. Then, cross-sectional ultrasonograms of BFlh were taken through a single sweeping from 30% to 70% of the thigh length while capturing the probe orientation in 3D space. The measurement was performed at three knee flexion angles, i.e. 0º, 30º and 60º. An open source software (MITK) was used to analyze the US scan. We calculated FL in two ways: 1) customary FL (CFL), i.e. using one 2DUS plane and representing the target fascicle in the mid-belly of BFlh by a straight line, and 2) true fascicle length (TFL), i.e. combining two planes visualizing the proximal and distal part of the target fascicle respectively. A non-parametric Friedman's test with post-hoc Tukey HSD tests were used to compare the FL differences between CFL and the TFL at each knee angle.
RESULTS: As expected, FL decreased when KF angle increase. For each subject and at each knee angle, CFL was significantly higher than TFL (CFL: 93.11±0.44, TFL: 83.79±0.39 at 0º KF; P<.05). There was an increase of the percentage of change of FL between methods along the different KF angles, with a higher FL difference at higher knee angles (0º KF:9.94%, 30º KF:11.04%, 60º KF:12.82%).
CONCLUSION: Our study presents a 3DUS approach for the assessment of FL in the BFlh. Results show that in BFlh fascicles located in the mid-belly are curved and do not run within a 2D plane. Additionally, the differences between methods are dependent on knee angle. Therefore, we conclude that a 3DUS approach taking fascicle bending into account is needed for an accurate assessment of fascicle length in BFlh.
REFERENCES
1) Weide, G et al., J. Vis. Exp. (129) (2017).
2) Franchi, M. V., et al.:Ultrasound in Med. & Biol., (2018).

### CHANGES IN HAMSTRINGS MUSCLE SIZE AND STRENGTH AFTER ISOMETRIC KNEE FLEXION TRAINING PERFORMED AT THE KNEE EXTENDED (MUSCLE LENGTHENED) VERSUS AT THE OPTIMAL JOINT ANGLE

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INTRODUCTION: Growing evidence suggests that training at long muscle lengths produces greater hypertrophy than training at short muscle lengths (Oranchuk et al., 2019; Maeo et al., 2021). However, it is unknown whether this superiority holds true when compared to training at the optimal joint angle for maximum torque production. We therefore compared the effects of isometric knee flexion training performed at the knee extended (muscle lengthened) versus at the optimal joint angle on hamstrings muscle size and strength.
METHODS: Twenty healthy males performed isometric knee flexion training in a seated position unilaterally with each leg: one leg at the knee fully extended angle (EXT: 0° of knee flexion) where the knee flexors are at long muscle lengths, and the other leg at the individually assessed optimal knee joint angle for knee flexion torque (OPT: 39 ± 18°). Both legs completed 5 sets of 10 repetitions (5-s contraction and 5-s relaxation per rep) at 70% of maximum voluntary torque of the corresponding joint angle during each training session, and 2 ses-

sions/week for 12 weeks. Another 11 healthy males served as controls (CON). Isometric maximum knee flexion torque (at 0, 20, 30, 40, 50, 65, 85° of knee flexion) and muscle volume of the individual and whole hamstrings were assessed before and after the intervention for each leg in all participants.
RESULTS: Throughout the intervention period, absolute torque output was always greater (+10% on average, $P < 0.05$) for the OPT than EXT as expected. After the intervention, no significant changes were found in all variables in the CON. In the trained legs, changes in muscle volume of the whole hamstrings were greater in the EXT than OPT (15% vs 8%, $P < 0.001$). In each hamstring muscle, changes in muscle volume were largely greater for the EXT vs OPT ($P < 0.001$) in the biceps femoris long head (15% vs 5%) and particularly in the semimembranosus (12% vs 0%), but not significantly different between the EXT vs OPT in the biceps femoris short head (12% vs 13%) and semitendinosus (20% vs 19%). Changes in muscle strength demonstrated joint-angle specificity in both training conditions (i.e., pronounced increases around the training angle), but changes in muscle strength over the entire knee joint angles (assessed as area under the curve) were not significantly different between the EXT vs OPT (+31% vs +43%, $P = 0.405$).
CONCLUSION: Training at a long muscle length produced greater hypertrophy than training at the optimal joint angle, suggesting that muscle length (joint angle) rather than absolute torque output is a more influential factor for stimulating muscle hypertrophy during resistance exercise. It is of clinical relevance that the biceps femoris long head and semimembranosus, that are susceptible to strain-injury, are very (or even only) responsive to the training at long muscle length.
REFERENCES:
Oranchuk et al. (2019). Scand J Med Sci Sports 29, 484-503.
Meo et al. (2021). Med Sci Sports Exerc 53, 825-837.

**HAMSTRING INJURIES IN PROFESSIONAL SOCCER PLAYERS GET COLDER. INFRARED THERMOGRAPHY AS AN ADDITIONAL TECHNOLOGY FOR RETURN TO PLAY DECISIONS**

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INTRODUCTION: Hamstring injuries are one of the most common injuries in professional soccer players (Diemer et al., 2021). Infrared Thermography (IRT) is a technique that allows measuring Skin temperature (Tsk) and has recently been shown as a technique to prevent and monitor injuries in football (Côrte et al., 2019). The aim of this study was to describe the thermal evolution of Tsk asymmetries before and after hamstring injuries in professional soccer players.
METHODS: 25 professional soccer players (age: 24.88±3.81 years; height: 1.78±0.05 m; weight: 72.32±5.57 Kg) from different top elite European professional teams were assessed before (15 cases) and after (25 cases) being diagnosed with a hamstring injury (biceps femoris, semitendinosus or semimembranosus) by physical examination and ultrasound and/or MRI. Thermal pictures from the hamstring region were taken using an infrared camera (FLIR T530) under controlled conditions and before training or treatment. ThermoHuman® software was used to extract Tsk asymmetries between injured region of interest (ROI) and healthy ROI. ANOVA multivariate analyses of repeated measures were performed to test for differences in Tsk asymmetries over time.
RESULTS: ANOVA multivariate analyses revealed significant changes on the thermal asymmetry evolution between the data before and after injury occurred ($p<0.01$). The average Tsk asymmetry before injury was 0.12±0.36. We found a significant reduction in the assessments performed during the 48 hours after the injury (-0.61±0.28), and during the first 15 days after the injury (-0.57±0.33) when compared to the values before injury ($p<0.01$). The values later than 15 days after injury showed a progressive reduction in Tsk asymmetries: between 15 to 30 days after injury (-0.29±0.28), 30 to 90 days after injury (-0.07±0.24) and more than 90 days after injury (-0.04±0.29).
CONCLUSION: Those results show a significant hypothermic pattern on the Tsk of the muscle region after the injury. During the recovery period, these values stayed significantly colder, coming back progressively to the values described before the injury. These outcomes show the value of Tsk as an objective indicator to describe the physiological evolution of the hamstring injury. In addition to that, the results show the potential of IRT as technique to add value and support return to play decisions.

## Oral presentations

### OP-PN37 Physiology I

**EFFECTS ON CARDIORESPIRATORY PARAMETERS, BODY COMPOSITION AND CIRCULATING MESENCHYMAL STEM CELLS DIFFERENTIATION OF A 4400KM ULTRA-ENDURANCE UNSUPPORTED NON-COMPETITIVE RACE IN MALE AMATEUR CYCLISTS**

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INTRODUCTION: NorthCape4000 (NC4000) is the most participated ultra-endurance cycling race: it covers 4,400 km with an elevation gain of 40,000 m. Most of the studies on cycling report acute effects on body composition and cardio-respiratory parameters in shorter races and data for longer distances are lacking. In addition, little is known regarding ultra-endurance modifications of circulating mesenchymal stem cells (MSCs) commitment. Therefore, we analyzed the effects of NC4000 in body composition, cardio-respiratory parameters and MSCs.
METHODS: Eight male healthy amateur Caucasian cyclists (47.5±13.5 yrs) were evaluated before the preparation period (PP), the week before NC4000 (BN) and 5.8±2.2 days after NC4000 (AN). Each evaluation included clinical assessment, bioelectrical impedance analysis (BIA), cardiopulmonary exercise testing (CPET) and blood samples. During PP and BN the self-managed training program was collected. Whole body dual-energy X-ray absorptiometry (DXA) was taken BN and AN to measure total and appendicular fat (FM) and lean mass (LM), while BIA was used to measure weight and to estimate FM. CPET assessed maximal oxygen uptake ($VO_2max$), the ventilatory thresholds and the ventilatory efficiency, estimated through $VE/VCO_2$ slope. MSCs were obtained from peripheral blood mononuclear cells (PBMCs). Expression of transcription factors RUNX2 and PPARG2 was analyzed. Skeletal muscle cells (SKMC) were obtained from PromoCells and examined in presence of subjects pooled sera to evaluate levels of sestrins (SESN1, SESN2) and sirtuin.

RESULTS: NC4000 finishing time was 21.2 ± 8.4 days, with a speed of 229.9 ± 68.8 km per day. Total body weight decreased during the preparation period (79.3±9.0 Kg vs 77.7±8.2 kg; p=0.042), but there were no substantial differences before and after the race (77.7±8.2 kg; 76.2±6.7 kg; p=0.105). FM decreased significantly between PP and BN (13.8±6.4 kg vs 11.2±5.1 kg; p=0.014) and after the race (11.2 ± 5.1 vs 9.2 ± 3.8 Kg; p=0,042). VO2max did not change significantly between PP and BN (49.6±10.5 ml/min*kg-1 vs 49.4±7.6 ml/min*kg-1; p=0.884), as well as BN and AN (49.4±7.6 ml/min*kg-1 vs 48.7±5,6 ml/min*kg-1; p=0.587). VE/VCO2 slope increased significantly only after the race (27.5±2.2 vs 30.4±3,2; p=0.014). Training significantly increased SESN1,2 and sirtuine-1 levels in SKMCs. In circulating MSCs, SESN1, UCP1, RUNX2 and PPARG2 expression were positively affected by training and NC4000.
CONCLUSION: In our sample, data show that ultra-cycling race leads to an increase in LM percentage and a decrease in FM without altering body weight. Despite no substantial modification in VO2max, a decrease in ventilatory efficiency is seen. Training for NC4000 leads to higher levels of sestrins and sirtuin-1 in SKMCs, counteracting adipogenesis and ageing. Conversely, ultra-cycling can lead to a reduction of SESN1 and SESN2 in SKMCs, while can increase UCP1 and sirtuin-1 levels in MSCs. These results suggest that ultra-cycling modifies cellular metabolism.

### TRIATHLETES EXPERIENCE DIVERSE AND EXTREME ENVIRONMENTAL CONDITIONS DURING THE IRONMAN WORLD CHAMPIONSHIP

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INTRODUCTION: Extreme environmental conditions are associated with adverse changes in health and performance. Changing environments during exercise can also impact nutritional needs. The IRONMAN World Championship (IMWC), held on the island of Hawai'i, sees athletes race 226.2 km through 4 climate zones across ~8 to 17 hours. The purpose of this investigation was to describe the environment that triathletes encountered during the 2019 IMWC and compare those conditions vs. the host-city temperature.
METHODS: We recorded a 10-min mean, environmental measurement (wet bulb globe temperature (WBGT), dry bulb (DB)) experienced by the leader (LEAD) and athletes finishing in ~9 (FRONT) and 11.5 h (MID). Measurements were taken at transition 1 (T1), three bike locations (~56, 100, 145 km; B56, B100, B145, respectively), transition 2 (T2), two run locations (5, 27 km; R5, R27, respectively) and the finish. Online reported DB temperature was also recorded for Kailua-Kona. Solar irradiance (W/m2) was measured for LEAD. Measurements were taken at 12 time points for each group, from ~06:30 to 18:50. Duration in WBGT heat stress flag levels was calculated for bike and run segments. Box Cox transformation was applied prior to ANOVA, followed by Tukey's HSD if significant ($p<0.05$).
RESULTS: There were significant differences in WBGT ($p=0.026$) and DB ($p<0.001$) on course, but not between groups. WBGT (°C) ranges were 24-30 (T1), 27-31 (B56), 25-28 (B100), 29-32 (T2), 28-30 (R8), 25-30 (R27), 29-30 (FINISH). The online reported DB for Kailua-Kona was significantly lower than what athletes experienced on course (29.1±0.22 vs. 30.5±0.53 °C, respectively, $P<0.001$). DB (°C) for LEAD, FRONT, MID, respectively, was 26.0, 28.1, 28.6 (T1), 29.6, 31.3, 31.2 (B56), 26.6, 27.8, 27.9 (B100), 31.3, MD, MD (B145), 35.5, 33.3, 33.5 (T2), 29.1, 30.4, 29.9 (R5), 31.7, 31.3, 29.2 (R27), 32.6, 32.1, MD (FINISH). Online DB (°C) for LEAD, FRONT, MID, respectively, was 26.4, 27.2, 27.2 (T1), 27.8, 28.6, 29.2 (B56), 28.9, 29.4, 30.0 (B100), 29.4, 30.0, 30.0 (B145), 30.0, 30.0, 29.4 (T2), 30.0, 30.0, 29.4 (R5), 30.0, 29.4, 28.6 (R27), 29.7, 29.2, 27.8 (FINISH). Solar irradiance for LEAD ranged from 17-1005 W/m2. Duration (h) in high stress was 4.2 (LEAD) and extremely high 2.8 (LEAD), 7.8 (FRONT).
CONCLUSION: While mean environmental conditions were similar between groups, athletes experienced changing conditions during the race. Importantly, leaders spent less time in high/extremely high heat stress conditions compared to slower racers, which may have implications for pacing strategy of the latter. Easing race intensity during the bike may, therefore, enable higher intensities during a run performed in less extreme environmental conditions. As environment impacts exercise performance and nutritional needs, when developing a racing and nutrition strategy for events in extreme environments, athletes should consider both the environment for the host city and how the environment may change based on the course and expected finishing times.

### A HIGH DOSE OF ISOMALTULOSE ALTERS IMMUNE CELLS COUNT AFTER PROLONGED CYCLING EXERCISE

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INTRODUCTION: It is well established that prolonged and intense exercise alters immune system cell count [1]. Increased hemodynamics and the release of catecholamines and glucocorticoids are responsible for white blood cells (WBC) to demarginate to the blood compartment [2]. This is caused by a greater mechanical force on the endothelium. Previous works have demonstrated that the ingestion of carbohydrates (CHO) alters the response of the immune system during exercise. There is strong evidence that CHO supplementation with a high glycemic index attenuates stress hormone response and consequently lowers WBC count [3]. The aim of this study was to investigate whether there is a dose-dependent effect of a low-glycemic CHO on immune cells count during and after cycling.
METHODS: After a preliminary incremental exercise test, 12 triathletes (age: 29.7±5.3yrs; peak oxygen uptake: 59.1±6.8mL/min/kg) performed four experimental 120 min constant load cycling ergometer trials at a Delta25% intensity and a subsequent 15-min self-paced time trial. During the trials participants were instructed to ingest in total 1.6 L lemon-flavored water with isomaltulose concentrations of either 0, 20, 40, or 60g/h. WBC and its subtypes (i.e., granulocytes, lymphocytes, and monocytes) were assessed using blood samples obtained from an antecubital vein prior, every 30min during and immediately after cessation of the time-trial. A two-way repeated measures ANOVA with Bonferroni-corrected post-hoc tests was used to determine main and interaction effects (time*concentration). Significance was accepted at $P<.050$.
RESULTS: A significant effect of time*concentration interaction was found for WBC ($P=.019$) and granulocytes ($P=.003$), but not for lymphocytes ($P=.557$) and monocytes ($P=.406$). Post-hoc procedures revealed that after the time-trial, WBC count was significantly lower using the highest concentration of isomaltulose (i.e., 60g/h) compared to the placebo (81.1x10^9 vs 65.5x10^9; $P=.019$). The rise in granulocytes was significantly alleviated from 120 min on also when using the highest concentration of isomaltulose compared to the placebo (45.8x10^9 vs. 33.4x10^9; $P=.040$ for 120 min and 53.4x10^9 vs. 38.1x10^9; $P=.009$ for 137 min). For lymphocytes and monocytes, a significant rise in cell count over time was detected (both at $P<.001$), however, no effects of interaction ($P>.050$) or concentration ($P>.050$) were observed.
CONCLUSION: The novelty of this work is that a dose of <60 g/h of isomaltulose is not sufficient to significantly reduce the number of WBC. Therefore, a dose as high as 60 g/h or even higher has to be ingested. It is noteworthy, that when ingesting a dose >60 g/h multiple transportable CHO have to be used. However, it is currently unclear if a reduced number of WBC has a significant effect on immune function and furthermore if this effect has a physiologically meaningful impact on performance.
[1] Souza et al. Biology 2021

[2] Simpson et al. Prog Mol Biol Transl Sci 2015
[3] Dimitrov et al. J Immunol 2010

### VALIDATION OF A NOVEL EQUATION MODEL TO PREDICT HEART RATE OVER TIME IN YOUNG ADULTS

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INTRODUCTION: An increase in Heart rate (HR) over time (heart rate drift of slow component HRsc), totally or partially dissociated from the oxygen uptake (V̇O2), has been observed during constant-load exercise in young and older adults. Unless this HRsc is accounted for, prescription of exercise using HR targets can lead to an undesired reduction in metabolic intensity over time. A mathematical model that estimates the HRsc based on relative exercise intensity has been developed in postmenopausal women; if confirmed accurate outside the original population, this tool could allow the adjustment of HR targets over time to grant stability of training intensity. The study tested the validity of the model for the prediction of HRsc in young individuals of both sexes.
METHODS: 14 adults (7 female, 25 ± 3 yrs) performed on a cycle ergometer: a ramp incremental test for gas exchange threshold (GET), respiratory compensation point (RCP), and V̇O2MAX detection and a total of six, 9-min constant-load trials, two GET/RCP/ RESULTS: Increments in HR between the 5th and the 9th min of exercise were confirmed at all relative exercise intensities, their amplitude being significantly larger with increasing intensity ($p<0.001$). Overall average HRpredicted and HRdirect were highly correlated ($r2=0.99$; $p<0.001$) yet significantly different (142±31 and 144±31 b•min-1 respectively, $p<0.001$), with a significant bias (-3.4 b•min-1) and a fair precision (3.1 b•min-1). The gap between HRpredicted and HRdirect increased significantly as function of intensity relative to RCP ($p<0.001$, $r2=0.37$).
CONCLUSION: Our data confirm the necessity to adjust HR targets over time to account for the existence of an intensity-dependant HRsc or drift. The prediction model developed in postmenopausal women significantly underestimates the dynamic of HR that is observed in young adults, providing an insufficient correction of the HR targets over time, the more so with increasing intensity. A higher potential for HR excursion inherent with younger age could explain this finding. More research is needed to explore the combined effects of age, sex, and exercise intensity towards the development of prediction models with a generalized validity.

## Oral presentations

### OP-BM11 Tendon mechanics

### QUANTIFICATION AND PREDICTION OF PATELLAR TENDON STRAIN DURING LOADED BACK SQUATS

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INTRODUCTION: The loaded back squat is an important exercise to load the patellar tendon in athletic and rehabilitation praxis. Recommendations for the individual loading for tendon anabolic responses are commonly based on the percentage of one repetition maximum (1RM) (1). However, the patellar tendon strain - a key determinant for tendon adaptation - achieved during squats has not been previously examined. The primary objective of this study was to quantify patellar tendon strain during back squats in different percentages of 1RM as a proxy for tendon mechanical loading. A secondary objective was to predict the individual patellar tendon strain in back squats by using simple predictor variables.
METHODS: In 10 experienced lifting athletes (30.5±3.49 yr., 172.62±11.7 cm, 73.58±15.47 kg) we measured the elongation of the patellar tendon using ultrasonography, calculated the knee joint moments by inverse dynamics and measured the electromyographic activity (EMG) of the vastus lateralis, vastus medialis, rectus femoris and biceps femoris during back squats with 40% (s40), 60% (s60) and 80% (s80) of 1RM. In an additional trial, the maximum patellar tendon strain during maximum voluntary isometric contractions (iMVC) for each participant has been measured. Linear mixed-effects models (LMMs) were used to investigate the main effect of load. A fitting procedure with maximum strain during the iMVC and percentage of the 1RM as variables was used to predict the individual tendon strain in the back squats.
RESULTS: Patellar tendon strains during the squats were 4.67±0.95% in s40, 6.35±1.19% in s60 and 8.22±1.46% in s80. The resultant knee joint moments were 126.0±68.5 Nm in s40, 184.5±102.6 Nm in s60 and 226.5±106.1 Nm in s80. LMMs showed a significant influence of loading ($p < 0.001$) on both tendon strain and knee joint moment. The maximum tendon strain during the iMVC was 10.31±1.95% and related curvilinear to the s40, s60 and s80 strain values. Further, the maximum iMVC-strain showed a negative relationship to the EMG activity of the knee extensors during the squats. The accuracy of the individual tendon strain prediction was greater than 80%.
CONCLUSION: Our findings evidenced for the first time that patellar tendon strain is in the range that is considered optimal for tendon adaptation (4.5 to 6.5% strain) already in the lightweight (s40) to middleweight squats (s60). However, and despite the existence of a quasi-linear relationship between tendon strain and percentage of 1RM, the individual variability was too high to generalize these findings to all participants. The proposed prediction of individual patellar tendon strain may introduce new insights and possibilities in the individualized training control (2) in clinical and athletic praxis.
REFERENCES:
1) Morrison and Cook, J Sports Med, 2022
2) Arampatzis et al., Front. Physiol., 2020

### ACTIVE HEAT ACCLIMATION DOES NOT ALTER MUSCLE-TENDON UNIT PROPERTIES

MORNAS, A., BROCHERIE, F., GUILHEM, G., GUILLOTEL, A., LE GARREC, S., GOUWY, R., BEUVE, S., GENNISSON, J.L., RACINAIS, S.
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INTRODUCTION: Heat acclimation is strongly recommended before competing in hot and humid conditions (1). Repeated heat exposures have also been suggested to increase muscle strength (2), potentially related to positive changes in skeletal muscle contractile properties (3). However, such effects on muscle and tendon mechanical properties are not yet fully understood in humans. This study aimed to de-

termine the mechanical adaptations of gastrocnemius medialis (GM) muscle-tendon unit elicited by repeated acclimation cycling sessions in the heat (38°C). We expected positives changes in skeletal muscle structure (i.e., increased in muscle thickness), while the effect on muscle-tendon unit properties were exploratory.
METHODS: Thirty recreationally active male (n=16) and female (n=14) participants (26.6±3.4 yrs) were tested before and after 13 low-intensity cycling sessions (~1.3-2.5 W/kg), distributed over a 17-days period. Participants performed cycling sessions in control (CON: ~23°C, ~35% relative humidity [RH]; n=15) or in hot ambient environment (HOT: ~38°C, ~58% RH; n=15). During testing, maximal voluntary contraction (MVC) torque, GM muscle architecture, ankle joint and fascicle force-velocity relationship, passive muscle stiffness (i.e., shear modulus) and active tendon stiffness were assessed.
RESULTS: Muscle (38.4±0.5°C vs. 37.3±1.1°C) and core (39.4±0.4°C vs. 38.3±0.3°C) temperatures were higher after cycling 1 hour in HOT vs. CON (P<0.01). Core temperature and heart rate decreased from the first to the last session in HOT (-0.39±0.3°C and -13±10 beats.min-1; both P<0.01), suggesting heat acclimation. MVC torque was not affected in HOT and in CON (129±20 vs. 136±23 N.m-1 in HOT and 127±32 vs. 131±31 N.m-1 in CON; all P≥0.508). Fascicle length, pennation angle and muscle thickness were unchanged (respectively, 5.2±0.5 vs. 5.2±0.5 cm, 16.4±1.6 vs. 16.3±2.3° and 1.5±0.2 vs. 1.5±0.2 cm in HOT; 5.4±0.5 vs. 5.5±0.5 cm, 16.6±1.9 vs. 16.6±2.1° and 1.6±0.2 vs. 1.6±0.2 cm in CON; all P≥0.267). Muscle joint and fascicle force-velocity relationship did not change in HOT and in CON (all P≥0.22). Passive muscle stiffness and active tendon stiffness were not affected (respectively, 13.2±1.6 vs. 13.1±1.5 kPa and 26.0±8.1 vs. 25.6±7.4 N.mm-1 in HOT and 15.2±2.3 vs. 14.3±1.9 kPa and 23.4±6.1 vs. 23.6±6.7 N.mm-1 in CON; all P≥0.30).
CONCLUSION: The present findings show that 13 sessions of effective heat acclimation did not modify muscle-tendon unit properties. Previously reported improvement in muscle strength was not observed and may not be associated to such adaptations in muscle-tendon mechanical properties (2, 3). These data suggest that an active heat stress acclimation is beneficial from a physiological point of view without altering muscle architecture and muscle-tendon mechanical properties.
REFERENCES:
1) Racinais et al., Br J Sports Med P, 2015
2) Racinais et al., Am J Physiol Regul Integr Comp Physiol, 2017
3) Kim et al., JApplPhysiol, 2020

### ACHILLES TENDON MECHANICAL BEHAVIOR AND ANKLE JOINT FUNCTION AT THE WALK-TO-RUN TRANSITION

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INTRODUCTION: Humans switch from walking to running at a spontaneous speed of about 7-7.5 km/h (1) but the underpinning mechanisms of the walk-to-run transition are still not completely understood. The largest part of the total mechanical power generated during locomotion is provided by the ankle joint (2), and the majority of the ankle power is attributable to the Achilles tendon mechanical behavior. Investigating the mechanical behavior of the Achilles tendon and the ankle joint function at the walk-to-run transition could thus provide further insight into this topic.
METHODS: Ten healthy subjects (28.5 ± 5.3 years; 1.70 ± 0.05 m; 65.2 ± 7.2 kg) were recruited for the study. Kinetic data and the kinematics of the body segments were recorded during overground walking and running at speeds from 5.5 to 8.5 km·h-1; in addition, we recorded ultrasound data of the gastrocnemius medialis muscle-tendon junction. Based on these data the Achilles tendon force (ATf) and power (ATp) were calculated (during the propulsive phase) according to (3). and the ankle functional indexes (i.e. damper, strut, spring and motor like-function) according to (4).
RESULTS: ATf decreased as a function of speed in walking and increased as a function of speed in running. Significant differences in ATf between walking and running were observed at speeds > 7.5 km/h. ATp was higher in running (from 174±10 to 224±10 W at 6.5 and 8.5 km/h, respectively) than in walking (from 65±10 to 120±23 W at 5.5 and 7.5 km/h, respectively). Joint functional indexes were affected by speed in walking: strut index increased (from 24 to 30% at 5.5 and 8.5 km/h) and spring index decreased as a function of speed (from 60 to 52% at 5.5 and 8.5 km/h). No significant differences in joint functional indexes were observed in running and no significant differences were observed in terms of damper, motor and strut indexes at all the investigated speeds between walking and running. However, the spring index was higher in running than in walking at speeds > 7.5 km/h.
CONCLUSION: Our data suggest that the force acting along the Achilles tendon is impaired at walking speeds higher than 7.5 km/h. At this speed, the spring index of the ankle joint is lower in walking than in running and this suggest that the spontaneous walk-to-run transition that normally occurs around 7-7.5 km/h could be explain, among the others, by the need to preserve the spring-like function of the Achilles tendon.
REFERENCES
1. Minetti et al. Acta Physiol; 1994.
2. Arnold et al. J Exp Biol; 2013.
3. Lai et al. J Exp Biol; 2014.
4. Qiao & Jindrich. J Biomech; 2016.

### SEX DIFFERENCES IN ACHILLES TENDON T2* RELAXATION TIME IN RUNNERS

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INTRODUCTION: There is a higher incidence of Achilles tendon (AT) injury in males than in females [1]. In addition, chronic AT injury was reported to have the highest incidence of all running-related injuries [2]. Early stages of Achilles tendinopathy usually alter biochemical but not morphological tendon properties [3]. Biochemical structural properties may be expressed by the AT T2* relaxation time which has been shown to be associated with Achilles tendinopathy [4]. Therefore, the purpose of this study was to compare AT structure between male and female runners across running distance groups. The population with AT pathology shows longer relaxation times [4], therefore we hypothesized that males would have longer AT T2* relaxation time than females.
METHODS: Middle aged runners between 30-50 years (n = 293 total/ 196 males/97 females) were selected from the 4HAIE study [5]. Runners were divided into three groups according to running distance (6-20, 21-40 and more than 40 km/week). The main dependent variable was the AT T2* relaxation time of the AT insertion measured by Magnetic Resonance Imaging using 1.5 Tesla system. We controlled for covariates and there were no significant differences in age, VISA-A Total Score', running footfall pattern measured by Strike

index (%), step mean count per day and running distance per week between overall the male and female groups. We used Mann-Whitney U Test to test the hypothesis that the distribution of the AT T2* relaxation time would be the same between sexes. In addition, we used two-way ANOVA (sex, running distance).
RESULTS: On average, males (2.7 ms; CI 2.5-2.9 ms) were shown to have longer AT T2* relaxation time than females (2.3 ms; CI 2.1-2.6 ms) (p=0.014). The mean score for AT T2* relaxation time was longer for males in all three running distance groups (main effect p = 0.016).
CONCLUSION: Longer AT T2* relaxation times in male runners may be related to a higher incidence of AT injury in males compared to females [1]. This finding suggests that male runners may have altered water content and collagen orientation and thus greater risk of injury with compare to female runners.
REFERENCES:
1) Lantto et al., Scand J Med Sci Sports, 2014
2) Kakouris et al., J Sport Health Sci, 2021
3) Samiric et al., Matrix Biol, 2009
4) Juras et al., Eur Radiol, 2013
5) Jandacka et al., Int J Environ Res Public Health, 2020

## Oral presentations

### OP-BM25 Neuromuscular Physiology: Fatigue I

#### KINETICS OF NEUROMUSCULAR FATIGABILITY DURING CYCLING AT A FIXED RATE OF PERCEIVED EFFORT IN DIFFERENT ALTITUDE-LIKE SIMULATION METHODS.

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INTRODUCTION: This study aimed to investigate the effects of different training interventions known or believed to induce hypoxia on knee extensors neuromuscular fatigability (NMF). Specifically, the goal was to compare NMF during sub-maximal cycling at a given rate of perceived effort (RPE) in (i) systemic hypoxia vs (ii) localised blood flow restriction (BFR) vs an airflow restriction mask (ARM).
METHODS: Seventeen healthy, young male participants, cycled twenty minutes at a self-selected power output (PO) corresponding to a hard effort (15 on the 6-20 Borg scale). Exercise was performed on an innovative cycle ergometer allowing evaluation of the lower-limbs neuromuscular function without delay. Participants underwent the following 4 conditions in a randomized order: normoxia (NOR), normobaric hypoxia (SyH, inspired fraction of O2 = 0.13), BFR on lower limbs (50% of arterial occlusion pressure), and ARM supposed to simulate altitude (~3500m). Isometric maximum voluntary contraction of knee extensors (IMVC), along with central (voluntary activation, VA), and peripheral (peak twitch, Pt; low- to high-frequency doublets ratio, LF/HF) indices were measured before and regularly during cycling (at min 5, 10, 15 and 20). In addition, PO and SpO2 were continuously measured. Perception of quadriceps pain was assessed with the CR-100 scale throughout exercise.
RESULTS: No time effect was observed for PO throughout exercise. However, a condition effect was found ($p<0.05$), revealing that PO was lower in BFR and SyH compared to NOR and ARM (134±30, 159±21, 195±30, 194±28, respectively) with lower values in BFR than in SyH ($p<0.05$). SpO2 was significantly reduced in SyH only (mean of 77±4% throughout exercise). Compared to baseline, IMVC decreased in all conditions at min 5 then exhibited a plateau (~ -10 to -20% for NOR, SyH and ARM) except in BFR, where IMVC decrease was greater and continued to decline from -27±12% at min 5 to -40±14% at min 20. A main time effect also existed for VA which significantly decreased from min 15 ($p<0.05$). VA decreased more in BFR than in the other 3 conditions ($p<0.001$), reaching -24%±15% at min 20 and mirroring IMVC exacerbated alterations. A time effect was reported in peripheral neuromuscular indices, with no differences between conditions, e.g. mean decrease for all conditions around -14±6% for Pt and -11±3% for LF/HF at min 5, and then plateaued. Pain perception throughout exercise was higher in BFR compared to NORM (58±18 vs 36±16, respectively, $p<0.05$).
CONCLUSION: For a given RPE, a 20-min submaximal cycling exercise induced more neuromuscular fatigue in BFR than in the other 3 conditions. Similar levels of peripheral alterations were found but significantly greater reduction in VA was found, suggesting higher levels of central fatigue. This result may be due at least in part to enhanced pain in the lower limbs and illustrates the psychophysiological impact of pain on both maximal and submaximal motor production.

#### NEUROMUSCULAR FATIGUE IS DETERMINED BY THE AMOUNT OF WORK PERFORMED ABOVE THE CRITICAL POWER WHEN CYCLING IN THE EXTREME INTENSITY DOMAIN

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INTRODUCTION: Recently our laboratory has found that exercise of different durations-intensities performed to exhaustion (EXH) within the severe-intensity (SI) domain (i.e., above critical power; CP) is not dependent on the curvature constant (W) of the power-duration relationship but on the level of muscle activation, owning to a greater magnitude of neuromuscular fatigue (NMF) with increased power output (PO) and decreased duration (1). However, for work rates above SI, i.e., the extreme-intensity (EI) domain (EXH < 2-3 min), where the level of muscle activation is nearly maximal, the development of NMF regarding the influence of PO and depletion of the W remains unknown. We examined the etiology of NMF after work-matched EI exercises leading to the controlled partial and full depletion of W, with or without a fast start.
METHODS: Seven recreationally active participants (mean ± SD; age, 25.4 ± 4.7 yrs; 3 female) completed two 3-min all-out cycle tests against a fixed resistance for the estimation of CP and W. On separate days, participants performed six randomized cycling trials with (n = 3) or without (n = 3) a fast start (to modulate PO) in the EI domain set to deplete W into phases of 25%, 50%, and 100%. PO during the EI trials without a fast start (EICWL) were maintained at a constant workload of 487 ± 175 W. In the first half of the fast start EI trial (EIFS), PO was set to 487 ± 175 W, followed by the second half at a reduced PO above CP (270 ± 67 W). Global, central and peripheral fatigue was quantified via pre- to post-exercise (10-s through 15-min recovery) changes in maximal voluntary isometric contraction (MVC), voluntary

activation (VA) and potentiated twitch force, respectively. VA was measured using the interpolated twitch technique, and potentiated twitch force was evoked by single (QTsingle) and paired [10-Hz (QT10) and 100-Hz (QT100)] electrical stimulations of the femoral nerve.
RESULTS: The CP estimate in the 3-min all-out test was 195 ± 62 W and the W was 13.2 ± 7.4 kJ. ΔMVC force decreased to a greater extent when 100% W was depleted compared with 25% (–13 ± 4% vs. –22 ± 12%, p = 0.037). ΔQT100 (p = 0.008), ΔQT10 (p = 0.003), and ΔQTsingle (p = 0.004) were less in the 25% phases (–15 ± 6%; –26 ± 11%; –29 ± 12%) compared with 100% (–30 ± 17%; 49 ± 20%; –51 ± 19%), respectively. Reductions in QTsingle indices during the different phases were correlated to the % depletion of W (r = 0.51, p < 0.001). No exercise-induced reduction in VA was found in both conditions (p = 0.278). There were no main effects of condition (all p ≥ 0.449), nor condition × time interactions (all p ≥ 0.660) for any variable.
CONCLUSION: These results suggest that regardless of the level of PO (modulated with the use of a fast start), the magnitude of NMF remains the same when depletion of the W is controlled. Therefore, NMF during exercise within the extreme intensity domain is dependent upon the depleted amount of W.
1. Ducrocq & Blain (2022). Exp Physiol.

### NO REPEATED BOUT EFFECT ON KNEE FLEXOR NEUROMUSCULAR FUNCTION AND KNEE POSITION SENSE AFTER SUBMAXIMAL FATIGUING ECCENTRIC CONTRACTIONS

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INTRODUCTION: Significant position sense alterations have been observed following submaximal and maximal eccentric (ECC) contractions of knee extensors in human studies [1]. However, only one study focused on the effects of maximal ECC contractions of knee flexors (KF) on position sense [2]. Therefore, in view of the lack of information following submaximal ECC contractions, we investigated immediate and delayed effects of submaximal KF ECC contractions on knee position sense. We also investigated whether the protective effect (RBE) commonly observed after a first bout of ECC contractions [3] could extent to knee position sense.
METHODS: Sixteen healthy males performed two bouts of unilateral KF ECC contractions one week apart until reaching a 20% decrease in maximal voluntary isometric contraction force. During each bout, KF neuromuscular function and knee position sense were evaluated at three time points: before (PRE), immediately after (POST) and 24 hours after (POST24) the ECC exercise. Bilateral joint position matching tasks were used to evaluate knee position sense at 40° and 70° of knee flexion in seated (JPMS40 and JPMS70) and prone (JPMP40 and JPMP70) positions. The components of KF neuromuscular fatigue (i.e., central and peripheral fatigue) were assessed using voluntary and electrically evoked contractions. Muscle soreness was evaluated using a 0-10 numerical rating scale. These parameters were analyzed using two-way repeated measures ANOVAs (bout × time point).
RESULTS: No bout × time point interaction effect was found for any neuromuscular function and position sense parameters (p > .11), suggesting that no RBE occurred. The ECC exercise generated neuromuscular fatigue involving central and peripheral components at POST, as indicated by significant decreases in voluntary activation levels (p < .01) and electrically evoked torques (p < .05). At this time point, position errors towards knee flexion were only observed during JPMS40 tasks (p < .01). Although KF neuromuscular function had recovered at POST24, position errors towards knee flexion were still detected during JPMP40 task in presence of muscle soreness (p < .01).
CONCLUSION: Whatever the joint position matching task and time point, participants adopted a more flexed position at the knee of the fatigued limb at long muscle lengths (i.e., 40° of knee flexion). We postulate that such alterations represent an injury protective mechanism. In addition, while a previous study showed a correlation between the level of central fatigue and position sense alterations [4], the position errors observed at POST24 in the present study conflict with a central-based explanation. Future studies should thus focus on the relationship between muscle damage and position sense alterations.
REFERENCES:
1. Proske. Exp Brain Res, 2019
2. Paschalis et al. Eur J Appl Physiol, 2008
3. Hyldhal et al. Exerc Sport Sci Rev, 2017
4. Da Silva et al. Med Sci Sports Exerc, 2021

### BALANCE TRAINING UNDER FATIGUE: A RANDOMIZED CONTROLLED TRIAL ON THE EFFECTS OF BALANCE TRAINING IN AN UNFATIGUED OR FATIGUED STATE ON NEUROMUSCULAR PERFORMANCE

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INTRODUCTION: Balance training has been shown to improve postural control and power as well as to reduce injuries, particularly ankle injuries, in a variety of sports, populations and settings. One can, however, question the existing practice of putting the balance programs at the start of a training session, i.e. to train in an unfatigued state, because injuries occur more often at the end of the first half or at the end of the match and this has often been associated with fatigue. Furthermore, there is evidence that adaptations to balance training are task specific and balance requirements are also essential in fatigued conditions. The aim of the present study was therefore to assess the influence of balance training in a fatigued and unfatigued state on neuromuscular performance when tested in fatigued and unfatigued states.
METHODS: Overall, 52 volunteers (mean age 27.9 y; 19 women) were recruited for this study. The participants were randomly allocated to one of three different groups. All groups took part in the identical measurements before and after a 6 weeks intervention period and all groups trained the identical balance tasks. The time spent before and/or after the balance training, however, differed between groups. The reference group (BT) participated solely in the balance training (25 minutes per session). The other two groups trained the balance tasks either before (group BT-HIIT) of after (group HIIT-BT) a high-intensity interval training session. Thus, these groups trained the balance tasks either in a fatigued or unfatigued state. In PRE and POST measurements, balance (conditions single-leg stance on solid ground, soft mat, wobble board) and jump performance was obtained in a fatigued and, additionally, in an unfatigued state. Furthermore, we assessed shuttle-run performance to detect adaptations in endurance capacity. General linear models were calculated to evaluate potential training adaptations within and between groups.
RESULTS: The preliminary data analysis revealed enhanced shuttle-run performance after the intervention period in BT-HIIT (+12%) and HIIT-BT (+12%) but not in BT (+3%). Jump height did not differ from PRE to POST. The balance training that was performed by all groups resulted in reduced sway paths in all groups. However, the general linear models revealed larger adaptations in BT-HIIT and BT when compared to HIIT-BT. This effect was consistent for the testing conditions “unfatigued” and “fatigued”.

CONCLUSION: This is the first study that investigated the influence of balance training under fatigue on neuromuscular performance in a fatigued and unfatigued state. The data revealed that balance training under fatigue results in diminished adaptations, even when tested in a fatigued state. Thus, balance training should be implemented at the start of a training session or in an unfatigued state.

### TOWARDS AN IMPROVED UNDERSTANDING OF PROXIMITY-TO-FAILURE IN RESISTANCE TRAINING AND ITS INFLUENCE ON SKELETAL MUSCLE HYPERTROPHY, NEUROMUSCULAR FATIGUE, MUSCLE DAMAGE, AND PERCEIVED DISCOMFORT

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INTRODUCTION: The repetitions performed in a resistance training (RT) set lie on a continuum whereby the maximum termination point is "momentary muscular failure", defined as when an individual is unable to complete the concentric portion of a given repetition with a full range-of-motion and without deviation from the prescribed form of the exercise. Set termination may also occur a given number of repetitions from momentary muscular failure. This "proximity-to-failure" is considered an important RT prescription variable, but its influence on short-term and long-term responses to RT is uncertain.
METHODS: Given the ambiguity in the literature, a scoping review was undertaken to summarise evidence for the influence of proximity-to-failure on physiological adaptations (e.g., muscle hypertrophy) and short-term responses (e.g., neuromuscular fatigue, muscle damage and perceived discomfort) to RT. The literature search followed the PRISMA-ScR guidelines.
RESULTS: The initial search yielded 1214 results and after duplicates were removed, 715 articles were entered for title and abstract review. Subsequently, 38 out of the 72 articles that went through full text review were eligible to be included in the scoping review. The literature search identified three broad themes of studies comparing either: i) RT performed to momentary muscular failure versus non-failure, ii) RT performed to set failure (defined as anything other than the definition of momentary muscular failure) versus non-failure, and iii) RT performed to different velocity loss thresholds.
CONCLUSION: A major limitation of the current literature is not only that there is not a consensus definition of set failure, but many studies fail to explicitly state the definition of set failure applied. As a result, each study including in this scoping review was grouped into one of the three themes to improve the validity of study comparisons and interpretations within each theme. Further, in many of the studies reviewed, the proximity-to-failure achieved by participants in non-failure conditions was unclear and likely subject to within- and between-study variability, influencing the absolute difference in proximities-to-failure being compared and thus affecting study findings. Nonetheless, current research suggests that performing RT to set failure is likely not superior to non-failure RT to maximise muscle hypertrophy, but the optimal proximity to failure for muscle hypertrophy remains unclear, and may be moderated by other RT variables. Performing RT to set failure also induces greater neuromuscular fatigue and muscle damage (lasting up to 48-hours post-RT), and greater post-set perceived discomfort than non-failure RT. Increasing the time-course for recovery of neuromuscular function post-RT could limit the volume and/or frequency of subsequent RT, and higher ratings of perceived discomfort may negatively influence long-term adherence to RT, both of which may negatively impact long-term muscle hypertrophy responses.

### CAN THE MINIMUM TOE CLEARANCE DURING WALKING BE USED AS AN INDICATOR OF MOTOR PERFORMANCE FATIGUE IN MULTIPLE SCLEROSIS?

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INTRODUCTION: Fatigue is one of the most limiting symptoms in people with Multiple Sclerosis (pwMS). So far, no gold standard for the assessment of motor performance fatigue (the temporary decline in motor performance) in pwMS exists. The majority of studies assessing motor performance fatigue in pwMS used single muscle or muscle group performance tests, while only a few studies employed whole-body exercises such as walking. The latter is important because of its relevance for activities of daily life. Most walking test procedures were based on the 6-min walk test (6MWT) and referred to changes in walking speed as primary outcome. However, there are conflicting results regarding the suitability of the 6MWT and walking speed as the primary outcome to assess motor performance fatigue in pwMS. Therefore, we investigated not only 'classical' spatio-temporal gait parameters during the 6MWT, but also the minimum toe clearance (MTC), whose decreasing variability has been interpreted as a sign of motor performance fatigue.
METHODS: Twenty mildly to moderately affected pwMS (12 females/7 males; 47.8 ± 9.0 years; expanded disability status scale: 2.7 ± 1.0) and 24 healthy controls (15 females/9 males; 48.8 ± 7.6 years) completed the 6MWT equipped with inertial measurement units. The 6MWT was performed on a circular quite corridor at the clinic with a length of 34 m. The subjects should walk as fast as possible but safely and were accompanied by a physiotherapist. Data was analyzed using the attractor method to compare stability of gait parameters and spatio-temporal gait parameters including the MTC were calculated.
RESULTS: Motor performance fatigue could not be detected based on spatio-temporal gait parameters including the MTC during the 6MWT in both groups. Descriptive analysis indicated a decrease in MTC variability towards the end of the 6MWT in some pwMS, which is assumed to be indicative for motor performance fatigue.
CONCLUSION: Surprisingly, we found little evidence for statistically significant and uniform motor performance fatigue in all pwMS. Therefore, future studies should investigate motor performance fatigue during more intense and/or longer walking protocols adjusted to the level of disability in pwMS.

# Oral presentations

## OP-AP06 Strength testing

### THE EFFECT OF FLYWHEEL INERTIA ON PEAK POWER AND ITS INTER-SESSION RELIABILITY DURING TWO UNILATERAL HAMSTRING EXERCISES: LEG CURL AND HIP EXTENSION

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INTRODUCTION: It is of interest to better understand how different unilateral flywheel hamstring exercises respond to changes in moments of inertia for developing training management and prescription. The aim of the study was to determine the impact of different flywheel moments of inertia (0.029, 0.061, and 0.089 kg·m2) during unilateral flywheel leg curl and hip extension on concentric and eccentric peak power and eccentric:concentric peak power ratio.
METHODS: A cross-sectional design was employed, whereby twenty amateur male soccer athletes attended five visits – performing three sets of eight repetitions of either unilateral flywheel leg curl or hip extension exercise (all three inertias) per visit. Repeated measures analysis of variance (ANOVA) were employed to measure potential within condition (flywheel moment of inertia) differences for the unilateral leg curl and hip extension. Paired-samples t-tests were applied to analyse differences between concentric and eccentric peak power outcomes.
RESULTS: No differences existed between inertias ($p = 0.479$) but higher eccentric than concentric power was present for all inertias during leg curl ($p < 0.001$). Differences between inertias were reported for all measures during hip extension ($p \leq 0.002$). Specifically, 0.029 kg·m2 elicited the greatest concentric power ($p = 0.022$), no differences for 0.061 kg·m2 ($p = 0.391$), and 0.089 kg·m2 elicited the highest eccentric peak power ($p = 0.036$). Peak power measures obtained acceptable to excellent reliability while eccentric:concentric ratio reported unacceptable to good reliability.
CONCLUSION: Although the eccentric:concentric ratio should not be utilized for monitoring training outcomes, peak power measures should be utilised. Specifically, leg curl reliability varied from acceptable to good while hip extension reliability excellent. Moments of inertia impact two unilateral flywheel hamstring exercise outcomes differently with the same population. Even though similar peak power measures were seen between moments of inertia during the leg curl exercise, higher moments of inertia obtained higher peak power outputs. The moment of inertia-power relationship between the two exercises may differ due to biomechanical differences between the exercises. Such differences must be accounted for during training preparation and periodisation. Individualization of moment of inertia may be warranted to optimize peak power.

### A ROBOT FOR CLIMBING SPECIFIC FINGER STRENGTH TRAINING AND ASSESSMENT WITH REDUCTION OF SHOULDER LOAD

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INTRODUCTION: Climbing performance is strongly correlated with finger flexor strength (1). To train and assess finger strength, climbers commonly hang on a board which creates high loads on the shoulder. Accordingly, climbers who suffer from shoulder injuries, which are quite common among them, need to reduce or cease finger training. We developed a robot that creates forces on the fingers via a linear actuator (2). The counter force is in part created by a palm rest. The aim of this study was to estimate shoulder load reduction and correlate assessments with those performed during hanging to prove the robot's validity.
METHODS: A common wooden rung (depth of 23mm) was mounted on an actuated plate (up to 1000N pull force). Load cells measured forces applied on the rung and palm rest at 1kHz, sent to a PC for logging and visualization.
In Hangboard condition, the plate was fixed, palm rest was removed, the robot was mounted vertically, with the rung at above-head-height. Participants were standing and shifted their weight from their feet to the hold by bending knees. Ten experienced climbers performed maximum voluntary contractions (MVC) and intermittent contractions (INT) with visual feedback.
For the MVC assessment in Robot condition, climbers had to maintain their initial finger position (three fingers, open hand), while the robot attempted to move away from the initial position at 280mm/s. Once a deviation of 3mm to the initial position was reached, the robot stopped. In Hangboard condition, climbers had to smoothly increase the load on the hold until the largest force they could exert. INT was performed at 40% of MVC, with ten 7s contractions followed by 13s rest each. Each session started with a warm-up, followed by MVC assessment, with three consecutive repetitions for both conditions, with 3min rest. After another 10min rest, INT was performed once in each condition, with 10min rests in between.
In the Robot condition, the shoulder force was estimated as difference between measured finger force and palm rest force.
RESULTS: MVC in Robot and Hangboard condition were strongly correlated ($R2 = 0.63$, $p < 0.05$). For INT, median RMSE between desired and applied force was higher in Robot condition (median 14%, range 7% to 20%) than in Hangboard condition (median 10%, range 7% to 12%), but difference was not significant ($p = 0.21$). In Robot condition, the shoulder load was reduced by 31% to 99% (median 78%) for MVC and 41% and 97% (median 61%) for INT.
CONCLUSION: Assessment and training, as traditionally performed with a hangboard, can be performed with our robot, leading to comparable results for MVC and similar deviation from the desired force during INT. Shoulder load reduction varied drastically suggesting that proper utilization of the palm rest is important and can allow for a near complete reduction of shoulder load.
REFERENCES
1) Baláš et al., Europ J Sport Sci 12, 16-25, 2012.
2) https://www.youtube.com/playlist?list=PLAybb2NYODZa1SwtStXKCOSkhkt9eEFTC

## DATA ACQUISITION FOR STRENGTH-ENDURANCE PROFILES: COMPARING SINGLE-VISIT TO MULTIPLE-VISIT PROTOCOLS

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INTRODUCTION: The modeling of “strength-endurance profiles”, which express the individual relationship between load and repetitions to momentary failure (RTF) in a resistance training exercise, recently started to draw interest in sport science. Respective models provide substantial value for practitioners as a descriptive tool to analyze exercise-specific strength endurance, or as a prescriptive tool to guide the programming of resistance training with respect to the intended level of effort. Recently, individual strength-endurance profiles were shown to yield higher predictive accuracy compared to models that generalize the relationship across individuals. However, their computation depends on the availability of unbiased data from sets performed to momentary failure at different loads. The present study applied a randomized crossover design to compare two different approaches of data acquisition: an economic single-visit (SV) protocol and a multiple-visit (MV) protocol.
METHODS: Ten resistance-trained men (age: 24.2 ± 1.5 y, body mass: 85.2 ± 9.3 kg, bench press 1-RM relative to body mass: 1.49 ± 0.23 kg·kg-1) visited the laboratory on five occasions. On day 1, participants completed a one-repetition maximum (1-RM) test in the barbell bench press. On day 2 through 5, they were tested for the RTF they could complete at 70%, 80% and 90% of their 1-RM, once in the form of a SV protocol (i.e., all loads being tested in the same session with extended rest intervals in between) and once following a MV approach (i.e., loads being distributed across three sessions). Stratified randomization was applied to account for different sequences of tests. A Bayesian mixed effects model with weakly informative priors was calculated, using RTF as dependent variable and adjusting for load and test sequence as moderator variables. Posterior distributions were interpreted according to their means and 90% Highest Density Intervals (HDI).
RESULTS: Analysis revealed a substantial main effect and moderator effect for load, but not for test sequence. There was a high probability for the MV protocol to result in a larger number of RTF compared to the SV protocol at 70% 1-RM (mean [90% HDI] = 1.9 repetitions [0.9, 2.9]) and 80% 1-RM (0.8 repetitions [0.1, 1.5]), but not at 90% 1-RM (-0.3 repetitions [-1.3, 0.7]). The applied model yielded an adjusted $R^2$ of 0.78 [0.74, 0.82].
CONCLUSION: It could be assumed that the SV protocol resulted in the accumulation of fatigue across the tested loads, therefore reducing the maximum number of attainable repetitions at lighter loads. To avoid systematic bias during the assessment of individual strength-endurance profiles, practitioners should consider splitting the required sets to momentary failure across multiple training days close to each other, allowing athletes to perform under rested conditions.

## “ASSOCIATIONS BETWEEN ISOLATED LUMBAR EXTENSION STRENGTH MEASURED WITH A NOVEL EXERCISE DEVICE AND TRUNK EXTENSION ENDURANCE IN HEALTHY SUBJECTS”

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INTRODUCTION: Increasing evidence shows that optimal function of the deep M. multifidus is required for spinal health [1]. Thus, accurate functional assessment of this lumbar extensor muscle becomes more important in clinical practice. Measures such as the trunk extension endurance (TEX) test and the isometric, isolated lumbar extension strength (ILEX) measurement are ways to assess lumbo-pelvic functional capacity [2]. However, there is now an updated, digitally supported ILEX device allowing for a more accurate, segmental assessment. Therefore, the aim of this study is to reevaluate the use of ILEX in relationship to TEX with this novel exercise device and to give suggestions for appropriate assessment in clinical settings.
METHODS: 15 male and 15 female healthy subjects (BMI: 23,02 ±2,34) participated in this cross-sectional study. A modified version of the Biering-Sorensen test was used to measure TEX endurance. A maximal isometric ILEX strength test was performed using a novel device (Powerspine Back) allowing for standardized adjustments to the L4 lumbar spine segment pivot point by the use of a laser and a finely adaptable sitting height. A strength test was performed in six angles from 0° (extension) to 60° (flexion).
RESULTS: A Pearson’s correlation revealed only one significant moderate correlation in 12° (r = -0,378, p = 0,040) between TEX endurance and ILEX strength with no significant results in other angles (0°: r = -0,286, p = 0,125; 24°: r = -0,336, p = 0,070; 36°: r = -0,336, p = 0,069; 48°: r = -0,316, p = 0,097, 60°: r = -0,309, p = 0,089). TEX endurance correlates negatively with BMI (r= -0,456, p=0,011), while ILEX isometric strength (measured in angle 48°) showed a strong positive correlation with BMI (r = 0,556, p = 0,001).
CONCLUSION: The results of this study show that ILEX and TEX are not necessarily associated even though there is a trend. In contrast, BMI is a major influencing factor for both measures. This finding underlines that both ILEX and TEX provide important information for clinical practice and are relevant depending on whether a more focused segmental assessment or a more global assessment of the trunk and the hip extensors is of interest [2]. The features of the novel device offer many opportunities for further investigations at different segmental levels and/or with low back pain patients.
REFERENCES:
[1] Hodges, P. W. & Danneels, L. (2019). Changes in structure and function of the back muscles in low back pain: Different time points, observations, and mechanisms. Journal of Orthopaedic & Sports Physical Therapy, 49(6), 464-476.
[2] Conway, R., Behennah, J., Fisher, J., Osborne, N. & Steele, J. (2016). Associations between trunk extension endurance and isolated lumbar extension strength in both asymptomatic participants and those with chronic low back pain. Healthcare, 4(3), 70.

# Oral presentations

## OP-AP04 Swimming II

### OPTICAL HEART RATE MONITORING IN COMPETITIVE SWIMMING – AN AGREEMENT STUDY

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INTRODUCTION: In many sports, heart rate (HR) monitoring is used to quantify internal training load and to control and steer exercise intensity [1]. In swimming, the standard method of ECG-based HR recording is error-prone, as chest straps may slip during swimming and wall push-offs, especially when no swim suit is worn. The optical HR sensor Verity Sense (VS) by Polar may overcome the practical limitations of chest straps due to fixation on the swimming goggles. In this study [2], we evaluate the agreement between the VS and Polar H10 chest strap sensors during swimming.
METHODS: 36 competitive swimmers (12-31 yrs) were equipped with VS and H10 HR sensors during regular swimming practice (various intensities, rest periods, swimming styles and drills). The VS and H10 were worn as recommended by Polar, at the right temple and at the chest covered by a swim suit. Agreement between HR data series (stored with 1 HR value per second and manually synchronised for optimal overlap) was analysed at the individual level using Bland-Altman analysis [3]. Group summaries are presented as medians (interquartile ranges). In addition, qualitative analyses were performed by visual inspection of individual Bland-Altman plots and HR time series to identify potential sources of training content-related measurement error.
RESULTS: First analyses included datasets with 3199-9139 data pairs per athlete. The median standard deviation of differences (SDdiff) between sensors was 5.4bpm (interquartile range 4.2, 7.3) with median 95% limits of agreement from -10bpm (-15.4, -7.8) to 10bpm (8, 13.7). The median bias of the VS was -0.2bpm (-0.8, 0.1) compared to the H10. Intra-individual results varied substantially between swimmers with agreement ranging from excellent to unacceptable (95% limits of agreement minimum -4 to 4bpm, maximum -28 to 18bpm). Visual analysis indicated that larger errors tend to be present at low to moderate HR values, e.g. typically during rest periods or at the start and end of exercise sets.
CONCLUSION: Our preliminary analyses revealed an acceptable median agreement of the VS during regular swimming practice (SDdiff interquartile range ≤7bpm), with a substantial variability in results between swimmers. Qualitative analyses further indicated that a notable proportion of the observed errors occurred during specific exercise or rest periods. In summary, optical HR monitoring using the VS represents a practical alternative to the error-prone use of chest strap sensors (when used without a swim suit) for monitoring internal load and controlling exercise intensity in swimming. Nevertheless, users must be aware that measurement error can be unacceptably high in some athletes or during specific training periods, calling for familiarisation and an evaluation of whether the measured values are physiologically plausible.
REFERENCES: 1. Olstad & Zinner, 2020, PLoS ONE, 15:e0231522. 2. Schneider et al, 2022, Project repository https://osf.io/kb39x/ 3. Bland & Altman, 1999, Stat Method Med Res, 8:135-60.

### HOW MUCH STRENGTH THE YOUNG COMPETITIVE SWIMMERS ARE ABLE TO TRANSFER FROM DRY LAND TO WATER? A PILOT STUDY

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INTRODUCTION: Propulsive force plays a major role in the swimming performance being produced mainly by the upper limbs through the shoulder internal rotation (IR). While the shoulder rotators´ strength has been widely investigated in young competitive swimmers, the propulsive force mechanism retained little attention (1). Moreover, to our best knowledge, there is not any study aimed to quantify the relative force transfer (RFT) from land to in-water actions. Thus, the aim of this study was to analyze the RFT from land to water in young swimmers at the front-crawl stroke.
METHODS: Eleven young swimmers, eight boys and three girls (12.00±0.60 years, 49.95±7.19 kg, 156.41±8.26 cm of height and 263±56.78 FINA POINTS in 50-m freestyle short course), were recruited at the beginning of the competitive season. Dry land strength variables were measured with a digital handheld dynamometer (microFET®2, Hoggan Scientific, USA) allowing to retrieve the isometric peak strength of shoulder internal rotator (in Newton, N) for the dominant (IRD) and non-dominant (IRND) upper limbs. All swimmers underwent a 10-min warm-up, followed-up by a familiarization set (one set of two submaximal and one maximal repetition by each limb). Subsequently, the data were collected from two maximal IR repetitions, as described elsewhere (2). The highest value was considered for further analysis. The in-water propulsive force (N) at a 25-m front crawl (maximal bout) was measured with a differential pressure system (Aquanex 4.1, STR, USA) and values for the dominant (PFD) and non-dominant (PFND) upper limbs were retrieved as previously reported (3). The RFT (in %) was calculated for both limbs as: RFTD = [(100*PFD)/(IRD)]; RFTND = [(100*PFND)/(IRND)]. The paired sample t-test was used to compare the upper limbs in all variables.
RESULTS: Dry land strength was significantly higher when compared to in-water propulsive force in dominant (IRD: 92.55±20.88 N, PFD: 38.65±7.33 N; $p<0.01$) and non-dominant (IRND: 87.60±23.02 N, PFND, 37.16±6.16 N; $p<0.01$) upper limbs. No differences were found when comparing upper limbs at the same environment. The RFT on water based on dry-land assessment was 43.58±12.19 % and 44.30±11.15 % for the dominant and non-dominant upper limbs, respectively
CONCLUSION: Young competitive swimmers seem able to transfer approximately 44% of their maximum strength from land to the water during front crawl actions. The current results provide a first clue about the strength level that young swimmers could apply in water by considering the dry land assessment. Despite both upper limbs eliciting similar strength, the swimming coaches should be aware of the hypothetical muscle imbalances that could impair the force transfer and, therefore, swimming performance.
REFERENCES:
1) Santos et al., Sports Biomech, 2021
2) Batalha et al., Int J Environ Res Public Health, 2021
3) Morais et al., Sci Rep, 2020

**THE EFFECTS OF WARMING-UP USING AN UNDERWATER PARACHUTE ON 50-M FREESTYLE SWIMMING PERFORMANCE**

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INTRODUCTION: Post-activation performance enhancement (PAPE) is a phenomenon that occurs when explosive efforts are potentiated in response to warm-up routines consisting of near-maximal efforts such as resistance exercises and/or powerful actions. Several studies have investigated different warm-up interventions aiming to potentiate swimming performance, with most of them requiring methods and materials that are not easily adaptable to training/competition settings. The aim of our study was to investigate the effectiveness of an ecologically valid warm-up routine consisting of parachute-resisted sprints in improving 50-m freestyle performance in trained swimmers.
METHODS: Twelve trained swimmers (23.9±2.2 years, 179±7 cm, 77.1±10.6 kg) volunteered to participate in this study. They performed two bouts of swimming at the same day separated by 40 minutes of recovery, in a randomized order. The warm-up routines performed prior to 50-m freestyle swims consisted of 500 m of swimming at a self-selected velocity followed by two minutes of resting interval and four maximal 10-second sprints separated by 1-minute rest intervals. During the experimental (EXP) warm-up, the participants performed the sprints using hand paddles and a swimming parachute attached to their waists while during the control (CON) warm-up, sprints were performed freely. Six minutes following each warm-up routine, participants swam a simulated 50-m freestyle race in a 25-m swimming pool. Mean stroke frequency and length, and propulsive time were determined during each 25-m lap of the swim by under- and overwater filming, and 25- and 50-m time partials were calculated. Student's t tests for paired samples were used to screen for significant ($p<0.05$) differences between conditions.
RESULTS: No significant differences in 25- and 50-m times (CON: 12.6±0.8 s vs EXP: 12.5±0.8 s; and CON: 26.8±1.6 s vs EXP: 26.7±1.7 s, respectively) were observed between conditions. Mean stroke length (CON: 1.84±0.26 m·cycle-1 vs EXP: 1.81±0.25 m·cycle-1), stroke frequency (CON: 0.92±0.09 cycles·s-1 vs EXP: 0.94±0.09 cycles·s-1), and propulsive time (CON: 0.62±0.07 s vs EXP: 0.61±0.06 s) were also not different between the investigated conditions.
CONCLUSION: The addition of external load conferred by wearing a swimming parachute and hand paddles during the experimental warm-up routine did not result in enhanced 50-m freestyle swimming performance in the present study. It is possible that the stress imposed by the four unresisted sprints performed at the CON warm-up is enough to induce the priming effects that result in PAPE. It is also possible that the additional resistance imposed during EXP sprints might have primed the athletes further while also inducing greater amounts of fatigue, which culminated in negligible effects on swimming performance. We conclude that performing parachute-resisted sprints during warm-up does not enhance 50-m freestyle swimming performance in experienced swimmers.

**REDUCED VENTILATION DURING UNDERWATER FIN-SWIMMING IN HYPEROXIA**

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INTRODUCTION: Normobaric hyperoxia reduces ventilation (V'E), heart rate (HR), and whole blood lactate [Lac-] during exercise depending on intensity and modality (1). The effect might be allocated to an elevated arterial oxygen partial pressure ($PaO_2$), enhancing muscular diffusion and reducing local $O_2$ deficits (2,3). In turn, anaerobic metabolism and respiratory acidosis might be delayed (4). These laboratory results become practically relevant in SCUBA-diving, where an increased ambient pressure creates hyperoxic conditions with normal air. 40% $O_2$, equal to 56 kPa inspiratory oxygen pressure ($PIO_2$) at 4m depth, reduces V'E during high-intensity fin-swimming compared to air (29 kPa, 4m) (5). However, higher $PIO_2$ is common in SCUBA diving and we hypothesize deviating effects for transient exercise intervals (TI) and steady-state intervals (SSI) which have to be distinguished for applied scenarios. All effects on V'E are highly relevant for dives with limited gas supply.
METHODS: 15 healthy (5 female; 28±6.2 age), physically fit participants performed an underwater incremental step test at 4m depth, determining resting and maximum values for HR and [Lac-] (6). Subsequently, 8 min each of low (LOW), moderate (MOD), and vigorous (VIG) exercise intensity were conducted on 3 separate days differing solely by the breathing gas (21%, 40%, 100% $O_2$). V'E, HR, and velocity (v) were recorded continuously and [Lac-] sampled post-exercise. ANOVAs with repeated measures were performed on the factors gas and intensity for v, V'E for TI (min 2-3) and SSI (min 6-7), and max [Lac-].
RESULTS: Significant main effects were found for V'E at TI and SSI for gas, intensity, and a gas*intensity interaction (TI: all $P\leq0.003$; $\eta2p\geq0.258$; SSI: all $P\leq0.014$; $\eta2p\geq0.274$). V'E was significantly lower for 100% and 40% compared to air (TI: all $P\leq0.021$; SSI: all $P\leq0.029$). [Lac-] and v significantly differed between intensities but were unaffected by gas.
CONCLUSION: A sufficient $PaO_2$ supply to the working muscle with air is assumed during LOW, explaining no beneficial effect of increased $PIO_2$. Significant reductions in V'E with $PIO_2$ of 56 kPa and 140 kPa (100% $O_2$, 4m) during TI and SSI for MOD and VIG compared to air might reduce V'E. However, missing reductions from 56 kPa to 140 kPa indicate that $PIO_2$ >56 kPa might not benefit oxidative processes any further. Since [Lac-] and v were not influenced by gas, increased $O_2$ capacity at muscle level might be compensated by an increased sport-specific movement in the attempt to swim faster, whereby water resistance can no longer be overcome after a certain point. Otherwise, it is to speculate whether this increased exercise attempt takes advantage of the increased $O_2$ capacity resulting in similar V'E and [Lac-] values to 56 kPa $PIO_2$ rather than increasing them. Any possible [Lac-] delay effect at TI was reversed with duration.
1 Ulrich et al. (2017) 5 Möller et al. (2021)
2 Sperlich et al. (2013) 6 Steinberg et al. (2011)
3 Stellingwerff et al. (2006)
4 Peacher et al. (2010)

# Oral presentations

## OP-BM13 Outdoor Sports

### ANALYSIS OF AERODYNAMIC FORCES ACTING ON A SKI JUMPER FROM TAKEOFF TO LANDING USING COMPUTATIONAL FLUID DYNAMICS

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INTRODUCTION: In biomechanical studies of ski jumping, the sequence of jumping movements is often divided into six phases: inrun, takeoff, initial flight, stable flight, preparation for landing, and landing. Each phase has a unique function to maximize the flight distance. It is also believed that the performance in one phase depends on the previous phase (Schwameder, 2008). The purpose of this study was to construct an aerodynamic analysis system that can consider the body shape and movements of individual athletes, and to build a framework that can analyze the aerodynamic characteristics in a series of ski jumping movements.
METHODS: For motion measurements, we used an IMU sensor-based motion capture suit. At the same time, we measured the flight trajectory of the ski jumper by collecting position information using a GNSS sensor. Next, we measured the three-dimensional morphology of the ski jumper and the ski using a laser scanner. A 3DCG animation was created by superimposing the joint angles obtained from the motion measurements on to the 3D geometry of the athlete. Then, the unsteady aerodynamic force acting on the ski jumper with skis was calculated from takeoff to landing phase using Computational Fluid Dynamics (CFD). In this study, a hierarchical Cartesian meshing technique known as Building Cube Method (BCM, Nakahashi, 2001) was adopted for generating the computational grid. In this method, the computational domain is divided into cubic regions called Cubes, and each Cube is further divided into equally spaced regions called Cells. Due to the adoption of BCM for mesh generation and an immersed boundary method for geometry treatment the preprocessing time is very short. This method has high computational efficiency in parallel computation and can reduce the time to solution. In this study, CUBE, which was jointly developed by Kobe University and RIKEN, was used as the fluid analysis software (Jansson et al., 2019). The finite volume method was used to discretize the basic equations (the continuity equation and the Navier-Stokes equations). The QUICK scheme was used to discretize the convective term, and the second-order accurate central difference was used to discretize the viscous term. For the direction and velocity of the airflow, the translational speed of the ski jumper was obtained from the change in positional coordinates obtained from the GNSS sensor, and a uniform flow that changed with time was specified as the inflow boundary condition in the computational domain.
RESULTS: Thereafter, the drag force was found to decrease and then to increase gradually during the flight phase. The lift force, on the other hand, did not decrease as much as the drag force after early flight. And the lift force was found to increase gradually in the flight phase.
CONCLUSION: We have succeeded in analyzing the airflow conditions around the jumper and the changes in aerodynamic characteristics during a series of ski jumping movements.

### EFFECT OF SPEED ON LOWER EXTREMITY COORDINATION IN CROSS-COUNTRY SKIING: A VECTOR CODING APPROACH WITH DOUBLE POLING TECHNIQUE

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INTRODUCTION: The vector coding method (VCM) is commonly used in biomechanics to quantify the inter-segmental coordination and joint coupling coordination1. The coordination of several activities in sports have been investigated by the VCM, and the coordination variability can be related e.g. to the skill level and injury status. The aims of this study were to quantify the lower extremity coordination in double poling (DP) technique in cross-country skiing by using VCM and to investigate the effect of skiing speed on lower extremity coordination.
METHODS: 9 experienced male skiers (Age:28.2±7.4 years, Height: 181.3±6.1 cm, Weight: 77.5±9.3 kg) participated in this study. DP technique was performed on treadmill with 13, 15, 17, 19 and 21km/h. Vicon system (Vicon, Oxford, UK) was used to record the three-dimensional trajectories of reflective markers and joint coordination was calculated for hip and knee, knee and ankle (all flexion/extension). The coordination was classified into four patterns: In-phase (joints couples rotate in the same direction), antiphase (joint couples rotate in opposite directions), distal phase (distal joint rotates exclusively), and proximal phase (the proximal rotates exclusively). For each portion of skiing cycle (poling and recovering phase), the pattern frequency of each coordination pattern was determined.
RESULTS: During poling phase a higher anti-phase and knee coordination pattern than other patterns were found in hip-knee couple and in knee-ankle couple. The anti-phase coordination pattern frequency at 17 km/h was significantly lower than that at 13km/h in hip-knee couple ($p<0.05$) and the ankle coordination pattern frequency at 21km/h was lower than that at 13km/h ($p=0.022$) in knee-ankle couple. During the recovery phase a higher anti-phase and a higher knee coordination pattern than other patterns were found in hip-knee couple and knee-ankle couple. The anti-phase coordination pattern frequency at 19km/h was higher than that at 15km/h in hip-knee couple ($p<0.05$) and the in-phase coordination patter frequency at 21km/h was lower than that at 13km/h ($p=0.022$) in knee-ankle couple.
CONCLUSION: Although some differences were observed the coordination was generally stable in the range of speeds used in this study. The pattern of coordination was continuously changing and could not be categorized into one single coordination pattern. Whether the coordinate pattern can be related to skiing performance, skiing economy and skiing injury need further investigation.
References:
1. Floría P, et al. (2019) The effect of running speed on joint coupling coordination and its variability in recreational runners. Human movement science.66,449-458

## ON-FIELD BIOMECHANICAL ASSESSMENT OF HIGH AND LOW DIVING IN COMPETITIVE GOALKEEPERS' THROUGH WEARABLE SENSORS AND PRINCIPAL COMPONENT ANALYSIS

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INTRODUCTION: Diving saves are the most important tasks of football goalkeepers. Effective trainings of diving skills are fundamental in football academies to improve goalkeepers' saving performance. In particular, the assessment of preferred (PS) and non-preferred (nPS) side differences is critical to improve trainings. Few biomechanical investigations have been proposed in this field, and none was conducted in a sport-specific environment.
The purpose of the present study was to investigate the underlying relevant motion characteristics of goalkeepers' dive in relation to their PS and nPS. It was hypothesized that lower limb and trunk kinematical differences would exist in frontal and transverse plane between PS and nPS.
METHODS: Nineteen young competitive goalkeepers (16.5 ± 3.0 years, Tegner Level 9) were enrolled. Every participant performed a series of high and low dives on their preferred and non-preferred side. The dives were performed in a regular football goal on a natural grass football pitch. Full-body kinematics (ankle, knee, hip, pelvis, trunk, shoulder, elbow, wrist joints) was collected through a set of 17 wearable inertial sensors (Awinda, Xsens). Data were normalized from the initial contact of the contralateral foot to the end of the dive [1]. Diving time was compared among the dive height and side (two-way ANOVA). Two separate principal component analyses (PCA) on high and low dives were conducted to reduce kinematic data dimensionality (input matrix 19 participants x 101 data points x 6 trials x 8 angles x 3 axes). The PCA scores were extracted for each kinematic variable and compared between PS and nPS side (Student's t-test with Cohen's d effect size) if the relative explained variability was >5% [1].
RESULTS: Dive timing differed between high and low dives ($p<0.003$, $\eta p^2> 0.041$) but did not differ between PS and nPS ($p>0.05$, $\eta p^2<0.007$). In high dive, participants exhibited greater hip internal rotation ($p=0.008$, ES=0.52) and less trunk lateral tilt ($p=0.047$, ES=0.39) in PS compared to nPS. In low dives, participants exhibited less hip adduction and knee rotation, and greater pelvis and trunk rotation in the initial diving phase in PS ($p<0.037$, ES 0.40-0.57) compared to nPS
CONCLUSION: When diving on their nPS, goalkeepers adopted sub-optimal motion pattern with delayed pelvis and trunk rotation and limited explosiveness towards the diving direction (hip external rotation and adduction). This is in line with current literature highlighting the need to improve horizontal and lateral skills in diving [2-3]. The differences were more evident in the low dives. The present study was the first to investigate academies goalkeepers' biomechanics in a sport-specific environment adopting an innovative approach with wearable sensors plus PCA dimensionality reduction. Such an analysis might be useful to goalkeepers' coaches to define the dominant differences in diving motion between PS and nPS and improve training effectiveness

## VIDEO ANALYSIS METHOD FOR EXTRACTING THE DEPENDENCE OF MOVEMENT BETWEEN BODY PARTS IN BASEBALL HITTING FORM USING TRANSFER ENTROPY

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INTRODUCTION: Sports analytics using IT is introduced actively into competitive sports. In baseball, training efficiency is expected to be improved through data analysis for amateur baseball players. However, it has not been widely used in the past due to the need for special equipment and device for measurement and the difficulty of data interpretation. Therefore, to create an environment where amateur athletes can easily measure their own condition and practice trial and error based on the data, we propose a method to visualize the characteristics of their form from videos taken with smartphones in an easy-to-understand manner.
METHODS: We developed a video analysis method to extract the dependence of movement between body parts in baseball form. Our developed method recognizes the positional coordinates of the skeleton from only videos of athletes captured by a smartphone, quantifies the dependence of the movements between body parts using transfer entropy[1], and visualizes the relationships as a network of directed graphs. This method applies the technique of analyzing the network of a group of players[2]. Data for evaluation was obtained from one amateur baseball player. Ten each of normal toss batting and tee batting, in which the player worked on improvement, were performed and captured on video for analysis. To improve his hitting form in the tee batting, he worked on stabilizing his lower body and strengthening his upper body rotation. In the evaluation, we hypothesized trends in the data for the points of improvement that the player was aware of and made statistical comparisons for each of them. The significance level for statistical evaluation was set at 0.05.
RESULTS: Stabilization of the lower body in the hitting form significantly reduced the variability of transfer entropy in all body parts and also significantly reduced the transfer entropy starting from the lower body part. In addition, enhanced upper body rotation resulted in a significant increase in transfer entropy from the elbow to the wrist. The results were consistent with the hypothesis in terms of players awareness of improvement. This evaluation confirmed that the players themselves intuitively understood and noticed the effects of their improvement effort.
CONCLUSION: As a result of interviews with players, it was evaluated that it was easy to intuitively understand the changes before and after the improvement. Toward the development of data analysis technology for widespread use in amateur baseball, we have concluded that the proposed method is easy for players to understand the characteristics of their own form and that it can contribute to improving the efficiency of training for more players than ever before through the accumulation of future data and the verification of many hypotheses.
[1] Staniek, Matthäus, et al., Physical Review Letters (2008) [2] Tanaka, Takeshi, et al., IPSJ Journal (2021)

# Oral presentations

## OP-BM18 Motor learning and visual processing

### ARE CORTICAL BIOMARKERS OF VISUAL PROCESSING DURING THE MOTOR PREPARATION PHASE RELATED TO PERFORMANCE ON A COMPLEX MOTOR-COGNITIVE ATHLETIC TASK?

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Studies have demonstrated the relationship between cognitive measures and reaction times (RT) in a jumping and/or cutting task (Wilke et al., 2020). Also, attention is thought to influence both cognitive and motor task performance (Kida et al., 2017). However, it is not known whether cortical electrophysiological markers of event-related potentials (ERP; the P1, N1, and P2 components) recorded at the time of elevated attentiveness to the upcoming motor task show association with the drop-cutting task performance. This pilot study investigated the relationships between cognitive test performance, drop-cut performance, and ERP components.

Ten healthy males aged 29.5 ± 8.61 years performed 64 drops to a force plate from a 60 cm high platform followed by a cut jump to one of 4 predetermined directions (equidistant, covering frontal 120°, positioned at 150% of leg length distance). The motor preparation cue (blue light activation) signaled a self-paced take-off from the platform, which triggered a yellow light stimulus in one of the 4 jumping directions. A successful trial deactivated the yellow light sensors (the foot landed ≤ 30 cm away) and a single-leg stance was maintained for an additional 2 s. Drop-cut RTs (time between deactivations of blue and yellow sensors; [ms]) and contact times (from landing until jumping to a direction; [ms]) were investigated. Mobile electroencephalography (EEG) was recorded and ERPs time-locked to the blue light activation were extracted from the Oz. The amplitude [mV] and latency [ms] of the P1, N1, and P2 components were examined. Cognition was assessed on sensorimotor speed (simple and choice RT; sRT and cRT; [ms]), and executive function (Trail-Making Test; TMT-A and TMT-B; [s]). The relationship between variables was inspected by correlation analyses.

On average, 73% (± 11.7) of drop-cuts were performed successfully; mean RT was 883 (± 91.8) ms. We observed a relationship between cRT and contact time ($r = .654$, $p = .040$), and P2 latency and TMT-A ($r = .648$, $p = .043$).

The co-occurrence of slower sensorimotor speed and longer contact times could indicate a prolonged decision-making process regarding the execution of the correct motor command. In addition, our data seem to indicate that during attentive states, the effectiveness of executive function and the speed of visual search relate to the latency of the cortical potential at the second positive peak – the visual P2 component. The lack of relationship between ERPs and motor performance might indicate that task-relevant cognitive processing occurs at a later stage during task execution.

Kida, T., Tanaka, E., & Kakigi, R. (2017). Attention as a determinant of task performance: From basics to applications. J Phys Fitness Sports Med, 6 (2): 59-64.

Wilke J, Groneberg D, Banzer W, & Giesche F. (2020). Perceptual-Cognitive Function and Unplanned Athletic Movement Task Performance: A Systematic Review. Int J Environ Res Public Health, 14; 17(20).

### HOW CORTICAL BIOMARKERS OF VISUAL PROCESSING PREDICT LOWER-LIMB VISUOMOTOR RESPONSE PERFORMANCE IN HEALTHY MEN

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INTRODUCTION: In interceptive sports, executing rapid motor responses to visual stimuli is critical for performance and injury prevention (Wilkerson et al. 2012). While visuomotor response tests provide a general assessment of task performance, the underlying neural mechanisms remain unclear. The primary aim of this pilot study was to investigate how cortical biomarkers of visual perception and processing measured with mobile electroencephalography (EEG) predict lower limb reaction time (RT) performance.

METHODS: Ten healthy men (age: 30±9 years) performed a simple (n=100) and a choice RT task (n=100) with their lower limb in a standing position. Four FitLight sensors (FitLight Trainer™) were equidistantly positioned in front of the participants in semicircular order. For simple RT task, the participants were responding only to a single sensor at each position (n=25). For choice RT task, a random sequence (n=25 each) was used. To measure the accuracy of FitLight the RTs were compared with those calculated from photodiod sensors (gold standard) attached to the FithLight sensors and connected to a Triggerbox. A custom-made pipeline was used for EEG pre-processing and extraction of RTs, and visual evoked potential (VEP) components (P1, N1, and P3; Oz electrode). Paired sample t-test was used to compare simple and choice RTs. The intraclass correlation coefficient (ICC) was calculated to test the reliability of FitLight. Multiple stepwise regression analyses were applied to test the predictive value of ERPs for both RTs.

RESULTS: Mean lower-limb simple RT (482 ms) was significantly shorter ($p<0.001$) than choice RT (561 ms; Triggerbox data). Although the ICC comparing both systems indicated high reliability for both RTs (ICC=0.992, $p<0.001$), mean RTs were significantly shorter for FitLight ($p<0.001$). Simple RT was significantly predicted by P3 amplitude ($p=0.001$) and N1 latency ($p=0.010$) that explained 81% of variance. Choice RT was significantly predicted by P3 latency ($p=0.004$) and explained 63% of variance.

CONCLUSION: Our results show that detection of VEPs associated with lower limb RT tasks is feasible and demonstrate the crucial role of visual processing in reactive motor performance, highlighting the potential of visual training. This could help not only younger athletes who want to improve performance and avoid injuries, but also older adults in whom slowing lower limb RT has been associated with falls (Neville et al., 2020). Future trials examining VEPs in more motor-cognitively demanding tasks are warranted.

REFERENCES:

Neville, C., Nguyen, H., Ross, K., Wingood, M., Peterson, E. W., Dewitt, J. E., ... & Najafi, B. (2020). Lower-limb factors associated with balance and falls in older adults: A systematic review and clinical synthesis. Journal of the American Podiatric Medical Association, 110(5).

Wilkerson, G. B. (2012). Neurocognitive reaction time predicts lower extremity sprains and strains. International Journal of Athletic Therapy and Training, 17(6), 4-9.

**INTENSITY EFFECT OF NEUROMUSCULAR ELECTRICAL STIMULATION COMBINED WITH MOTOR IMAGERY ON CORTICOSPINAL EXCITABILITY**

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INTRODUCTION: Neuromuscular electrical stimulation (NMES) consists of evoking muscle contraction by an external electrical current without voluntary activation. On the contrary, motor imagery (MI) is the mental simulation of contraction without its corresponding motor output. Some studies analyzed the impact of MI and NMES on corticospinal excitability highlighted by the motor evoked potential (MEP). The authors reported that MI and NMES performed alone increased the MEP compared to rest (2,3) as well as the combination of both compared to one or the other modality alone (1, 2). However, the intensity of NMES may alter the corticospinal excitability (2). For instance, Saito et al. (2013) showed that the corticospinal excitability was increased only with NMES applied above the motor threshold compared to MI alone. Therefore, these results question the impact of the intensity of NMES on corticospinal excitability when combined with MI. The purpose of the present study is to assess corticospinal excitability during either MI, NMES, or a combination of both at different stimulation intensities of NMES.
METHODS: In this pilot experiment, seven healthy subjects (age: 27.7 ± 5.3) participated in one session consisting of 6 conditions targeting flexor carpi radialis muscle (FCR): rest, MI, NMES evoked at 5 % and 20 % maximal voluntary contraction (MVC) and MI and NMES performed simultaneously (MI+NMES) with both NMES intensities. During each condition, corticospinal excitability was assessed by evoking MEP of FCR by using transcranial magnetic stimulation. Maximal M-wave (Mmax) was measured by using nerve stimulation of the median nerve. The evoked force has been measured as the force-time integral (FTI) during each condition.
RESULTS: Preliminary results showed no significant differences on FTI between NMES and MI+NMES for both 5 % and 20 % MVC. A repeated measures ANOVA revealed a main effect among conditions ($P = 0.01$). We found a significant difference on MEP/Mmax at rest compared to NMES and MI+NMES at 20 % MVC ($P < 0.007$). Furthermore, a two-way ANOVA (condition [NMES, MI+NMES] x intensity [5 %, 20 %]) revealed an intensity effect ($P = 0.04$). The post hoc analysis showed a higher MEP/Mmax during NMES and MI+NMES at both 20 % compared to 5 % MVC.
CONCLUSION: The additional effect of MI on MEP/Mmax may occur with NMES at 20 % rather than 5%. This suggests that a sufficient muscle activation is required to improve the cortical command from MI and enhance the activation of both cortical and subcortical structures. Therefore, the combination of MI and NMES could result in improvement of the corticospinal excitability of FCR.

**CORTICOMOTOR PLASTICITY UNDERLYING THE PRIMING EFFECTS OF MOTOR IMAGERY ON STRENGTH PERFORMANCE**

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INTRODUCTION: Neural plasticity is capacity of neurons to reorganize their connectivity in response to cognitive and behavioral demands. Neural plasticity allows short-term modulations of strength through improved cortical gain over motor units. There is now convincing evidence that covert motor strategies such as motor imagery (MI) and action observation (AO) contribute to limit strength loss and prevent maladaptive plasticity [1][2][3]. The main objective of this study is to extend current understandings of the neurophysiological processes underlying strength gains as a result of embedded MI or AO within strength training sessions.
METHODS: In a counterbalanced design involving three experimental conditions (AO, MI, Control) we recorded the total force, the integrated electromyograms of agonist and antagonist muscles (biceps brachii, triceps brachii and anterior deltoideus) and the ongoing electrical brain activity in 20 participants who performed 10 maximal isometric contractions of elbow flexor muscles against a force platform (10 s duration). During the one-minute inter-trial rest periods, participants then randomly performed: i) AO of the same strength task performed by an expert athlete, ii) MI of the task using first-person visual and kinesthetic imagery, and iii) AO of a video documentary about basketball shooting (Control).
RESULTS: The linear mixed effect analysis carried on total force data revealed a CONDITION x MUSCLE interaction ($p= 0.0384$). Irrespective of the trial number, total force values were higher during MI compared to the Control condition ($p= 0.005$). Electromyograms showed a reduced relationship between triceps brachii activity and total force during MI. Also, the relationship between agonist electromyograms and the total force was greater during MI. Eventually, corticomotor connectivity, indexed from coherence between electric brain potentials and the electromyograms of the agonists within the alpha frequency range (8-12 Hz), was greater during MI compared to AO and Control. The topographical distribution of corticomotor connectivity values emphasized sensors located within the central and pre-central regions.
CONCLUSION: Present findings provide new insights to the neurophysiological processes underlying strength gains in response to motor stimulation. The data showed improved strength performance only when MI was performed during the inter-trial recovery periods of strength training sessions. Topographical patterns of corticomotor connectivity provide evidence, for the first time, of the effect of MI training on corticomotor plasticity. Short-term corticomotor plasticity might thus represent an important underlying mechanism to the priming effects of mental training on strength performance.

**CAN TALENTED PLAYERS IMITATE MOVEMENT EXECUTIONS OF A SIDESTEP CUTTING TASK SHOWN BY AN EXPERT?**

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INTRODUCTION: Unfortunately, current prevention programs do not result in a decrease of ACL injuries in the long term[1]. Observational learning is considered as powerful to promote implicit motor learning[2]. Implicit motor learning is effective in learning complex motor skills[3]. While video instruction is a common tool in practice, little is known about to what extent athletes are able to imitate movement executions shown on video. The aim of this study was to examine if subjects were able to imitate optimal and suboptimal sidestep cutting movement execution of an expert.
METHODS: Frontal and sagittal plane videos of an expert performing a 45° sidestep cut (SSC) were obtained prior to the study. This expert was part of a Regional Talent Centre (RTC) and was selected by coaches and deemed to have excellent motor skills. We demonstrated the imposed optimal (OPT) and suboptimal (SUBOPT) executions using previously reported figures[4] and verbal instructions. OPT and SUBOPT videos were selected based on variables previously shown to be related to ACL injury risk (e.g. knee flexion angle, frontal knee moment and vertical ground reaction force (vGRF)). Ten basketball players (age 15.5±1.2 y, height 189.9±3.1 cm, mass 75.4±7.1 kg) from the same RTC performed SSC trials in baseline followed by two counterbalanced experimental conditions (each 10 trials). Subjects watched the expert videos (matched by sex, height and mass) of OPT and SUBOPT movement executions and were asked to imitate this to the best of their

ability. One-sample t-tests with Statistical Parametric Mapping were performed to examine to which extent the subjects were able to copy the movement execution of the expert (OPT and SUBOPT). Nine variables were examined; sagittal angles and moments of hip, knee and ankle, frontal moments of hip and knee, and vGRF over the entire stance phase (SP) (from first contact till toe-off).
RESULTS: Regarding the OPT condition, subjects showed significantly smaller ankle dorsiflexion angles (p<.001, 0-94% SP), smaller knee flexion angles (p<.001, 0-83% SP) and larger vGRF (p<.001, 0-19% SP) compared to the expert. Significant differences in the SUBOPT were only found for small time frames; smaller ankle dorsiflexion angles (p=.013, 0-10% SP) and larger vGRF (p=.013, 0-8% SP; p=.029, 13-17% SP) in the subjects compared to the expert.
CONCLUSION: In general, the subjects were able to partly imitate movement execution of the expert, especially for the hip and knee moments, but not for ankle placement and vGRF. Furthermore, subjects were better able to imitate the SUBOPT compared to the OPT condition (e.g. knee flexion angle). This study indicates that imitation from video works to change movement execution. Further research should focus on additional instructions (e.g verbal) or feedback methods (e.g. timing of feedback or self-modeling) to increase the effects of observational learning.
1)Weitz et al. 2020, KSSTA
2)Benjaminse & Otten, 2011, KSSTA
3)Masters et al. 2008, JMB
4)Dempsey et al. 2007, MSS

## Oral presentations

### OP-MH14 Body composition

#### DOES AN OBESOGENIC FAMILY ENVIRONMENT MODERATE THE ASSOCIATION BETWEEN SPORTS PARTICIPATION AND BODY COMPOSITION IN CHILDREN? THE ENERGY PROJECT

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INTRODUCTION: Obesity among children is a global public health concern. Organized sports participation is an important venue for promoting recommended levels of moderate-to-vigorous physical activity (1), thereby contributing for healthy weight maintenance among children. However, the literature on the association between sports participation and body composition is overall mixed (2). Concurrently, the family home is considered one of the most influential environments on childhood obesity (3). Thus, the association between sports participation and body composition in children might depend on the degree of the obesogenic home environment. The aim of this study was therefore to investigate if an obesogenic family environment moderates the association between organized sports participation and body composition in children.
METHODS: A total of N= 3999 children (11.6 y (SD 0.6), 54% girls) and their parent(s) were included from the ENERGY project. Data on an obesogenic family environment, organized sports participation, and demographic characteristics were obtained by child and parent questionnaires. Ten items related to the PA, food, and media environment in the family were dichotomized and summed up into a composite obesogenic family environment risk score with scores between 0 (low risk) and 9 (high risk). Body mass index (BMI) and waist circumference (WC) were obtained by trained researchers. Path analyses were used to investigate moderation by the obesogenic family risk score on the association between sports participation and body composition, taking school clustering and country into consideration.
RESULTS: A higher composite obesogenic family environment risk score was associated with higher WC (1.11, 95% CI 0.97 to 1.25) and BMI (0.36, 95% CI 0.31 to 0.41). The obesogenic family environment risk score significantly moderated the association between sports participation and both WC and BMI. In children from families with moderate and high obesogenic family environment risk, organized sports participation was significantly associated with lower WC (moderate: -0.29, 95% CI -0.45 to -0.14; high: -0.46, 95% CI -0.66 to -0.25) and BMI (moderate: -0.10, 95% CI -0.16 to -0.04; high: -0.14, 95% CI -0.22 to -0.06), but not in children from a low obesogenic family environment.
CONCLUSION: Enrolling children in sport activities from an early age may be important for a healthy weight maintenance, especially among children from obesogenic family environments.
1. Kokko et al. 2019. Does sports club participation contribute to physical activity among children and adolescents? A comparison across six European countries. Scand J Public Healt. 47(8):851-8
2. Lee et al. 2018. The Role of Youth Sports in Promoting Childrens Physical Activity and Preventing Pediatric Obesity: A Systematic Review. Behav Med. 44(1):62-76.
3. Boonpleng et al. 2013. Ecological influences of early childhood obesity: a multilevel analysis. West J Nurs Res. 35(6):742-59.

#### RELATIONSHIPS BETWEEN HEALTH-RELATED PHYSICAL FITNESS, BODY MASS INDEX, AND ACADEMIC ACHIEVEMENT OF MIDDLE SCHOOL STUDENTS QATAR

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INTRODUCTION: Physical inactivity is a growing public health and educational concern1. Empirical studies have reported that health-related physical fitness (PF) aids not only children's physical and mental health but also their academic achievement2. This study aimed to investigate associations between academic achievement, body mass index (BMI), and physical fitness status, including aerobic and muscular fitness in adolescent middle school students in Qatar State.
METHODS: Fifty-one males (age: 13.0 ± 0.81 years; body mass: 68.3 ± 17.0 kg; height: 1.63 ± 0.10 m; BMI: 25.2 ± 3.98 kg/m2) were recruited from a school in a Doha Community (Qatar). Different anthropometric measurements (height, mass, and BMI) and physical performance tests (Stork test of static balance; 10 and 15 m sprint; Handgrip Strength Test; agility T-half test; medicine ball throw (MBT)) were performed. Aerobic capacity was evaluated using the Yo-Yo Intermittent Recovery Test level 1 (Yo-Yo IR1). Academic achievement was assessed through school records of grades point average (GPA) in Mathematics, Science, and Arabic.

RESULTS: Between academic and physical performance parameters, we detected the most relevant (r>0.5) correlation coefficients for mathematics. The relations ranged between r = 0.502 (sprint 15 m) and r = 0.691 (Yo-Yo IR1 test). Science was correlated with the Agility T-half test (r = 0.543), and Arabic showed a relevant correlation to the Yo-Yo IR1 test (r = 0.558). The BMI was only related to mathematics (r=-0.675). Three physical performance parameters (sprint 10 m, stork balance test, handgrip strength) did not show any relation to academic performance. Between BMI and science (r = -0.419) and Arabic (r = -0.406) the interactions were considerably lower.
CONCLUSION: Our results suggest that students with high PF levels were more likely to have a high GPA compared to those with low PF levels. Based on these findings, we suggest that interventions aiming to improve PF, such as aerobic exercise and muscular exercise, may have implications not only for health but also for academic success. Therefore, students should be encouraged to engage in regular physical activity. Furthermore, an innovative physical activity curriculum including yoga, fitness, walking, and dance should be implemented in schools.
1Cadenas-Sanchez et al., J. Sports Sci. 38, 731–740 (2020)
2Baxter et al., J Acad Nutr Diet. 113:551–7 (2013)

**FAT-TO-MUSCLE RATIO: EXPLORING ASSOCIATIONS WITH MOTOR COMPETENCE AND PHYSICAL FITNESS IN 7-YEAR-OLD CHILDREN FROM A SEX PERSPECTIVE**

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INTRODUCTION: The negative effects of an excessive fat mass on physical fitness (PF) and motor competence (MC) parameters are well known considering body mass index (BMI), the skin-folds, and waist circumference (WC) in children (1). However, less attention has been paid to the role of muscle mass in combination with fat mass in these relations (2). Fat-to-muscle ratio (FMR) is the ratio of fat mass, to muscle mass, and is being used to assess metabolic syndrome and cardiovascular diseases (3) in adults. The objectives are: 1) to explore the association between body composition (FMR, WC and BMI) with MC and PF in 7-year-old children from a sex perspective; 2) to ascertain whether FMR modifies the associations between MC and FF depending on sex. 3) to explain, in boys and girls, the role of fat mass and muscle mass in PF.
METHODS: A total of 171 children (7yr; 84♂, 87♀) were included. Anthropometric (BMI, WC, and FMR -fat and muscle mass were calculated with TANITA), MC (CAMSA test), and PF (the sum of z-scores: 1/2 mile run, handgrip strength, 10x5, standing long jump, and sit and reach tests) variables were collected.
RESULTS: There were no significant differences in WC and BMI, while there was a significant difference in FMR between 7-year-old boys and girls (p=0.008). It also showed stronger and negative associations with motor competence (p<0.0001) and physical fitness index (p<0.0001) than WC and BMI. Sex (p<0.0001), MC (p<0.0001) and FMR (p<0.0001) were independent predictors of PF, explaining together 41.8% of its variability. However, in girls, only MC (p<0.0001) explained 24.9 % of PF variability. While the association between MC and PF was strongest and positive in children with low FMR (p<0.0001), this association is not present in boys with low FMR. Furthermore, only in girls with low FMR, was fat mass (p=0.001) an independent predictor of PF, which, taken together with MC (p<0.0001) and muscle mass (p=0.013), explains a variability of 58,2 %.
CONCLUSION: Studying the relation between FMR and MC improves the assessment of PF in children considering sex. Moreover, children with low FMR have higher MC and PF, and have shown a stronger association between MC and PF than children with high FMR. Further studies are needed to consider the interrelation between fat and muscle mass and the role of skeletal muscle performance, rather than fat mass reduction, in improvements in MC, PF, and body composition in 7-year-old children, especially in girls.
REFERENCES:
1. Cattuzzo, M. T. et al. (2016). Motor competence and health-related physical fitness in youth: A systematic review. Journal of Science and Medicine in Sport, 19(2), 123–129
2. Smith, J. J., et al. (2014). The Health Benefits of Muscular Fitness for Children and Adolescents: A Systematic Review and Meta-Analysis. Sports Medicine, 44(9), 1209–1223.
3. Chen, Y.-Yet al. (2019). Fat-to-muscle ratio is a useful index for cardiometabolic risks: A population-based observational study. PLOS ONE, 14(4), e0214994.

**IS BODY COMPOSITION ASSOCIATED WITH PHYSICAL FUNCTION IN OLDER MEN?**

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INTRODUCTION: In a study by Orssatto et al.1, total body fat was negatively associated with physical function (Timed-up-and-go, Stair ascent, and Stair descent) in older adults but not for total lean mass. Many studies have focused on associations at baseline; however, fewer studies have examined associations between training-induced changes. Therefore, the objective of the present study was to investigate the associations between body composition and physical function at baseline and with training-induced changes in these variables in older men.
METHODS: Forty-nine older men (67.7±5.3yrs, 83.4±10.5kg, mean±SD) completed a 10-weeks biweekly power training intervention. Body composition was measured by Dual-energy X-ray absorptiometry. Physical function was assessed as a composite Z-score combining measures from Sit-to-stand power (MuscleLab force plate), Timed-up-and-go time, as well as loaded and unloaded Stair climbing time (15 steps). Linear and quadratic regression analyses were performed to determine associations between body composition and physical function.
RESULTS: At baseline, total lean mass was positively associated with Sit-to-stand power (R2=0.32 B=34.7 [19.3; 50.1], p<0.05), but not with physical function (p>0.05). Total fat mass (R2=0.11, F(2, 45) = 3.92, p<0.05) and body composition expressed as percentage fat mass (R2=0.15, F(2, 45) = 5.26, p<0.01) had a significant quadratic relationship with physical function. The apex of the quadratic regression for body composition was at 21.5% fat mass. Total lean mass (1.3±2.1, p<0.020), Timed-up-and-go time (-1.6±4.9, p<0.017), unloaded Stair climbing time (-5.2±6.6, p<0.001), and loaded Stair climbing time (-4.4±6.1, p<0.01) all improved after the training intervention. Furthermore, there was a significant association between changes in body composition (percentage fat mass) and physical function from pre- to post-intervention (R2=0.15, F(2, 45) = 4.94, p<0.05).
CONCLUSION: The present studys findings indicate that total lean mass is positively associated with Sit-to-stand power, while total fat mass and body composition were associated with physical function in older men at baseline. Furthermore, changes in body composition were

associated with changes in physical function. In accordance with previous research, body composition in older subjects follow a non-linear relationship with physical function.2 Neither excessive nor low levels of body fat seem to be beneficial for physical function in older subjects. In the present study, subjects with a body composition of ~20% fat mass displayed the highest level of physical function. Randomised controlled trials with larger sample sizes, more extended intervention periods, and exercising- non-exercising control groups are needed to examine how body composition variables may influence physical function in older adults.

1. Orssatto et al., Clinical Biomechanics, 2020
2. Hardy et al., PloS One, 2013

**BODY COMPOSITION AND LEVEL OF PHYSICAL ACTIVITY OF MIDDLE - AGED PRIMARY SCHOOL TEACHERS**

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INTRODUCTION: In Hungary, about 77, 000 people work as teachers in primary school. Generally, stressful work negatively affects health and can increase the risk of cardiovascular and metabolic diseases. Teachers health status is often assessed using questionnaires (Seibt et al.2011), and as a result, there is a lack of research using objective measures of body composition and information about the level of physical activity. To collect data about body composition and daily physical activity of middle - aged primary school teachers and to compare some results to the EHIS study results reported in 2019.
METHODS: 102 subjects (mean age: 50.5±6.5 years.) were recruited from different primary schools using the snowball research method. Data collected included body mass index (BMI), body composition (BF%), and information of a health behaviour questionnaire assessing level and frequency of physical activity (WHO 2010). The participants involved were over 35 years of age and had more than ten years' experience as primary school teachers. Descriptive statistical analysis and Chi square tests were used with SPSS Statistics program version 22.
RESULTS: The mean BMI was 26.3±5.1 and BF% was 28.8±5.5 in teachers, 36% were overweight and 19%was obese. According to the questionnaire, 8% was physically active every day, 27% reached the recommended 5 MVPA per week. The frequency of 45% was reported to engage the recommended 150 minutes moderate physical activity per week, and 60% reported participating in different activities. The most popular forms of activities were running, gymnastics and cycling. Compared to data from the European Health Interview Survey (EHIS) teachers in this study were less active (45% vs. 61%) and were the same overweight and obese (55%vs. 54%) as Hungarian women in the general population.
CONCLUSION: According to the results, health-related concepts and physical activity promotion programs for teachers would be essential to prevent the deterioration of their health.

Seibt R, Steputat A, Ulbricht S, Rehm U, Scheuch K. (2011): Occupational medical examinations: Report on the health situation of the Saxon Education Agency in 2010. Chemnitz: Sachsische Bildungsagentur; 2011. German.
World Health Organization (2010). Global Recommendations on Physical Activity for Health (p. 57). Geneva: World Health Organization.

## Oral presentations

### OP-SH10 Social equality and sustainability

**THE POLICY OF THE INTERNATIONAL OLYMPIC COMMITTEE ON GENDER EQUALITY IN OLYMPIC SPORT**

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INTRODUCTION: With the revival of the Olympic Games (OG) in 1896, the IOC opposed allowing women to compete. However, over time, women were admitted to competitions due to socio-cultural influences (including strong influence of feminist organizations) [1]. Nowadays the OG have become one of the biggest global platforms for advancing gender equality in sport (after launching the Gender Equality Review Project in 2017) [2], but some current developments need to be critically discussed. The aim of this study was to discuss the impact of IOC policies on the development of womens sports in the world and the problems that arise in this regard.
METHODS: All data from the Gender equality & inclusion report of the IOC [2] were analysed.
RESULTS: By the 2020 OG in Tokyo, some of the planned actions of the Gender Equality Review Project have already been implemented. In fact, women made up 48% of athletes, 13% of coaches, 38% of international technical officials, 20% of chefs de mission, 38% of IOC members, 33% of the IOC Executive Board, 37% of IOC commission chairs, and 48% of IOC commission members. The increasing number of female athletes can be explained mainly by the introduction of womens competitions in traditional male sports. That leads to active development of such sports for women around the world and could lead to significant problems with their health and social adaptation in future.
For the first time, the IOC has faced the problem of admitting transgender athletes to the OG, and the debate over the issue of hyperandrogenism in sport continues.
CONCLUSION: The IOC is committed to ensuring gender equality by 2024, not just among athletes, but also among coaches, support staff, staff and management of the IOC, NOCs, and sports federations. However, IOC should consider firstly the medical-biological, social and aesthetic aspects of sport, values of the ideals of Olympism [3].
The IOC therefore needs to consider three main aspects: i) to develop traditional womens competitions (at the moment only 2 female sports: artistic swimming and rhythmic gymnastics with 2 medals events each) instead of introducing more events for women in traditionally mens competitions (e.g. 5 medal events in female boxing); ii) to pay attention to threats for the health of female athletes and their subsequent adaptation; iii) to develop recommendations for the athletes with hyperandrogenism and transgender athletes to make competitive conditions equal for all women. In general, the IOC is facing the difficult task of ensuring women's rights and the need to eliminate discrimination while respecting the principles and ideals of the Olympic Movement.

References:
1. Bulatova MM, Bubka SN, Platonov VM. The Olympic Movement: History and Modernity [in 2 books]. Kyiv: Olympic Literature, 2021.
2. IOC Gender equality & inclusion report 2021.
3. Platonov VN. Basics of athletes' training in Olympic sports. Coachs table book [in 2 vols.]. M.: LLC "PRINTLETO", 2021.

**UNDERREPRESENTATION OF WOMEN IN SPORTS COACHING. A SOCIOCULTURAL ANALYSIS.**

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*UMEÅ UNIVERSITY*

Despite numerous interventions for equality between women and men in sports, the number of women sport coaches has not increased. Even though women's participation in sports and qualification for coaching has increased, the representation of women in sports coaching has rather declined (La Voi, 2014). That said, scholars have recently argued that the underrepresentation of women in the coaching role is a cultural problem related to male dominance, rather than related to women's personal qualification deficits (Knoppers, de Haan, Norman & LaVoi, 2021; Kane, 2016). Thus, the overall aim of this study was to explore coaches' perceptions and understandings of the underrepresentation of women as coaches within organized sports in Sweden and what action is required to facilitate future involvement of women coaches. Data were gathered through semi-structured focus group interviews with 16 floorball coaches, 8 women and 8 men. The results show how sociocultural patterns of interactions, behaviour and perceptions related to the gender of coaches do influence the women's opportunities, difficulties or choices to become a floorball coach and how the male norm is maintained. Furthermore, the study highlights how both women and men find it easier for a man to become and act as a coach in a male-dominated leadership culture.

**COMPREHENSIBLE AND MEANINGFUL, BUT COMPLEX TO MANAGE. SWEDISH SPORT FEDERATIONS' WORK WITH ENVIRONMENTAL SUSTAINABILITY**

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*MALMO UNIVERSITY*

Sport impact the environment and climate through consumption of natural resources, non-renewable resources, production of garment, gear and clothes, and greenhouse emissions (McCullough et al., 2017). Awareness of the environmental issue in relation to climate and a sustainable world is not sufficient. A bigger responsibility and demand is put on sport and its organizations and actors. In Sweden, different sport impact the environment in different ways, due to for instance geographical location, being an indoor or outdoor sport, and different regulations to execute the sport. Of relevance for this study is that sport federations' change to a more sustainable sector is dependent on people's engagement, knowledge and motivation. The aim of this study was to increase knowledge about Swedish sport federations' work with environmental sustainability. The theoretical framework consists of SWOT-analysis and Antonovsky's sense of coherence. The Swedish sport confederation (SEF) and 16 of its affiliated sport federations (SF) were included in the study. The 16 SF websites were analyzed and 10 sustainability coordinators were interviewed. The main results show that many SF recognize the importance of environmental sustainability since climate changes impact possibilities to train and compete (for instance, skiing and access to snow). Most SF have policies and check lists related to environment and to act more sustainable. Still, in many SF the issue of environmental sustainability is not definitely established on the agenda, in some cases due to lack of resources such as time and economy, in others due to a lack of holistic commitment. Transportation and emissions is identified as the main problem, due to the fact that sport's goal (train and compete to strive for achievement) disrupts the environmental sustainability goals. The sense of coherence related to work with environmental sustainability is uneven in most SF. All show adequate levels of comprehensibility and they draw their work mainly on knowledge based on natural sciences. However, different types of knowledge, for instance pedagogical, psychological and historical, is needed to increase awareness of attitudes and behavioral change. The aspect of manageability is more complex, as some SF does not seem to work with the issue as a natural part of its organization. Of importance, though, is that all SF show an established meaningfulness. In conclusion, the 16 SF have initiated a work towards a more environmentally sustainable sport organization, but the issue needs to be established at their agendas. Although national guidelines and policies are provided by SEF, its affiliated SF ask for a clearer governance from either the sport confederation or the government.

McCullough, B. & Kellison, T. (2017). Routledge Handbook of Sport and the Environment. London, Routledge.

**TOWARDS MORE SUSTAINABLE SPORTS – AN ANALYSIS OF ADOLESCENTS' TRANSPORTATION HABITS TO SOCCER PRACTICE IN SOUTHERN NORWAY**

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INTRODUCTION: Mitigating climate change is a great global challenge demanding efforts from all sectors, and sports are no exception. While transportation is one of the key issues regarding sustainable sports, the methods by which children and adolescents get to practice has not received much attention. Therefore, the objectives of this study were (1) to present how adolescents in Southern Norway travel to soccer practice and (2) to assess how mode of transportation is related to sex, socioeconomic status, age, and distance from home to practice.

METHODS: Cross-sectional data were collected from 558 adolescent soccer players (398 boys and 190 girls) from Southern Norway using a self-reported electronic questionnaire. The participants were 13-19 years old (M =15.7 SD =1.4) and came from 30 different clubs from settlements of varying rurality. The data was analyzed using a logistic regression analysis.

Results: The majority of adolescents opted for passive transportation to practice; 39% by car, 11% by moped/motorbike, 3% by bus and 2% by electric scooter, in total 55%. A total of 45% opted for active transport; 29% by bike, 9% by e-bike, and 8% by foot. Most of the participants lived within cycling distance; 27% within 2 km, 67% within 4 km and 91% within 10 km. A logistic regression analysis found the odds of opting for passive transport to practice to increase with traveling distance (OR was 6.5, 25.0 and 224.9 respectively for those living 2-4, 4-10 and more than 10 km away compared to those living less than 2 km away) and age (OR was 1.4, 1.6, 3.1 and 3.9 respectively for 15, 16, 17 and 18-19 year-olds vs 13-14 year-olds). Sex and socioeconomic status were not significantly associated with mode of transportation from home to practice.

Conclusion: A minority of adolescent soccer players in Southern Norway reported active modes of transportation to soccer practice. While traveling distance and age were associated with active transportation habits, sex and socioeconomic status were not. Further research is needed to examine the main barriers to active travel for this already active population, as active transport represents an opportunity for sports to become more sustainable.

## Oral presentations

### OP-MH19 Children: Cardiorespiratory fitness

#### THE ASSOCIATION BETWEEN CARDIORESPIRATORY FITNESS AND CLUSTERED CARDIOMETABOLIC DISEASE RISK AMONG ADOLESCENTS FROM SAUDI ARABIA: A CROSS-SECTIONAL STUDY

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INTRODUCTION: Cardiometabolic disease risk factors (CMRF) start from early childhood which track into adulthood and predict future CVD burden in adulthood. Cardiorespiratory fitness (CRF) has been shown to be inversely associated with CMRF among adolescents from Europe and the United States of America. The first study in Saudi Arabia was in 1993 that examined the associations between CMRF and CRF among 63 boys 7-12 year old, with a mean VO2max = 48.4 ± 6.0 ml. kg-1. min-1. This study found weak associations between CMRF and CRF. However, since 1993 no study has examined the associations between CMRF and CRF among adolescents of both sexes from Saudi Arabia. Therefore, the aim of this cross-sectional study was to examine the association between CRF and clustered CMRF score in adolescents from Saudi Arabia.
METHODS: Data collection took place in 2019 on a sample of 109 adolescents (males= 53, and females= 56) who were randomly selected from eight schools in Riyadh city, stratified for location (mean age 13.6 ± 1.1 year, stature 154.5 ± 7.5 cm, body mass 53.9 ± 14.9 kg). The PACER 20 metre shuttle run test was used to estimate adolescents CRF, and laps were converted to VO2max using the FitnessGram predicted VO2max equation (VO2max = 45.619 + (0.353 * PACER laps) − (1.121 * age). In addition, males and females were classified as having a healthy CRF if their VO2max ≥42 and ≥35 ml. kg-1. min-1 for male and female adolescents, respectively. CMRF score was calculated using sex-specific z-scores summed from waist circumference, mean arterial blood pressure, fasting HDL cholesterol, LDL cholesterol, triglycerides, and glucose (Lipids and glucose were estimated using CardioChek PA analyser). Participants were also categorised at risk if their CMRF score was >1 SD. Statistical analysis was conducted using linear regression with adjustment of covariates (age, stature, region, and dietary score computed from fruit, vegetables, drink milk or eat milk products, and carbonated soft drinks intake).
RESULTS: Males mean VO2max= 37.9 ± 4.2 ml. kg-1. min-1 and females VO2max= 35± 2 ml. kg-1. min-1, with significant difference between sexes (P= <0.001). Moreover, VO2max of few males n= 8 (15.1%) and almost half of females n= 26 (46.4%) were above the healthy CRF cut-points, with significant difference between sexes (P= <0.001). In addition, males n= 18 (34%) and females n= 21 (37.5%) were at risk of CMRF score >1 SD, with significant difference between sexes (P= <0.001). Linear regression indicated that CRF in both sexes were not associated with CMRF score in males (β= -0.115, P= 0.158) or females (β= -0.133, P= 0.619) after adjustment for confounders.
CONCLUSION: Few males and nearly half of females Saudi adolescents CRF is above the healthy VO2max cut-points, although this does not seem to be associated with CMRF score.

#### THE ASSOCIATION OF CARDIORESPIRATORY FITNESS AND GRAY MATTER VOLUME IN COGNITIVELY NORMAL OLDER ADULTS: A CROSS-SECTIONAL STUDY FROM THE AGUEDA TRIAL

TOVAL, A.1, SOLIS-URRA, P.1, MORA-GONZALEZ, J.1, COCA-PULIDO, A.1, BELLÓN, D.1, TRIVIÑO-IBAÑEZ, E.M.2, BUSTAMANTE-ARA, N.3, STILLMAN, C.4, ORTEGA, F.1, ERICKSON, K.I.1,4, ESTEBAN-CORNEJO, I.1

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INTRODUCTION: Aging is associated with changes in brain structure which, in turn, leads to a decline in brain function and cognition. Fortunately, emerging evidence has shown that this deterioration process may be avoidable. In this sense, cardiorespiratory fitness is a well-known marker of health across the lifespan, and in addition, it has recently been associated with improvements in various cognitive functions. However, evidence of the relationship between cardiorespiratory fitness and brain structure in this sensitive population (older people) is still scarce. In the present study, we examined the association between cardiorespiratory fitness and gray matter volume in cognitively normal older adults.
METHODS: A cross-sectional study involving 84 cognitively normal older adults (65 to 80 years old; 59.5% women) from the AGUEDA trial was carried out. We assessed cardiorespiratory fitness using the 6-minute walking test and the 2-kilometer walking test, and total completion distance and time were registered, respectively. For the 2-kilometer test, longer time indicates poorer performance, so the variable was inverted (multiplied by -1) so that higher scores indicate better performance in both cardiorespiratory fitness tests. Gray matter volume was determined by magnetic resonance imaging, using voxel based morphometric analysis. General linear models were performed to determinate the association between cardiorespiratory fitness and gray matter volume, adjusting by sex, age, and years of education. AlphaSim spatial extent threshold and Hayasaka correction were applied.
RESULTS: Results from whole-brain volumetric analysis showed that cardiorespiratory fitness, measured by the 6-minute test, was not positively or negatively associated with gray matter volume in any region of the brain. No brain regions showed a significant positive association with the 2-kilometer test. Conversely, better performance in the 2-kilometer test was negatively associated ($p<0.001$) with gray matter volume in solely one cluster corresponding to thalamus region ($k=113$, $t=-3.6$).
CONCLUSION: Higher cardiorespiratory fitness, measured by the 6-minute walking test and the 2-kilometer walking test, is not associated with higher gray matter volume in cognitively normal older adults. However, a solely and unexpected association was found between better performance in the 2-kilometer walking test and lower gray matter volume in the thalamus. Future exercise-based randomized controlled trials should examine whether exercise-induced changes in cardiorespiratory fitness may influence gray matter volume in this population.

**COMPARISON OF 12-WEEK POLARIZED TRAINING VS. HIGH INTENSITY INTERVAL TRAINING ON CARDIORESPIRATORY FITNESS, BODY COMPOSITION AND FAT METABOLISM IN OBESE ADULTS.**

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*UNIVERSITY OF UDINE*

INTRODUCTION: The positive effects of High Intensity Interval Training (HIIT) and Moderate Intensity Continuous Training (MICT) on peak O2 uptake (V'O2peak) and body composition are well documented in obese adults (1). The combination of HIIT and MICT, called Polarized Training (POL), induces greater improvements in body composition, and maximal oxygen uptake (V'O2max) in well-trained athletes compared to HIIT or MICT alone (2,3). However, POL has never been applied in adult males with obesity. Thus, the purposes of this study were to investigate changes in body composition, physical capacities and fat oxidation, induced by a 12-week either POL or HIIT program in obese male adults under their normal living conditions
METHODS: Thirty-four male patients (mean age 39 y; mean body mass index [BMI] 33 kg·m−2) participated in this study (n: 18 POL, n: 16 HIIT), attending ~ 36 sessions of training, supervised online by researchers. At baseline (PRE) and at the end of the training period (POST) body composition, V'O2peak, and fat oxidation rates were measured. The POL group performed ~45min of training per session, while HIIT group performed ~33min of training per session. The two training programs were iso-caloric. A two-way repeated measures ANOVA was performed to detect differences in means on endpoints. Significant main effects were followed-up by Šídák post-hoc procedures. Significance was set at P<0.05.
RESULTS: At POST, body mass (BM) decreased by -3% (P < 0.05) in a similar way for POL (PRE: 106.6±10.8, POST: 104.0±16.0 kg, P= 0.004) and HIIT (PRE: 103.8 ± 9.3, POST: 100.2 ±9.6 kg, P= 0.001) groups, as well fat mass (FM) decreased by -9% (P < 0.05) in both groups POL (PRE: 43.6±10.2, POST: 40.1±10.2 kg, P= 0.001) and HIIT (PRE: 38.1±4.7, POST: 34.2±4.7 kg, P= 0.001). V'O2peak increased in both groups by 16% (P < 0.05), POL (PRE: 2.95±0.43, POST: 3.42±0.40 L min-1, P< 0.001) and HIIT (PRE: 3.12±0.45, POST: 3.58±0.52 L min-1, P< 0.001). Fat oxidation rates increased in POL (P<0.001) and HIIT (P=0.009) without differences between groups at all exercise intensities (P=0.984). Exercise intensity corresponding to maximal fat oxidation (MFO), expressed as a percentage of V'O2peak, increased in a similar manner in both groups (by 6±7%, P= 0.006), without group effect (P=0.430).
CONCLUSION: POL and HIIT were equally effective in improving V'O2peak, body composition and fat oxidation in obese subjects. At the same time, POL training proved to be less intense and more tolerable than HIIT. The results of this study could provide the foundation for a correct combination of HIIT and MICT during a single training session, in a weekly schedule, and represent a good alternative from HIIT to improve anthropometric characteristics, physical capacities and fat oxidation in obese subjects.
References
(1) Su et al., PloS one. 14:1, 2019.
(2) Stöggl and Sperlich et al., Front. Physiol. 5: 33, 2014.
(3) Kim et al., Healthcare (Basel) 9:851, 2021.

**RISK FACTORS OF NON-COMMUNICABLE DISEASES, FUNCTIONAL PERFORMANCE AND CARDIORESPIRATORY FITNESS IN WOMEN FROM A LOW-RESOURCED COMMUNITY: B-HEALTHY-STUDY**

OVIEDO GUILLERMO, R., TAMULEVICIUS, N., PHIDZA, M., MOSS, S.J.

*UNIVERSITY RAMON LLULL / THE UNIVERSITY OF TAMPA / NORTH-WEST UNIVERSITY*

INTRODUCTION: Non-communicable diseases (NCDs) are responsible for 71% of global deaths and 77% of deaths in low-and middle-income countries (1). Risk factors that arise around NCDs often lead to persons avoiding physical activity, which results in a decrease in functionality and deleterious effects on the cardiorespiratory system and general health of people (2). Socially disadvantaged, vulnerable and older people tend to suffer the most from NCDs. In low-resource communities, NCDs deplete family incomes and increases the risk of unemployment.
Aim: This study aimed to analyse and determine the relationship between risk factors of NCDs, functional performance, and cardiorespiratory fitness in women from a low-resourced community.
METHODS: Eighty-one adult women (AW) (48.15 ± 8.30 years) and 99 senior women (SW) (68.58 ± 7.02 years) accepted to be part of this study. Risk factors that arise around NCDs and functional performance were assessed with a view to the following activities: sit to stand, handgrip (HG), timed up and go (TUG), static balance, and cardiorespiratory fitness test for maximum oxygen consumption (VO2max). All variables were summarised using mean ± SD. A partial correlation was performed with adjustment of age. Independent t-tests were used to compare adults vs. seniors.
RESULTS: The results show a significant relationship between BMI and TUG in both groups (AW: p = .019; SW: p = .031). In the AW the waist circumference (WC) correlated with TUG (r =.348; p = .006). High-density lipoprotein cholesterol (HDL-C correlated inversely with the right HG (r = -.301; p = .019). WC correlated positively with the right HG (r = .259; p = .039) and inversely with the left single leg stance (SLS) (r = -.254; p = .042) in the SW. We also found significant relationship between VO2max (p < 0.001) and both right and left HG (p < 0.001). The adult's sit to stand test correlated positively with VO2max (p ≤ .001). A significant inverse relationship was reported between the TUG and VO2max in both groups: (r = -.471; p < 0.001) and (p = .003) respectively. The right- and left single leg stance correlated with VO2max in adult and senior groups: (r = .261; p = .037 and r = .274; p = .028) and (r = .265; p= .032 and r = .354; p = .004).
CONCLUSION: Our findings suggest that an increase in obesity as a risk factor related to NCDs corresponds with a reduction in balance and handgrip strength. Our results support and further substantiate previous studies showing that improved functional performance is associated with high levels of aerobic capacity.
Future interventions targeting risks of suffering NCDs such as obesity should be delivered through primary health care institutions to improve functional performance and aerobic capacity of women from low-resourced communities.

## 13:15 - 14:30

## Oral presentations

### OP-PN18 Amino acids and proteins III

**NON-ANIMAL AND OMNIVOROUS HIGH PROTEIN DIETS SUPPORT EQUIVALENT DAILY MYOFIBRILLAR PROTEIN SYNTHESIS RATES AND SKELETAL MUSCLE ADAPTIVE RESPONSES TO HIGH VOLUME RESISTANCE TRAINING IN YOUNG ADULTS.**

MONTEYNE, A.

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INTRODUCTION: It remains unclear whether non-animal-derived dietary protein sources (and therefore vegan diets) can support resistance training-induced skeletal muscle remodelling to the same extent as animal-derived protein sources.
METHODS: In Phase 1, 16 healthy young adults (m=8, f=8; age: 23±1 y; BMI: 23±1 kg/m2) completed a three-day dietary intervention (high protein, 1.8 g·kg bm-1·day-1) where protein was derived from omnivorous (OMNI1; n=8) or exclusively non-animal (VEG1; n=8) sources, alongside unilateral daily resistance exercise. Resting and exercised daily myofibrillar protein synthesis (MPS) rates were assessed using deuterium oxide. In Phase 2, 22 healthy young adults (m=11, f=11; age: 24±1 y; BMI: 23±0 kg/m2) completed a 10 week, high-volume (5 d/week), progressive resistance exercise programme whilst consuming an omnivorous (OMNI2; n=12) or non-animal-derived (VEG2; n=10) high-protein diet (~2 g·kg bm-1·day-1). Muscle fibre cross sectional area (CSA), DXA whole-body lean mass, MRI thigh muscle volume, muscle strength and muscle function were determined pre, after two (W2) and five (W5) weeks, and post-intervention. Two-way ANOVA and t-tests were used to detect differences in all variables (group × time).
RESULTS: Daily myofibrillar protein synthesis rates were ~12% higher in the exercised compared with rested leg (2.20±0.33 vs 2.46±0.27 %·d-1 and 2.36±0.53 vs 2.62±0.56 %·d-1in OMNI1 and VEG1 groups, respectively; P=0.0005) and equivalent between groups (P>0.05). Resistance training increased lean mass in both groups by a similar magnitude (OMNI2 2.6±0.3 kg, VEG2 3.1±0.8 kg; P>0.05). Likewise, training equivalently increased thigh muscle volume (OMNI2 8±1%, VEG2 8.2±1.4%; P>0.05), and muscle fibre CSA (OMNI2 33±10%, VEG2 32±17%; P>0.05). Both groups increased muscle strength (1-RM) in a variety of multi-joint lifts, to comparable degrees (OMNI2 18±8%, VEG2 29±17%).
CONCLUSION: Omnivorous and non-animal-derived diets can support equivalent rested and exercised daily myofibrillar protein synthesis rates in healthy young adults consuming a high-protein diet. This translates to equivalent skeletal muscle adaptive responses during prolonged high-volume resistance training irrespective of dietary protein provenance.

**MYCOPROTEIN INGESTION WITHIN OR WITHOUT ITS WHOLE-FOOD MATRIX RESULTS IN EQUIVALENT STIMULATION OF POST-EXERCISE MYOFIBRILLAR PROTEIN SYNTHESIS RATES IN HEALTHY YOUNG MEN.**

WEST, S.1, MONTEYNE, A.1, WHELEHAN, G.1, ABDELRAHMAN, D.2, MURTON, A.2, FINNIGAN, T.3, BLACKWELL, J.1, STEPHENS, F.1, WALL, B.1

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INTRODUCTION: Ingestion of mycoprotein stimulates skeletal muscle protein synthesis (MPS) rates to a greater extent than concentrated milk protein when matched for leucine content, potentially attributable to the whole-food nature of mycoprotein. We hypothesised that bolus ingestion of mycoprotein within its whole-food matrix would stimulate MPS rates to a greater extent compared with a leucine matched bolus of protein concentrated from mycoprotein following a bout of resistance exercise.
METHODS: Twenty-four healthy young (age; 21±2 y, BMI; 24±3 kg·m2) males participated in a randomised, double-blind, parallel-group trial. Participants received primed, continuous infusions of L-[ring-2H5]phenylalanine and completed a bout of unilateral resistance leg exercise before ingesting either 70 g mycoprotein (MYC; containing 31.4 g protein, 2.5 g leucine, 996 kJ; n=12) or 38.2 g of a protein concentrate obtained from mycoprotein (PCM; containing 28.0 g protein, 2.5 g leucine, 558 kJ; n=12). Blood and muscle samples (vastus lateralis) were taken pre- and (4 h) post-exercise/protein ingestion to assess postabsorptive and postprandial myofibrillar protein fractional synthetic rates (FSRs) and phosphorylation status of key proteins that regulate MPS, in rested and exercised tissue. Two- and three-way ANOVAs were used to detect differences in plasma amino acid kinetics (group × time) and myofibrillar FSRs (group × time × exercise), respectively. When significant interactions were observed, Sidak posthoc tests were performed to correct for multiple comparisons and detect individual differences.
RESULTS: Protein ingestion increased plasma essential amino acid and leucine concentrations (P<0.0001), but more rapidly (both 60 vs 90 min; P<0.0001) and to greater magnitudes (1367 vs 1346 µmol·L-1 and 298 vs 283 µmol·L-1, respectively; P<0.0001) in PCM compared with MYC. Protein ingestion increased myofibrillar FSRs (P<0.0001) in both rested (MYC, ?0.031±0.007%·h-1 and PCM, ?0.020±0.008%·h-1) and exercised (MYC, ?0.057±0.011%·h-1 and PCM, ?0.058±0.012%·h-1) muscle, with no differences between conditions (P>0.05). mTOR phosphorylation increased following protein ingestion, with no difference between groups (P>0.05), or rested and exercised muscle (P>0.05).
CONCLUSION: Leucine matched bolus ingestion of mycoprotein results in equivalent postprandial stimulation of resting and post-exercise MPS rates irrespective of whether it is consumed within or without its natural whole-food matrix. These data support the efficacy of mycoprotein as an effective post-exercise nutritional strategy to support muscle reconditioning, irrespective of whether it is consumed as a whole food or as a (more) isolated protein source.

**COLLAGEN PEPTIDES INCREASE ADAPTIONS OF PATELLAR TENDON MORPHOLOGY FOLLOWING 14-WEEKS OF HIGH-LOAD RESISTANCE TRAINING: A RANDOMIZED-CONTROLLED TRIAL**

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INTRODUCTION: The purpose of this study was to investigate the effect of specific collagen peptides (SCP) supplementation combined with resistance training (RT) on changes in structural properties of the patellar tendon. Furthermore, patellar tendon stiffness as well as maximal voluntary knee extension strength and cross-sectional area (CSA) of the rectus femoris muscle were assessed.
METHODS: In a randomized, placebo-controlled study, 50 healthy male participants completed a 14-week resistance training program (70-85% of 1 repetition maximum) for the knee extensors. While the SCP group received 5g of specific collagen peptides daily, the other group received the same amount of a placebo (PLA) supplement.
RESULTS: The SCP supplementation led to a significant greater ($p < 0.05$) increase in patellar tendon CSA compared with the PLA group at 60% and 70% of the patellar tendon length starting from the proximal insertion. Both groups increased tendon stiffness ($p < 0.01$), muscle CSA ($p < 0.05$) and muscular strength ($p < 0.001$) throughout the intervention without statistically significant differences between the groups.
CONCLUSION: The current study shows that in physically active men, supplementation of SCP in combination with RT leads to greater morphological patellar tendon changes than RT alone. Since underlying mechanisms of tendon hypertrophy are largely undocumented, further studies should investigate potential mechanisms causing the increased morphology adaptions following SCP supplementation.

**DIETARY ANIMAL PROTEIN INTAKE REDUCES THE EFFLUX OF MUSCLE DAMAGE BIOMARKERS, BUT DOES NOT IMPROVE PHYSICAL FUNCTION**

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INTRODUCTION: High intensity, eccentric or unaccustomed exercises cause muscle damage, leading to muscle structure and function impairment. Considering that dietary protein intake plays a key role in numerous physiological processes, it is suggested that peri-exercise protein intake may also have a role on facilitating recovery processes. Specifically, higher protein intake decrease muscle soreness (1) and plasma creatine kinase, myoglobin, and lactate dehydrogenase levels (1,2) during post-exercise recovery period but not performance indicators (2). We therefore suggest that dietary protein intake will counteract muscle soreness and muscle damage biomarkers efflux.
METHODS: Healthy males (n=17, 23 ± 0.7 years, BMI 23.7 ± 0.4) and females (n=4, 24 ± 2 years, BMI 21.5 ± 1.2) underwent 10 repeated 40-meters sprints with a 3-minute rest pause between each repetition. Participants recorded their dietary intake during the 3 days following the exercise, and indirect indicators of muscle damage in lower limbs (force generation capacity (FGC), soreness, range of motion (ROM)) and biochemical indicators of muscle damage were tested at baseline and immediately after, at 24-, 48- and 72-hours post-exercise. Participants who did not recover at 72h baseline mtCK values were classified as responders (n=11) and those in which mtCK was unaffected as non-responders (n=6). Two-way repeated measures ANOVA (time x group) followed by a paired t-test with a Bonferroni correction was performed to identify changes from baseline. Unpaired T-test or Mann-Whitney test (decision based on Gaussian distribution) were used to analyse differences in macro and micronutrients intake between groups. The level of significance was set at $p < 0.05$, and data are presented as mean ± SEM.
RESULTS: Repeated sprints resulted in a loss of more than 20% of the FGC and approximatively 20% of the ROM in the most affected leg of the responder group at +24h and remained unrecovered +72h following exercise. No differences were observed between groups for muscle soreness. Serum mtCK increased from baseline (20.0 ± 3.4 ng·mL-1) until a significant peak at +24 h (86.29 ± 14.8 ng·mL-1) and remained significantly elevated at +72h (53.6 ± 10.9 ng·mL-1). Total protein intake during the recovery period differed between groups, accounting for a higher intake by non-responders (MD = 44.7, $p < 0.05$). Moreover, there were no differences between groups in vegetable protein intake ($p = 0.91$), while animal protein intake was the main source of the higher intake of non-responders (MD = 35.4, $p < 0.05$, ES = 1.2).
CONCLUSION: Muscle function (FGC, ROM) remains impaired during the 3-day post-10 repeated 40-meters sprints recovery period in the responder group, while mitochondrial structure and function may have been protected by increased animal protein intake during recovery period.
REFERENCES
1. Cintineo et al., Front Nutr, 2018, doi:10.3389/fnut.2018.00083
2. Nieman et al., Nutrients, 2020, doi:10.3390/nu12082382

**THE RECOVERY EFFECTS OF A NEW VEGAN PROTEIN-BASED MULTI-INGREDIENT SUPPLEMENT ON VOLUNTARY MUSCULAR CONTRACTION AND MUSCLE CONTRACTILE PROPERTIES IN PERI-MENOPAUSAL WOMEN, A CASE STUDY.**

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*UNIVERSITY OF GREENWICH*

INTRODUCTION: Protein-based multi-ingredient supplements including carbohydrates have been suggested to boost post-workout recovery. The present intervention evaluated the effects of providing post-resistance exercise training supplementation ingesting a vegan protein-based multi-ingredient (MTN) vs. carbohydrate alone (CHO) on the recovery of stimulated muscle contractile properties, voluntary muscle function, psychological perceptions of exertion, and perceived Delayed Onset Muscle Soreness (DOMS) after 3 successive intense resistance workouts.
METHODS: The protocol followed a double-blinded, crossover design. Three recreationally active peri-menopausal women (52.2 ± 5.7 years) completed 2 equal 5-days microcycle periods. For this purpose, the participants performed 3 consecutive days of a circuit-shape resistance training sessions, followed by 2 rest days. After every workout and after the first rest day, the subjects ingested either MTN or CHO. Subsequently, the participants were assessed 1, 24, and 48 hours after the termination of the third training session. The primary outcome was Tensiomyography (TMG) (muscle displacement [Dm], contraction time [Tc], and contraction velocity [Vc]) of the Anterior Deltoids (AD), Vastus Medialis (VM) and Biceps Femoris Long Head (BFLH) muscles. Secondary outcomes were upper- and lower-body performance, DOMS, Self-Perceived Energy Feelings (SPEF), and Sleeping Quality.

RESULTS: Significantly decreased ($p < 0.05$) Dm and Vc were observed for both conditions (Dm: MTN -1.74 ± 1.3, CHO -1.61 ± 1.6 mm; Vc: MTN -0.02 ± 0.03, CHO 0.04 ± 0.04 m·s-1) in the BFLH. At 48 hours, all Tensiomyography variables were recuperated under the MTN and CHO conditions. Maximal Isometric Force, Vertical Jump performance, and Seated Medicine Ball Chest Throw showed a performance decrease after 1 and 24 hours and returned to baseline levels after 48 hours. DOMS showed a higher result in CHO vs MTN after 24 hours but was similar in both conditions after 48 hours. Sleeping Quality and SPEF were slightly superior in MTN vs CHO for the three cases over the course of the week.
CONCLUSION: In a preliminary small sample size of healthy and recreationally active peri-menopausal women, the ingestion of only carbohydrates vs vegan post-workout protein-based multi-ingredient supplementation does not seem to provide further benefits in relation to muscular contractile properties or performance. Conversely, slight improvements in Self-Perceived Energy Feelings, Sleeping Quality and DOMS were observed after a MTN vs CHO consumption.

## Invited symposia

### IS-PN06 Redox biology in exercise. A “radically” different approach.

#### ROLE OF REDOX SIGNALING IN SKELETAL MUSCLE DAMAGE AN ADAPTATION TO TRAINING

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The contractile function of skeletal muscle is reliant on multinucleated muscle cells (myofibers), which comprise sarcomeres linked by structural proteins. Despite inherent muscle strength and flexibility, the mechanical strain and stress induced by muscle contraction can result in muscle damage. Physical exercise induces mild musculoskeletal injuries that need rapid and efficient repair to preserve muscle homeostasis. Reactive Oxygen Species (ROS) play a role in this damage which is repaired by muscle resident stem cells (satellite cells). Although stem cell-dependent muscle repair has been widely researched, it is unknown whether myofibers are able to self-repair without satellite cell activation. Using in vitro, ex vivo, and in vivo models (animals and humans performing eccentric exercise protocols) of local muscle damage we found that localized injuries, as experienced through exercise, activate a myofiber self-repair mechanism that is independent of satellite cells in mice and humans. The repair mechanism that we have described is preserved in the three models that we have studied and represents a very efficient and highly relevant protection mechanism for minor muscle injuries as those caused by ROS. The muscle injury triggers a signaling cascade involving calcium, Cdc42, and phosphokinase C that attracts myonuclei to the damaged site via microtubules and dynein4. These nuclear movements accelerate sarcomere repair and locally deliver Messenger RNA for cellular reconstruction. Myofiber self-repair is a cell-autonomous protective mechanism and represents an alternative model for understanding the restoration of muscle architecture during exercise.
These results open the way to a better understanding of muscle injury repair both in the field of exercise (a more physiological context) and in the field of disease (more clinical context).

#### THE EFFECTS OF DIFFERENT EXERCISE MODALITIES ON MITOCHONDRIAL FUNCTION IN HUMAN SKELETAL MUSCLE

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Mitochondrial function (mitochondrial respiration, mitochondrial content and mitochondrial $H_2O_2$ emission) is improved after an exercise intervention. These improvements are linked to many health parameters such as glucose metabolism. Whether the same magnitude of improvement is seen when it comes to mitochondrial respiratory capacity and mitochondrial content is at the moment debated, and whether different exercise modalities are affecting this. These adaptations are seen after a period of training (2-6 weeks or longer).
Interest has also been on the effect of an acute bout of exercise. It is known that an acute exercise bout leads to a transient increase in $H_2O_2$ emission, and it is speculated that the transient increase in mitochondrial $H_2O_2$ emission is involved in mitochondrial biogenesis. Data suggests that this transient increase in $H_2O_2$ emission is exercise intensity dependent. Whether the increase in $H_2O_2$ emission after an acute exercise bout is beneficial or damaging for a training adaptation depends on different factors (baseline levels of $H_2O_2$ emission and the cellular antioxidant system). This supports the concept exercise-induced hormesis, where to little or too much $H_2O_2$ emitted from the skeletal muscle after exercise leads to no exercise adaptation (mitochondrial biogenesis).
The effects of exercise on mitochondrial function will be discussed focusing on mitochondrial respiration, content and $H_2O_2$ emission, before and after an exercise intervention or an acute bout of exercise.

#### ILLUMINATING ROS/RNS-INDUCED ALTERED SKELETAL MUSCLE FUNCTION IN HEALTH AND DISEASE

LANNER, J.

*KAROLINSKA INSTITUTET*

Strenuous endurance exercise is a potent stimulus to induce beneficial skeletal muscle adaptations leading to increased muscular health and aerobic capacity due to e.g., mitochondrial biogenesis and angiogenesis. Reactive oxygen/nitrogen species (ROS/RNS) increases in skeletal muscle during physical exercise and contributes to the favourable effects of endurance training. At the same time, conditions with prolonged increases in ROS/RNS (such as rheumatoid arthritis, malignant hyperthermia, and in overtraining syndrome and normal ageing) exhibit skeletal muscle dysfunction with altered mitochondrial function and muscle weakness. Thus, increased ROS/RNS production have both beneficial and detrimental effects on skeletal muscle function and the outcome depends on a combination of factors, including the type of ROS/RNS, the magnitude, duration, and location of ROS/RNS production, as well as the defence systems including both endogenous and exogenous antioxidants. In this symposium we will: i) provide mechanism-of-action of how ROS/RNS-induced post-translational modifications interfere directly with actin and the force generation in skeletal muscle without a reduction in muscle mass. ii) Elaborate how molecular pathways involved in exercise-induced mitochondrial biogenesis (e.g. PGC-1α) differs between healthy in diseased conditions and iii) despite previous failed attempts of antioxidant treatments, present why site-targeted antioxidants can be groundbreaking in improving muscle function for patients afflicted with disease-induced muscle weakness.

References.
1. Gomez-Cabrera MC, Arc-Chagnaud C, Salvador-Pascual A, et al. Redox modulation of muscle mass and function. Redox Biol 2020; 35: 101531.
2. Flensted-Jensen M, Gram M, Dela F, Helge JW, Larsen S. Six weeks of high intensity cycle training reduces H. Free Radic Biol Med 2021; 173: 1-6.
3. Liu Z, Chaillou T, Santos Alves E, et al. Mitochondrial NDUFA4L2 is a novel regulator of skeletal muscle mass and force. FASEB J 2021; 35(12): e22010.
4. Roman W, Pinheiro H, Pimentel MR, et al. Muscle repair after physiological damage relies on nuclear migration for cellular reconstruction. Science 2021; 374(6565): 355-9.
5. Gomez-Cabrera MC, Pallardo FV, Sastre J, Vina J, Garcia-del-Moral L. Allopurinol and markers of muscle damage among participants in the Tour de France. Jama 2003; 289(19): 2503-4.

# Oral presentations

## OP-BM05 Running and biomechanics

### THE EFFECTS OF HYPOXIA AND RUNNING VELOCITY ON REGULARITY AND FRACTAL DIMENSION OF JOINT ANGLES IN MALE RUNNERS

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INTRODUCTION: Previously, running velocity has been implicated with changes to the variability and complexity of movement dynamics (1). However, it remains unclear as to whether movement dynamics are altered because of increased velocity, or because of physiological responses to exercise. Hypoxic environments can accentuate physiological stress when compared to normoxia for any given running velocity (2). Therefore, the aim of this study was to examine the relationship between exercise intensity and movement complexity, separate to running velocity, using moderate hypoxia.
METHODS: Ten healthy male participants (Mean±SD; Age: 28.9±10yrs, height: 1.81±0.07m, mass: 74.0±8.3kg) performed two graded exercise tests (GXT) on a treadmill on separate days until task failure, with one conducted at normoxia (20.9% FiO2; NORM) and the other conducted in hypoxia (15% FiO2; HYP) in a randomised order. Sagittal joint angles of the hip, knee, and ankle were sampled throughout all stages of both GXTs using 3D motion analysis. Regularity and fractal scaling of kinematics of each stage were quantified using sample entropy (SampEn) and detrended fluctuation analysis-α scaling exponent (DFA-α) Two-way repeated-measures ANOVA (condition X velocity) were used to analyse differences in regularity, fractal scaling, and variability on each GXT stage, from the first stage until the last stage common to all participants.
RESULTS: Peak velocity during GXTs were 4.96±0.30 m·s-1, and 4.61±0.32 m·s-1with similar B[La] of 11.1±3.2 and 11.2±4.5 mmol·L-1 for NORM and HYP, respectively. The last common stage for all participants across both conditions was 4.2 m·s-1, with a total of 15 stages used for analysis. A main effect for velocity on SD was evident at the ankle ($P<0.001$), knee ($P<0.001$), and hip ($P<0.001$), with SD increasing as velocity increased. An interaction between velocity and condition was noted for hip SD ($P=0.014$). There was no velocity x condition interaction for DFA-α or SampEn. DFA-α decreased with increasing velocity, indicating a more random movement pattern, at the ankle ($P<0.001$) and hip ($P<0.001$). A difference in DFA-α was evident between NORM and HYP at the ankle ($P=0.02$). SampEn increased, indicating greater complexity, with increased running velocity at the ankle ($P<0.001$), knee ($P<0.001$), and hip ($P<0.001$).
CONCLUSION: As running velocity increased DFA-α decreased, SampEn values increased, and SD increased in both NORM and HYP conditions, suggesting greater complexity and variability change in line with velocity. Temporal profiles of measures of complexity and variability were consistent between NORM and HYP. Therefore, changes in variability and complexity during running are more strongly mediated by running velocity rather than the physiological demand of exercise.
1. Hunter et al. (2021). Eur J Appl Physiol, 121: 1297–1313.
2. Sharma et al (2019). Med Sci Sports Exerc, 51: 174–182.

### IMPACT OF SPEED AND SLOPE ON STRIDE VARIABILITY

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INTRODUCTION: Evaluation of variability in stride while running is increasing as some evidences have linked changes in some metrics to fatigue, injury or overreaching (1,2,3). Several kinematic parameters can be used such as stride time (Ts), contact time (Tc), flight time (Tf) or cadence (C) (3). Their variability can be described through different indexes: the amount of stride-by-stride variation (AV), predictability (P), and complexity (Cp) (3,4). However, the impact of running speed or slope on variability of these parameters has not been reported. Hence, our aim was to study the effects of slope and speed on stride variability.
METHODS: 20 recreational runners performed an 11-randomized-conditions treadmill test with 5 conditions derived from preferred running speed (PRS; 80%, 90%, 100%, 110%, 120%) and 6 inclines (-8%, -5%, -2%, 0%, 2%, 5%, 8%) at 90% of the PRS. Ts, Tc, Tf and C were measured with an Optogait system (Microgate, Bolzano, Italy). AV was quantified by coefficient of variation (CV) (3). P and Cp were evaluated using coefficient alpha 1 of detrended fluctuation analysis (aDFA) and Higuchi fractal index (HFI) following recommendations (4). Two separated one-way repeated measures ANOVA were performed to assess the effect of slope and speed.
RESULTS: The effect of slope on AV was significant and similar for the different kinematics . CV was higher for negative slopes than for positive slopes ($p<0.05$) for Ts (at -8%: 3.12%±1.52; at 8%:2.44%±0.41), Tc, Tv and C. There were no differences between the positive slopes and the flat condition for all kinematic parameters studied (e.g. Tf at 0%: 17.96%±6.66 and at 8%: 17.82%±6.82; $p>0.05$). The effect of speed was different depending on the kinematic studied. As speed increased, CV for Tv decreased (80%: 23.16%±7.04; at 100%: 13.18%±4.60; at 120%: 9.18%±2.81; $p<0.05$). CV for Tc was significantly higher at 80% than the other conditions (80%: 2.72%±0.93; at 120%: 2.34%±0.62; $p<0.05$). As regards P, higher values on positive slopes and flat compared with negative slopes were observed for Ts

only (aDFA at -8%: 0.59±0.14; at 0%: 0.65±0.09; at 8%:0.67±0.18; p<0.05). As well P, lower value at 120% than other conditions was observed for Tc only (aDFA at 80%: 0.85±0.09; at 120%: 0.77±0.1). For Cp, no significant changes with slopes were observed for Ts, Tc, Tf and C. On the contrary, lower value at 80% of PRS than other conditions was observed for C (HFI at 80%: 0.93±0.29; at 120%: 1.16±0.9; p<0.05).
CONCLUSION: AV was more sensitive to slope and speed than P and Cp, with low speed and negative slopes having higher CV values. Further studies are required to establish best practices for these indices measure and to study other conditions known to alter running kinematics (e.g., gender, footwear, or age).
REFERENCES
1 Bellenger et al., J. Sci. Med. Sport,2019
2 Mann et al.,Scand J Med Sci Sports,2015
3 Garcia-Pinillos et al., J Hum Kinet,2020
4 Phyniomark et al., Front. Physiol.,2020

## EFFECT OF MIDSOLE HARDNESS ON KNEE ABDUCTION ANGULAR IMPULSE: AN ASCENDANT HIERARCHICAL CLUSTERING IN 123 RUNNERS

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INTRODUCTION: Forty-two percent of running-related injuries occur at the knee joint, with 46% of these injuries being due to patellofemoral pain (1). Subjects with patellofemoral pain demonstrate increased knee abduction angular impulse (KAAI) compared to healthy subjects during running (2). Mathematically, KAAI represents the integral of knee abduction/adduction moments over the stance phase. Footwear midsole hardness affects running kinematics (3). This study aimed at investigating whether it affects KAAI. It was hypothesized that the effect of midsole hardness on KAAI would be runner-dependent with clusters of runners responding similarly to changes in midsole hardness. Based on this hypothesis, a secondary purpose was to describe these clusters from biomechanical, morphological, and running practice-related variables.
METHODS: Three midsole hardness conditions (Asker C-40, Asker C-55, and Asker C-65, hereinafter called 'soft', 'medium' and 'hard', respectively) were tested in 123 subjects (51 females, 65.4 ± 9.7 kg, 171 ± 8 cm) who ran at their preferred running speed on a motorized treadmill for ten minutes in each condition. Ground reaction forces and 3D lower limb kinematics were collected. Knee abduction/adduction moment was obtained from inverse dynamics, then KAAI was calculated as the integral of the knee abduction/adduction moment signal over the stance phase. KAAIs in the soft and hard conditions were normalized to KAAI in the medium condition. Relative KAAIs were used as the dependent variables to cluster runners using an ascendant hierarchical clustering. Subjects were clustered based on relative KAAIs to ensure classification on the footwear effect rather than on the absolute KAAI magnitude. Age, gender, mass, height, body mass index, fat mass, weekly volume of practice, weekly mileage, experience in running, running speed, and foot strike angle were used as independent variables to describe clusters.
RESULTS: To minimize intra-class variance and maximize inter-class variance, the number of clusters was set at 3. Cluster 1 (n = 16) demonstrated lower KAAI in the medium compared to soft and hard conditions ($p < 0.0001$). Cluster 2 (n = 62) demonstrated greater KAAI in the hard compared to soft and medium conditions ($p < 0.0001$). Cluster 3 (n = 45) demonstrated greater KAAI in the medium compared to soft and hard conditions ($p < 0.0001$). No significant difference in independent variables were observed across clusters.
CONCLUSION: Midsole hardness differently affects KAAI in runners. Half of the present sample increases KAAI with hard midsole; 37% increases KAAI with medium midsole; only 13% decreases KAAI with medium midsole. Despite that the present data do not permit to characterize these clusters, the findings provide insights for the development of running footwear, especially regarding midsole conception.
REFERENCES:
1) Taunton et al., BJSM, 2002
2) Stefanyshyn et al., Am J Sports Med, 2006
3) Nigg et al., J Biomechanics, 2012

## EFFECTS OF DIFFERENT PROTOCOLS OF STRENGTH TRAINING ON RUNNING BIOMECHANICS: A SPRING-MASS MODEL APPROACH

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INTRODUCTION: Heavy and plyometric strength training enhances running performance by eliciting metabolic adaptations such as a lower energy cost (EC) (1). However, little is known about these effects on the mechanical energy saving represented by the spring-mass model. The total mechanical work (Wtot) quantifies the mechanical energy produced by the body during running [summation of external (Wext) and internal (Wint) work denoting the energy variation of the body concerning the environment and from its limbs regarding the body centre of mass] (2). Then, we aimed to analyse the effects of planned heavy and plyometric training on mechanical work parameters in recreational runners.
METHODS: Twenty-four runners were allocated to heavy (HG, n=8), plyometric (PG, n=9), [which added 8 weeks of strength training (twice per week)], and control group (CG, n=7). Runners performed three evaluation sessions (before and after the training period, interspersed by 48h): maximal progressive test, submaximal running test at constant speeds associated with 60 (EC60) and 110% (EC110) of their maximal intensity. A 3D kinematic analysis recorded an 18-markers model (3) to measure mechanical work parameters during the second session. The third session evaluated the 5-km run performance (t5km). Two-way ANOVA with repeated measures was performed to identify probable treatment interactions, and a paired t-test was done to compare intragroup differences pre-and post-training.
RESULTS: The t5km improved for both strength groups (SH: 1430±265 to 1355±208 s, p=0.03; SP: 1464±143 to 1377±156 s, p=0.02) without significant differences for CG (1662±259 to 1637±262 s, p>0.05). Unchanging values of EC60 and EC110 accompanied this performance gain in HG and PG. Concomitantly, Wtot60 maintained similar in HG and PG, but its component, Wint60, increased only for the HG (0.35±0.02 to 0.39±0.01 J.kg-1.m-1, p=0.03). On the other hand, Wtot110 showed a significant increasing pre-to post-training in HG and PG (HG: 2.04±0.06 to 2.33±0.09 J.kg-1.m-1, p=0.006; PG: 2.06±0.07 to 2.21±0.06 J.kg-1.m-1, p=0.02), whereas Wint110 remained similar and Wext110 increased for both groups (HG: 1.39±0.04 to 1.60±0.07 J.kg-1.m-1, p=0.006; PG: 1.39±0.06 to 1.51±0.05 J.kg-1.m-1, p=0.04).
CONCLUSION: The increase in the performance by reducing t5km for both strength training methods reinforces its benefits for running. However, the mechanical work operated differently between the two intensities since Wtot60 kept similar while Wtot110 increased for

both experimental groups. Such behaviour reflected a higher Wext110 despite the unchanged EC110. Our results reveal that heavy and plyometric strength training similarly influences the spring-mass model primarily in high physiological intensities and reflects it in running performance.
REFERENCES:
1) Denadai et al., SportsMed 2017
2) Peyré-Tartaruga et al., ExpPhysiol 2021
3) Saibene & Minetti, EurJAppPhysiol 2003

**ACUTE EFFECTS OF ELECTROSTATIC CHARGING ON ENDURANCE PERFORMANCE. A DOUBLE-BLIND, RANDOMISED, PLACEBO-CONTROLLED CROSS-OVER DESIGN**

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INTRODUCTION: Accompanied by paradigm shifts and research gaps, redox-mediated signalling mechanisms are thought to modulate muscle performance, stress-related muscle damage, inflammation, or recovery (1). Interestingly, however, these cellular or subcellular processes seem to be positively influenced by reducing the electrostatic charge of the human body. Accordingly, grounded sleeping has been found to accelerate recovery from stress-related muscle damage (2). However, the potential acute effects of electrostatic charging on endurance performance have never been tested. Here, we propose to evaluate the impact of grounding or sham grounding and thus of electrostatic uncharged or high charged individuals on performance outcomes during incremental treadmill tests until exhaustion.
METHODS: In a cross-over design, nine healthy endurance tests-experienced women (n = 3) and men (n = 6) were randomised to a grounded or sham grounded treadmill test (HP Cosmos Pulsar 3p). The ramp testing (7.0 km·h−1; increment: 1.5 km·h−1 every 5 min, with 30 s recovery between stages, inclination 1%) was separated by one week and comprised absolute maximum oxygen uptake (Cosmed K5 breath-by-breath mode), lactate measures at rest and after each recovery phase, ultrasound-guided near-infrared spectroscopy for vastus lateralis O2 extraction (Moxy), power (Stryd Power Meter), heart rate (Suunto), total running time, and rate of perceived exertion (Borg 6-20 scale). High electrostatic charging was achieved using prototype shoes of pronounced triboelectrification. Voltages were recorded at 5 Hz using a high voltage voltmeter (Kleinwächter HMK 40). Except for total running time, the final two minutes of the last fully completed running stage were analysed. A mixed ANOVA was used.
RESULTS: Individuals absolute V̇O2max was 3.88 ± 0.66 (L·min-1). The sham and grounded groups average electrostatic charging was 6.7 ± 1.4 kV and 0.0 ± 0.1 kV. This charging did not affect measured endurance outcomes ($F < 2.02$, $p > .198$). We observed a learning effect on the lactate ($F$ 17.00, $p = 0.004$) and heart rate ($F$ 13.33, $p = 0.008$) values.
CONCLUSION: Contrary to our hypothesis, these preliminary results suggest that grounding the human body has no acute meaning for intense endurance activities. This statement seems well-found, as similar high triboelectric effects transferred by our prototype shoes are unlikely to occur in the natural environment. The learning effect found in lactate concentration and heart rate but not in other closely related parameters remains challenging. However, it potentially indicates that the latter parameters are more sensitive to detecting changes in the coordination pattern of treadmill running.
REFERENCES
Le Moal et al., Antioxid Redox Signal 2017
Müller et al., Front Physiol, 2019
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## Invited symposia

### IS-MH06 Hamstring Strain Injury Mitigation in Intermittent Running Sports

**HAMSTRING STRAIN INJURIES: THE EFFECTS OF FATIGUE AND RECOVERY ON MUSCULO-SKELETAL SYSTEM**

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Exercise-induced muscle damage (EIMD) is characterized by histopathological muscle tissue changes that originate skeletal muscle damage. The destruction of skeletal muscle fibers causes an inflammatory response that decreases the athlete's physical work capacity and sports performance (Mielgo-Ayuso and Fernández-Lázaro, 2021), specially on hamstrings. Thus, muscle recovery becomes a key role and a priority for top elite athlete. This is evidenced by the significant increase in scientific publications during the last 10 years as teams look to find a competitive edge. Recovery is recognized to be an integral component to assist athlete preparation in the restoration of physical and psychological function, and subsequently, performance in elite team sports athletes (Calleja-González et al. 2021).
This presentation could contribute sensibly and legally to athletes to adequately complement their training to obtain better performance or try "shortcuts" to reach the sport's elite in less time, with treatments and/or prohibited artificial methods that improve their ability to achieve more extraordinary physical performance (Mielgo-Ayuso and Fernández-Lázaro, 2021). In order to achieve optimal muscle recovery, athletes often combine additional recovery strategies (biological, pharmacological, mechanical, and nutritional) in the hope of improving physiological responses and competitive performance However, it is necessary to optimize the consumption of adequate amounts of energy, nutrients, and liquids, methods, timing establishing the correct frequency and associated with the temporality of training and competition.
Finally, all their personal performances should be coordinated and put into practice by the sports team. In this scientific and applied proposal, we primarily dealt with the individual treatment of players in order to improve their personal performance and, consequently, the teams sporting performance and minimizing the risk of injury.

### THE EFFECTS OF FATIGUE ON SPRINT AND COD MECHANICS AND ITS RELATIONSHIP WITH HSI

ALCARAZ, P.

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Hamstrings strain injury (HSI) is the most common injury in intermittent running sports such as Australian football, American football, rugby, and football (soccer) (Jones et al., 2019; Mack et al., 2020; Opar, Williams, & Shield, 2012; Orchard et al., 2020; Prieto-Lage, Louzao-Neira, Argibay-González, & Gutiérrez-Santiago, 2020; Ribeiro-Alvares et al., 2019). This type of injury is characterized by acute pain in the posterior thigh with disruption of the hamstrings muscle fibres, where direct external contact with the thigh is excluded as a cause of injury (Liu, Garrett, Moorman, & Yu, 2012; Opar et al., 2012; Poudel & Pandey, 2020). Injury rates are particularly high in football, accounting for 37% of all muscle related injuries (Ekstrand, Hägglund, & Waldén, 2011), and the recurrence rate is also remarkably high (Ekstrand et al., 2020; Martin Hägglund et al., 2013; Heiderscheit, Sherry, Silder, Chumanov, & Thelen, 2010; Woods et al., 2004).Thus, minimizing the risk of first injury is considered a key aspect of overall hamstrings injury reduction strategies. Despite the increasing research focus in this area, the potential injury mechanisms are not well defined (Sun et al., 2015) and injury incidence seems to have increased (Eirale, 2018; Ekstrand, Waldén, & Hägglund, 2016; Martin Hägglund et al., 2013) in recent years
One factor that is known to critically affect injury risk is the level of neuromuscular fatigue (Huygaerts et al., 2020; Lehnert et al., 2017). This fatigue may result from either acute, residual (recovery from competition or training) or chronic physical exercise burden. Epidemiological evidence for an influence of acute fatigue is provided by data showing higher injury rates towards the late stages of a football game (Ekstrand et al., 2011). The accumulation of fatigue across training and competition periods is also linked to injury risk, especially when abrupt increases in total training loads, intensities or high speed running are observed (Green, Bourne, van Dyk, & Pizzari, 2020) or when match density is high, allowing only short recovery between competitive play (Calleja-Gonzalez et al., 2020). However, acute and chronic neuromuscular fatigue might influence risk in very different ways and since player monitoring practices, which are commonly performed and considered a cornerstone of player welfare systems (Matinlauri, Alcaraz, et al., 2019; Taberner & Cohen, 2018), should reduce the risk of chronic fatigue-related injury risk, the current presentation will focus predominately on neuromuscular factors that might trigger an acute hamstring injury event. Specifically, since the majority of HSI occur at maximal or near-maximal running speeds (Sugiura, Sakuma, Sakuraba, & Sato, 2017), the present presentation will describe how acute fatigue could affect mechanical and neuromuscular variables during high-speed running and Change of Directions.

### EFFECTS OF SPRINT, STRENGTH AND MUSCULAR ENDURANCE TRAINING ON THE RISK FACTORS FOR HAMSTRINGS INJURIES

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This presentation will address the prevention of hamstrings strain injuries (HSI) in football, which is currently costing a lot to clubs financially and in terms of players' time loss and re-injuries. There are two separate areas that are crucial for this, the first one is working on muscular endurance to ensure that hamstring strength is sustained during the 90-min of a football match. Indeed, it is obvious that injuries occur towards the end of matches, when fatigue takes place. In addition, many authors have shown a greater loss of strength after football matches in the hamstrings (high proportion of fast twitch muscle fibres) compared to the quadriceps (mixed fast and slow twitch fibres), for example (Delextrat et al., 2020; Greig et al., 2008). Several studies have highlighted the benefits of muscular endurance training on performance indicators, but a lot less have looked at risk factors for injuries. For the hamstrings, these risk factors include, for example, the angle of peak torque and the torque-angle relationship. A recent study by our research group has shown that 7 weeks of muscular endurance training reduced the loss of hamstring strength observed at the end of a match in amateur players (Delextrat et al., 2018). The second essential area to focus on is the mechanism of injury itself. The main mechanism of hamstring injury, affecting the biceps femoris, is sprinting, where this muscle is prone to tears in the late swing phase in particular. This has led practitioners to avoid maximal sprints in practice sessions in order to prevent injuries, which is paradoxical, as sprinting is probably what is needed to ensure optimal adaptation of the hamstrings during this specific activity. Indeed, the main limitations of strengthening exercises are that they do not reproduce all the demands placed on the hamstrings during a cyclic activity like sprinting and do not consider this muscle group as a constitutive element of the motor chain. However, there is only limited research on the effects of sprint training on the risk factors for HSI . Freeman et al. (2019) showed that two 4-week training programmes based on NHE and sprint training, respectively, improved hamstring eccentric strength but sprint training resulted in greater improvements (moderate vs. trivial) in maximal speed in recreational team sport players. More recently Mendiguchia et al. (2020) conducted a prospective interventional study comparing the effects of sprint, NHE and football training. Compared to the other types of training, sprint training resulted in a greater increase in the fascicle length of the biceps femoris and greater improvement in sprinting biomechanics, in particular the maximal theoretical horizontal force (F0). These results are of particular importance because F0 has been correlated with hamstrings electromyographic activity during the swing phase and eccentric knee flexor peak torque (Morin et al., 2015).

## Oral presentations

### OP-BM21 Neuromuscular Physiology: Ageing

### ASSOCIATION OF VASTUS LATERALIS MUSCLE SIZE WITH THE FORCE-VELOCITY RELATIONSHIP, RATE OF FORCE DEVELOPMENT AND PHYSICAL PERFORMANCE: TOLEDO STUDY FOR HEALTHY AGING IN MIDDLE AGE

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INTRODUCTION: The difference in muscle size in different regions of the quadriceps muscle may show different relationships with the force-velocity (F-V) relationship, explosive strength and physical performance. However, these relationships are still poorly analysed. This

study evaluated different muscle sizes along the vastus lateralis muscle and their association with the force-velocity (F-V) relationship, the rate of force development (RFD) and the muscle power estimated with the 5 sit-to-stand repetition test.
METHODS: A total of 42 individuals (mean age: 54.7 ± 1.5 years; BMI: 25.8 ± 5.0; 57% woman) from the Toledo Study for Healthy Aging in Middle Age (THSA-ma) were included. Cross sectional area (CSA) of the vastus lateralis muscle was measured at 35%, 50% and 65% of the distance between the proximal border of the greater trochanter and the superior border of the patella (0% = proximal, and 100% = distal). Three transversal panoramic scans of the vastus laterals muscle were obtained for each region using the extended field of view (EFOV) of the scanner. At least 15 minutes of rest in this position were provided for body fluid shift stabilization prior to imaging. The F-V relationship, maximal isometric force (MIF) and RFD were assessed with the leg press exercise, while physical performance was assessed in the 5-repetiton Sit-to-Stand (5-STS) test.
RESULTS: There were significant associations between all the muscle size measures and i) 5-STS mean power (r=0.59-0.79; p<0.05), ii) estimated maximum force at null velocity (r=0-67-0.71: p<0.01); and iii) maximum muscle power (r=0.59-0.76; p<0.01). Both proximal and middle muscle CSA were significantly associated with relative leg press muscle power (r=0.70-0.76; p<0.05), while only proximal muscle CSA was significantly associated with RFD at the first 100, 200, 300 y 400 ms (r=0.66-0.76; p<0.05) and with the MIF (r=0.70, p<0.05)
CONCLUSION: The vastus lateralis muscle CSA appears to be closely related with muscle function at higher forces and lower velocities. Moreover, proximal vastus lateralis CSA showed the highest correlations with the neuromuscular function measures.

**INFLUENCE OF GROWTH AND MATURATION ON THE FORCE-VELOCITY PROFILE IN GIRLS**

SUDLOW, A., GALANTINE, P., PEYROT, N., DEL SORDO, G., DALLEAU, G., RAYMOND, J.J., GAVARRY, O., DUCHÉ, P.
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INTRODUCTION: Sprinting is fundamental to many individual and team sports and relies on maximal force, velocity, and power capabilities (1). During childhood and adolescence these capacities are greatly influenced by growth and maturation (2), but whether differences in between children of different maturity are mainly due to changes in anthropometrics and body composition is unclear. Moreover, research in girls is sparse and merits further attention. Therefore, the primary aim of this study was to determine the influences of growth and maturation on the Force-velocity (F-v) profile in girls.
METHODS: Sixty girls were recruited from local athletics clubs for this study. Body mass (BM), height, and sitting height were measured in order to estimate years to or from peak height velocity (PHV±Y). Subjects were divided into four equal groups according to their maturity status (PHV-4, PHV-2, PHV-0, PHV+2). Whole-body fat free mass (FFM) was calculated via skinfold measurements. Participants performed two maximal 30-m sprints during which raw velocity-time data were measured using a radar device (Stalker ATS II, Texas, USA). Processed speed-time data were used to derive the mechanical parameters of the F-v profile (3). Both maximal force (F0) and power (Pmax) outputs were normalised to BM and FFM. Theoretical maximal velocity (V0) was also examined. One-way ANOVAs were performed to detect differences in mechanical parameters between maturation groups.
RESULTS: Absolute F0 and Pmax were greater for more mature groups in all cases (P<0.001, ES=0.64, P<0.001, ES=0.67 respectively). V0 was also greater for more mature groups (P<0.001, ES>0.66) except for PHV-0 vs PHV+2. When F0 was normalised to BM and FFM force production was similar between groups except for PHV-4 vs PHV-2 (F0/BM: 5.63±0.64 vs 6.34±0.82 N/kg, P<0.05, ES=0.45; F0/FFM: 6.76±0.82 vs 7.88±0.85 N/kg, P<0.001, ES=1.06). When Pmax was normalised to BM power production was similar between groups except for PHV-4 vs PHV-2 (Pmax/BM: 7.51±1.21 vs 9.78±1.51 N/kg, P<0.001, ES=1.19). When Pmax was normalised to FFM power production was similar between groups except for PHV-4 vs PHV-2 (Pmax/FFM: 9.02±1.49 vs 12.2±1.55 N/kg, P<0.001, ES=0.73) and PHV-2 vs PHV-0 (Pmax/FFM: 12.2±1.55 vs 13.9±1.22 N/kg, P<0.01, ES=0.51).
CONCLUSION: Around and post puberty, differences in F0 and Pmax between girls of varying maturity are predominantly due to increases in BM and FFM. For prepubertal girls and especially very prepubertal girls (PHV-4) anthropometric parameters did not account for all differences indicating that neuromuscular development is perhaps more important at this stage. BM and FFM normalisations were applied to attempt to control for changes in body size and composition but may not have fully accounted for the higher levels of force/power required to accelerate with increasing fat mass.
1. Samozino et al., Scand J Med Sci Sports, 2021
2. Edwards et al., Journal of Sports Sciences, 2021
3. Samozino et al., Scand J Med Sci Spor

**EFFECTS OF SIX WEEKS ISOKINETIC ECCENTRIC TRAINING (AND DETRAINING) ON PLANTARFLEXOR MUSCLE-TENDON MECHANICS IN OLDER ADULTS**

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*1: UON , 2: CU , 3: ECU*

INTRODUCTION: Joint range of motion (ROM) is compromised in ageing and numerous neurological conditions where muscle stretching techniques often provide limited improvements [1]. However, large increases in ROM (10-15°) with concomitant increases in muscle strength have been reported in young adults after eccentric-only training programmes [2]. Therefore, the present study examined the impact of a 6-week isokinetic eccentric plantarflexor and dorsiflexor training programme (and 8 weeks of detraining) on a range of musculoskeletal characteristics in older adults.
METHODS: Maximal isometric and eccentric plantarflexor torque, Achilles tendon and gastrocnemius medialis (GM) stiffness, GM architecture, and dorsiflexion ROM were measured in 11 participants (age [mean ± SD] = 67.4 ± 5.6 y, mass = 70.5 ± 15.6 kg, height = 1.6 ± 0.1 m) before and after the 6-week training programme using dynamometry and sonography. All measures were then re-examined 8 weeks later to quantify detraining effects. Training was performed twice weekly, which consisted of 5 sets of 12 maximal plantarflexor and dorsiflexor isokinetic eccentric contractions, performed at a velocity of 10°·s-1 through 20° plantarflexion to 10° dorsiflexion ROM.
RESULTS: Significant (P < 0.05) increases in isometric (22.4 ± 19.5%) and eccentric (40.1 ± 15.3%) plantarflexor strength, active Achilles tendon stiffness (20.4 ± 6.2%), GM thickness (8.5 ± 5.5%) and fascicle length (7.8 ± 6.1%), alongside decreases in passive muscle-tendon unit (16.4 ± 16.0%) and GM (22.9 ± 19.5%) stiffness were detected immediately after the 6-week training programme. No change in GM pennation angle (0.1 ± 0.8° [0.8 ± 4.6%]) was detected. Eight weeks later, no significant regression in any measure was detected, which remained significantly different to baseline.
CONCLUSION: The concomitant improvements in ROM, tendon stiffness, muscle strength and size after eccentric exercise, with limited regression eight weeks after the cessation of training, is indicative of substantive and prolonged functional benefit. Thus, as older adults are prone to musculoskeletal decline and periods of inactivity, these findings have important implications for clinical exercise prescription.

REFERENCES:
1. Harvey et al. (2017). Cochrane Database Syst Rev. 1(1):CD007455.
2. Nelson & Bandy (2004). J Athl Train. 39(3): 254-258.

### ACUTE AND REPEATED BOUT EFFECTS OF SUB-MAXIMAL ISOKINETIC ECCENTRIC EXERCISE ON NEUROMUSCULAR FUNCTION AND PERCEIVED EXERTION IN OLDER ADULTS.

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INTRODUCTION: The superior muscular adaptations accompanied by lower metabolic demand commonly reported following eccentric exercise make it highly suitable to combat age-related neuromuscular decline [1]. However, acute decreases in strength are often observed alongside muscle soreness following eccentric contractions [2], although these symptoms are usually alleviated following the initial exposure (i.e. “the repeated bout effect” [RBE]). Whilst muscle strength and soreness are commonly examined, few studies investigate other common fall-risk factors. Therefore, the present study examined the acute and RBE of eccentric exercise on neuromuscular fall-risk factors and perceived exertion in older adults.
METHODS: Neuromuscular function (sit-to-stand, timed-up-and-go [TUG], isometric and eccentric strength, explosive capacity, and postural sway) and rate of perceived exertion (RPE) whilst performing functional tasks were measured in 13 participants (age = 67.6 ± 4.9 y) pre- and post-eccentric exercise (0, 24, 48 and 72 h) in bout 1 (acute) and 14 days later in bout 2 (RBE). Eccentric exercise was performed on an isokinetic unilateral stepper ergometer at 50% of maximal eccentric strength for seven minutes (including 1 min warm-up and cooldown) at 18 step/min (126 steps per limb). Two-way repeated measures ANOVAs and post-hoc analyses were conducted to identify any significant ($P < 0.05$) differences.
RESULTS: Eccentric strength significantly decreased in bout 1 at 24 h post-exercise but then recovered; no significant reduction occurred in bout 2. Rate of torque development (0-200 ms) significantly decreased in both bouts at 24 h post-exercise but then recovered; contractile impulse (0-250 ms) did not decrease in bout one but did at 24 h post-exercise in bout 2 and then recovered. No significant reduction occurred in any other neuromuscular function measure in either bout. RPE during sit-to-stand remained significantly elevated for 72 h post-exercise in bout 1 but was only elevated immediately post-exercise (0 h) during bout 2. RPE during TUG remained significantly elevated for 72 h after both bouts of exercise.
CONCLUSION: Sub-maximal eccentric exercise results in minimal disruption to neuromuscular functional characteristics that are commonly associated with falls in older adults after the initial bout, which were eliminated in bout 2, indicative of a protective RBE. Low levels of muscle soreness evident after the initial exposure were also alleviated following the second bout. Despite no change in sit-to-stand or TUG performance, RPE was elevated when conducting these tasks. Nonetheless, the present findings suggest that sub-maximal low-volume eccentric exercise is a safe exercise modality to prescribe to community-dwelling older adults given the minimal impact on fall-risk characteristics.

1. LaStayo et al. (2014). J Appl Physiol. 116:1426-1434.
2. Hody et al. (2019). Front Physiol. 10:536.

### PHYSIOLOGICAL AND GENOMIC DATA SUPPORT THE NEURAL CONTRIBUTION TO SARCOPENIA: FINDINGS FROM THE GENOFIT STUDY

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INTRODUCTION: The loss of skeletal muscle strength and mass, termed ‘sarcopenia’, is a deleterious facet of aging, associated with a plethora of negative health consequences in this population. Despite considerable research into sarcopenia, its underlying mechanisms remain poorly understood and prevalence remains high. Further illumination of the regulatory processes underpinning muscle health is needed to help facilitate the refinement of preservative strategies. Although sarcopenia is recognised as a multifaceted disease, emerging evidence suggests neural pathways may be particularly relevant. In this study, we present physiological and genomic data that support the pertinence of neural processes to sarcopenia. Specifically, we report novel associations between plasma levels of neurofilament light chain (NfL), a marker of axonal integrity, and sarcopenia. Secondly, we present findings from a genome wide association study (GWAS) using whole genome sequence (WGS) data that suggest genes involved in neural processes are also linked with skeletal muscle health.
METHODS: For the NfL analysis, we recruited 300 adults aged between 50-83 years (mean age: 64.1 years; 50% female). Body composition was assessed using dual-energy x-ray absorptiometry (DXA), and a skeletal muscle index (SMI) was calculated. Grip strength was assessed with hand dynamometry. Sarcopenia was classified using the European Working Group on Sarcopenia in Older People criteria. Plasma NfL concentration was determined using a highly sensitive ELISA. For the genomic analysis, we performed a GWAS of lean mass, appendicular lean mass (arms and legs) and grip strength using WGS data from 6715 participants aged between 18-83 years (mean age: 44.8 years; 55% female). Body composition and grip strength were also determined using DXA and hand dynamometry respectively.
RESULTS: NfL levels were associated with grip strength and SMI ($p=0.005$, $p=0.045$, respectively) and were significantly elevated in sarcopenic individuals compared to non-sarcopenia participants ($p<0.001$). Overall, individuals with pre-sarcopenia (low grip strength or low SMI) had significantly higher NfL levels, compared to controls ($p=0.001$, $p=0.006$, respectively), although sex-specific differences were observed. NfL concentration demonstrated acceptable diagnostic accuracy for sarcopenia (area under curve=0.726, $p<0.001$). The GWAS revealed genes involved in neuromuscular transmission and neuronal integrity to be linked with skeletal muscle phenotypes relevant to sarcopenia.
CONCLUSION: Together, our findings support the relevance of neural processes to skeletal muscle regulation. Firstly, the associations reported between circulating NfL levels and sarcopenia status demonstrate the link between degrading axonal integrity and sarcopenia. Secondly, the candidate genes identified using WGS further support the pertinence of neural pathways in maintaining skeletal muscle health.

## OP-AP13 Training monitoring

### TRACKING FATIGUE WITH SUBJECTIVE SCALES IN SOCCER REFEREES

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INTRODUCTION: Fatigue can have a negative impact on performance, especially when it is not adequately monitored and there is not an appropriate workload to rest ratio [1]. This could result in non-functional overreaching and overtraining not only in players, but also in referees. Therefore, the aim of this study was to investigate the relationship between Hooper index (HI) taken before training session and rate of perceived exertion (RPE) after a submaximal standardized warm-up in soccer referees.
METHODS: After providing their written consent to participate in the study, 23 male referees from the Italian 4th and 5th divisions were followed during two months' soccer pre-season for a total of 244 training sessions. On average, each referee performed 11 trainings (min = 5; max = 24) with a standardized 10-min running warm-up (%heart rate max = 66±9%). Before all training sessions HI was administered [2], while at the end of the warm-up RPE was measured using the Borg category-ratio-10 scale. Intraclass correlation (ICC) was used to assess the internal consistency of the HI and RPE across the first five repeated standard warm-up sessions. High α coefficient (≥0.60) suggests good internal consistency and reliability. Relationship between HI and RPE responses were analyzed via linear mixed model (LMM) using HI and RPE as fixed effects, while the subjects' individual warm-up response as random effects. R-squared (R2) was calculated and Likelihood-ratio test was used to compare the LMM with the linear regression analysis. Significance level was set at 0.05.
RESULTS: The ICC of HI and RPE across the first five repeated training sessions were 0.80 and 0.69, respectively, thus demonstrating good internal consistency. LMM ($p<0.0001$; Wald $chi2=206.62$; $R2=0.48$) had an estimated standard deviation for the random intercepts of 1.61AU (95%CI: 1.18-2.21) with standard error of 0.26. Likelihood-ratio test showed that LMM offered a significant ($Chi2:132.59$; $p<0.0001$) improvement over a linear regression, meaning the intercepts were significantly different between subjects. The relationship between RPE and HI, combining the fixed and random intercepts, can be expressed with the following equation: $HI = 7.080777 + 1.336215*RPE + U0j + \varepsilon i$
CONCLUSION: Results from this study demonstrate that HI and RPE values are directly proportional during a standardized submaximal warm-up in soccer referees. This could indicate that HI and RPE could be valid and practical tools to investigate non-functional fatigue during submaximal warm-ups. Findings from the present study can be used to tailor the workload during period of training and conditioning to avoid non-functional overreaching or overtraining.
REFERENCES:
1. Haddad M et al (2013). Influence of fatigue, stress, muscle soreness and sleep on perceived exertion during submaximal effort. Physiology & Behavior, 119, 185-189
2. Hooper SL & Mackinnon LT (1995). Monitoring overtraining in athletes. Sports Medicine, 20(5), 321-327

### VALIDITY AND RELIABILITY OF FACIAL RATING OF PERCEIVED EXERTION SCALES FOR TRAINING LOAD MONITORING

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INTRODUCTION: Rating of perceived exertion (RPE) is often used by coaches and athletes to indicate exercise intensity, which facilitates training load monitoring and prescription. Although RPE is typically measured using the Borg Category-Ratio 10-point scale (CR10), digital sports platforms have recently started to incorporate facial RPE scales, which potentially have a better user experience. The aim of this study was to evaluate the validity and reliability of a 5-point facial RPE scale (FCR5) and a 10-point facial RPE scale (FCR10), using the CR10 as a golden standard and to assess their use for training load monitoring.
METHODS: Forty-nine participants (17 untrained, 19 recreationally-trained and 13 trained) completed nine randomly ordered home-based workouts (three intensities × three RPE scales) on the Fitchannel.com platform. Heart rate was monitored throughout the workouts. Participants performed three additional workouts to assess reliability.
RESULTS: Validity and reliability of both facial RPE-scales were low in untrained participants. In (recreationally) trained participants, validity was moderate for FCR5 and good for FCR10 and reliability was rather poor for FCR5 and moderate for FCR10. Reliability was excellent for CR10. In (recreationally) trained participants, session RPE scores were also strongly related to Edward's training impulse scores ($r\geq0.70$, $P<0.001$). User experience was best supported by the FCR10 scale.
CONCLUSION: In conclusion, researchers, coaches and digital sports platforms are encouraged to incorporate the valid and reliable FCR10 and not FCR5 to assess perceived exertion and internal training load of recreationally-trained and trained individuals.

### INJURY RISK CONTROL IN WOMENS ARTISTIC GYMNASTICS THROUGH THE SESSION-RPE METHOD

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INTRODUCTION: Nowadays, injuries are one of the most common reasons why athletes have a break in their sports career or end it. The appearance of these injuries is often related to stress or fatigue of the athlete. That is why the control of several variables can help to reduce their appearance. One of the most studied methods to monitor the internal training load is the session-RPE method (sRPE). Depending on the measurement of the internal load, certain calculations can be obtained to help control the risk of injury to our athletes. The most used indices are the ratio between chronic and acute workload (ACWR) (Hulin et al., 2016), training monotony (Tm), and training stress (Ts) (Foster, 1998). Womens artistic gymnastics is considered a demanding sport, and with a high injury rate, proportional to the level of performance of the gymnasts. Therefore, the aim of the present study was to assess the risk of injury in womens artistic gymnastics through the monitoring of the internal load, by means of the sRPE method.
METHODS: From the sRPE, we determined the indices to perform the injury risk control. A total of ten national top-level competitive gymnasts (age: 14.4 ± 2.9 years; height: 1.5 ± 0.1 m; mass: 43.3 ± 12.2 kg) participated in the study. The subjective perception of exertion (SPE) of each gymnast was recorded at a daily basis during four weeks after the end of each training block.

RESULTS: The results obtained from the ACWR index showed that all gymnasts had a moderate risk of injury (ACWR>1.0). In addition, the results of the Tm index showed values between 6.8 and 12.8, increasing in the last weeks of training, the same happened with the Ts index. Gymnasts have a higher risk of injury in the last weeks of training, in which the values of the Tm, and Ts index increase.
CONCLUSION: Our results seem to be in relation with previous studies, in which it is determined that high values of monotony and tension, together with high training loads, increase the risk of injury (Foster, 1998; Delecroix et al., 2019). These findings show that the indexes presented can directly help to establish a quantification of the risk of injury.
REFERENCES:
Delecroix, B., Mccall, A., Dawson, B., Berthoin, S., & Dupont, G. (2019). Workload monotony, strain and non-contact injury incidence in professional football players. Science & Medicine in Football, 3(2), 105–108. http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=136271114&lang=es&site=ehost-live&scope=site
Foster, C. (1998). Monitoring training in athletes with reference to overtraining syndrome. Medicine and Science in Sports and Exercise, 30(7), 1164–1168. https://doi.org/10.1097/00005768-199807000-00023
Hulin, B. T., Gabbett, T. J., Lawson, D. W., Caputi, P., & Sampson, J. A. (2016). The acute: Chronic workload ratio predicts injury: High chronic workload may decrease injury risk in elite rugby league players. In British Journal of Sports Medicine (Vol. 50, Issue 4, pp. 231–236). BMJ Publishing Group. https://doi.org/10.1136

### RELATIONSHIP BETWEEN INTERNAL AND EXTERNAL TRAINING LOAD VARIABLES IN ELITE TEAM HANDBALL

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INTRODUCTION: Monitoring and managing training load contributes to achieve desired training outcomes. Training load measured independently of internal characteristics is termed external load (e.g. distance, accelerations), while internal load reflects the individual physiological and biomechanical responses to the external load (1). Information about the relationship between internal and external training load has the potential to enhance training prescription and athlete management through a more detailed assessment of training efficacy. In this study we aimed to model the within- and between-player effects of different external load variables on the internal load variable session Rating of Perceived Exertion (sRPE) in elite team handbal
METHODS: Fifteen female team handball players from a team in the Norwegian Premier League were included. We included data from 24 on-field sessions from the in-season period. External load was measured via a tracking-device (Catapult ClearSky T6, Catapult Sports, Australia), which includes a local positioning system and an inertial measurement unit. The variables PlayerLoad™, PlayerLoad2D™, total distance, high speed running distance, very high speed running distance, and high intensity events were used. Players reported their sRPE via an online questionnaire, using a modified Borg CR-10 scale. sRPE was multiplied with session-duration to get sRPE training load (sRPE-TL). Data were analyzed using a linear mixed-effects model, where the external load variables were treated as predictor variables, with separate models for each predictor variable. Player-ID and session-ID were random effects in the models.
RESULTS: The mean±SD sRPE-TL was 425±170 a.u. All external training load variables showed a significant within-player effect on sRPE-TL, where a 2 SD change in external load produced a 17-37% change in sRPE-TL. PlayerLoad™ (Effects size [ES]:1.38), PlayerLoad2D™ (ES:1.24), and total distance (ES:1.19) had the largest effects. None of the external load variables showed a significant between-player effect. The models showed ESs from 0.28 to 0.50 for individual responses (random effect for Player-ID).
CONCLUSION: Our results show that sRPE-TL can differentiate between sessions with differing external load within individual players. sRPE is shown to be closely related to certain external load variables, in agreement with studies from other team sports (2). In contrast to previous research, no between-player effects were found, meaning that players with a typical high or low external load do not differ in their sRPE-TL response to the same external load. However, the individual response effects underline the need for an individual approach to load monitoring. These results contribute to the understanding of the dose-response relationship in handball training for female players.
1 Impellizzeri et.al.(2019). Internal and External Training Load: 15 Years On. IJSPP
2 Wiig et.al.(2020) Individual Response to External Training Load in Elite Football Players. IJSPP

### ON-COURT DRILLS IN ELITE BADMINTON PLAYERS - IMPACT OF INTERVAL LENGTH ON INTERNAL AND EXTERNAL LOAD

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INTRODUCTION: Typical on-court drills aim at different training goals, since the protocol (e. g. number and duration of intervals) has an impact on physiological, physical and performance outcomes. However, due to a lack of evidence regarding individual loads, protocols are prescribed solely following experts' opinion. The aim of the present study was to clarify the impact of drill prescription on loads and technical skill performance in elite badminton.
METHODS: On three experimental days thirteen German professional players (Ten male: 22.2 ± 3.3 years, 180 ± 6 cm, 72.2 ± 6.1 kg; Three female: 20.3 ± 2.5 years, 167 ± 5 cm, 57.7 ± 4.6 kg) completed three different sessions of the so-called "multifeeding drill" in a counterbalanced order (one coach feeds shuttlecocks in randomized direction to one player). The protocols varied in interval duration (10s, 30s and 50s) but were matched for the rally-to-rest-ratio (1:1) and playing time (30min). Cardiorespiratory responses (Portable Spirometry; cortex medical), energy metabolism (Blood Lactate, LA), player´s kinematics (Local Positioning System; kinexon), and technical skill performance (Video Analysis) were measured.
RESULTS: Mean and peak values of heart rate (averagely 160 ± 10 bpm and 179 ± 8 bpm), oxygen consumption (45.0 ± 8.0 ml/min·kg and 72.4 ± 10.6 ml/min·kg), respiratory exchange ratio (0.91 ± 0.04 and 1.15 ± 0.01) and total aerobic energy expenditure (917 ± 210 kcal) did not differ between the protocols. LA was significantly lower in the 10s (3.3 ± 0.9 mmol/l) and similar in the 30s and 50s protocols (5.5 ± 0.8 mmol/l and 6.0 ± 1.0 mmol/l). Striking frequencies (0.59 ± 0.06, 0.60 ± 0.04, 0.59 ± 0.06 shots per second), number of jumps (83 ± 44, 84 ± 36, 80 ± 45) and unforced hitting errors (13 ± 8 %, 17 ± 5 %, 16 ± 3%) did not differ. Overall larger distances were covered during 30min of the 10s protocol, compared to the 30s and the 50s protocol (1579 ± 582 m, 1329 ± 389 m, and 1106 ± 225 m). The average peak accelerations were comparable for the three protocols (3.5 ± 0.7 m/s^2, 3.3 ± 0.5 m/s^2, 3.4 ± 0.9 m/s^2).
CONCLUSION: External loads and technical skill performance are largely similar despite a different interval length and higher anaerobic metabolic loads in the 30s and 50s protocol. Apparently, players can tolerate the higher interval duration to a large extent probably by implementing pacing strategies since the 50s did not lead to higher LA compared to the 30s protocol. As striking frequencies remained equal while players covered less distances in 50s, the coach might feed the shuttlecock easier to reach. From a metabolic point of view the

10s intervals preferably reflect the mean badminton match play requirements. Extending the intervals beyond 30s cannot be recommended for anaerobic training since the metabolic stimulus remains constant.

## Oral presentations

### OP-AP07 Acute response to strength training

#### TIME COURSE OF RECOVERY FOLLOWING WORK-MATCHED STRENGTH-ORIENTED- VERSUS POWER-ORIENTED RESISTANCE EXERCISE BOUTS

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INTRODUCTION: The recovery process is a key aspect for athletes to regain full performance capacity and optimize adaptations. Resistance exercise with high-loads seems to require longer recovery times than lower-load power bouts when volume- or the concentric work is matched (1, 2). However, previous studies have not controlled for the eccentric work. Hence, the aim of this study was to compare the recovery of a strength- versus a power-oriented bout with equal concentric and eccentric work.
METHODS: Nine strength-trained male (n=6) and female (n=3) participants (age: 24¬±2 years, height: 175±8 cm, body weight: 78±13 kg) completed two randomized counterbalanced-crossover training bouts using the smith-machine squat (1RM: 137±27 kg). One strength-oriented (SO: 4 sets x 5 reps at 80% 1RM) and one power-oriented (PO: 6 sets x 5 reps at 40% of body weight [equated ~20-25% 1RM]) session was performed, both with 3-min rest-intervals between sets. Maximal voluntary isometric squat strength (MVC), countermovement jump (CMJ) height and power as well as subjective perceived recovery score was rated prior to, immediately after, 24h- and 48-h after training. Rate of perceived exertion (RPE) was rated immediately after training. A repeated-measure ANOVA with paired-post-hoc tests were conducted for the statistical analysis.
RESULTS: Greater strength loss was observed in the strength-oriented- compared to the power-oriented group (interaction, F=4.23, p=0.010) after training (SO: -9.5% [95% CI: -13.0, -6.1]; PO: -2.6 [-4.7, -0.6]) that was still lower at 24h (SO: -6.7% [-10.7, -2.6], PO: 0.7% [-2.5, 3.8]). CMJ average power decreased more after training in the strength-oriented group (-5.3% [-8.0, -2.7]; PO: -2.2 [-5.2, 0.8]). With no group differences, both groups decreased CMJ height (SO: -11.9% [-17.5, -6.3]; PO: -8.8% [-12.7, -4.9]), and there was a tendency for the strength-oriented group to not be fully recovered at 24h (-5.6% [-11.4, 0.2]). Ratings of perceived recovery was rated lower in the strength-oriented group (interaction, F=4.96, p=0.013), with 2.1-point [0.4, 3.8] lower ratings in the strength-oriented group at 24h. RPE was rated 4.2-points [3.1, 5.4] higher after the strength- versus the power-oriented bout.
CONCLUSION: The strength-oriented bout acutely elicited a more pronounced training stress with greater strength and power loss, higher perceived exertion, in addition to slower strength recovery up to 24h after training and lower overall ratings of perceived recovery, compared to the power-oriented bout. No group-differences were observed in CMJ performance at the 24- and 48h time point; however, this may be due to low statistical power combined with relatively lower sensitivity of the CMJ measurements. More research is needed to provide greater insight into the topic.
1. Helland C, Midttun M, Saeland F, Haugvad L, Olstad DS, et al. 2020. PeerJ.
2. McCaulley GO, McBride JM, Cormie P, Hudson MB, Nuzzo JL, et al. 2008. Eur J Appl Physiol.

#### ACUTE RESPONSES TO DIFFERENT BLOOD FLOW RESTRICTION-RESISTANCE EXERCISE PROTOCOLS DIFFERING IN THE REST TIME BETWEEN REPETITIONS

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INTRODUCTION: Blood flow restriction resistance exercise (BFR-RE) has been shown to induce marked hypertrophic responses and acute metabolic signalling (1,2). On the other hand, the cluster set method (short rest times between repetitions) allows athletes to achieve greater strength, velocity and power in each repetition and lower metabolic stress with respect to traditional training (3,4). However, it remains unknown whether the use of this cluster method in BFR-RE could influence the effects induced by this methodology. Therefore, the aim of this study was to analyze the acute responses to two different BFR-RE protocols that differed in the rest-time between repetitions in the full-squat (SQ) exercise.
METHODS: Twenty resistance-trained young men performed two BFR-RE protocols in the SQ exercise which consisted of 3 sets of 8 repetitions at maximal intended velocity against the 60% 1RM with 2-min rest between sets and a 50% of individual arterial occlusion pressure, but differed in the rest time between repetitions: 30-s rest every 2 repetitions (BFR-Cluster) or traditional repetitions (BFR-Trad). The occlusion was maintained during the entire training session and all repetitions were recorded with a linear velocity transducer and a force platform. In order to analyze the acute responses to these BFR-RE protocols, blood lactate concentration, countermovement jump (CMJ) height, maximal isometric force (MIF) and maximal rate of force development (RFDmax) during a maximal isometric SQ contraction, as well as mean propulsive values of velocity, power and force (MPV, MPP, MPF) against the 60% 1RM load were assessed at Pre- and Post- protocols, in this order. Moreover, MPV, MPP, MPF, percentage of velocity loss (VL) in the set were evaluated in each resistance exercise protocol (average of 24 repetitions) to observe the descriptive characteristics.
RESULTS: Significant “protocol x time” interactions ($p<0.05$) and significant “time” effects ($p<0.05$) were found for lactate concentration and CMJ height. On the other hand, no significant “protocol x time” interactions ($p>0.05$) were found for the rest of the variables analyzed. However, significant “time” effects ($p<.001$) were observed for all parameters. Both protocols showed significant ($P<0.001$) increases in blood lactate and decreases in CMJ height with higher impairments for BFR-Trad ($p<0.05$). Moreover, both protocols resulted in significant ($p<0.01$) decreases in MIF, RFDmax, MPV, MPP, and MPF, these decreases were significantly ($p<0.05$) higher in BFR-Trad in MPV, MPP, MPF. On the other hand, BFR-Cluster resulted in significantly ($p<0.001$) higher values of MPF, MPV, MPP and lower %VL in the training session compared to BFR-Trad.

CONCLUSION: Despite both protocols performed SQ exercise under the same conditions (volume, intensity, rest time between sets and occlusion), the rest time between repetitions with BFR proved to be a tool to induce a lower decrease in mechanical responses and a lower increase in metabolic response even in BFR-RE settings.

### TRAINING BACKGROUND AFFECTS TIME COURSE OF NEUROMUSCULAR FATIGUE DURING POWER AND HYPERTROPHIC LOADING PROTOCOLS

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INTRODUCTION: Persons with different training backgrounds have specific long-term training adaptations, which may also lead to dissimilar progression of neuromuscular fatigue and strategies to compensate for fatigue during resistance exercises. This study aimed to examine the time course of neuromuscular fatigue during three different resistance exercise loadings, and whether it is affected by the training background.
METHODS: Power athletes (PA, n=8), strength athletes (SA, n=8) and nonathletes (NA, n=7) performed power (PL, 7x6x50% of 1-RM), maximal strength (MSL, 7x3x3-RM) and hypertrophic (HL, 5x10x10-RM) loadings in Smith-machine back-squat. Average power (AP), sEMG amplitude (sEMGRMS) and sEMG mean power frequency (sEMGMPF) were measured during the concentric phases of selected repetitions during all loading sets. For PL and HL, the values of averaged 1st and 2nd repetition (REPIN) were used to represent the first repetition of sets. Blood lactate concentrations (BL) were collected before (PRE) and immediately after (POST) the loadings.
RESULTS: Significantly greater 1-RM and AP at a load of 50% of 1-RM were observed in both PA (144.6 ± 24.2 kg and 664.2 ± 136.6 W) and SA (176.8 ± 31.0 kg and 729.8 ± 112.0 W) compared to NA (106.4 ± 19.8 kg and 450.8 ± 94.9 W) ($p \leq 0.05$). During PL, there was a significantly greater absolute decrease in AP from REPIN of SET1 to the REPs of SET7 in NA (-4.6%) compared to PA (+0.1%) and SA (+4.4%) ($p \leq 0.05$). During MSL, no significant differences were found between groups in any variable. During HL, significantly greater absolute decreases in AP were observed within SET1 and SET5 and from REPIN of SET1 and SET3 to the REPs of SET5 in PA and SA compared to NA ($p < 0.005$). During HL, a significant group×repetition interaction occurred also from REPIN of SET3 to the REPs of SET5 in relative sEMGMPF but the post hoc test did not indicate significant differences between groups. The greatest decreases in absolute AP and relative sEMGMPF and increase in relative sEMGRMS were observed during MSL and HL in all groups. Significant increases in BL from PRE to POST were observed in all groups during all loadings.
CONCLUSION: Training background seemed to affect the progression of neuromuscular fatigue during PL and HL. During PL, the athletes maintained their higher AP levels throughout the loading, which could be due to the changes in the neural activation strategies, but this can not be confirmed by the data of the present study. During HL, the athletes demonstrated clearer absolute decreases in AP, and the training groups may have also demonstrated slightly different strategies to compensate for accumulating fatigue. For instance, within SET1, the increase in sEMGRMS with the concurrent decrease in sEMGMPF was observed in NA, whereas in SA and PA only decreases in sEMGMPF were observed. However, the training background seemed to have a limited effect on neuromuscular fatigue during MSL.

### ACUTE EFFECTS OF SEPARATE UPPER OR LOWER BODY COMPARED TO WHOLE BODY STRENGTH LOADING ON EXPLOSIVE STRENGTH PERFORMANCE

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INTRODUCTION: We have previously shown that not lower body endurance loading alone, but combined lower body endurance and lower body resistance loading induces an acute reduction in upper body explosive strength.1 Whether this reduction is due to the impact of the strength loading or the duration of the combined loading remains unknown. Therefore, it is of particular interest whether an acute strength loading does not only affect the explosive strength in the previously exercised extremity, but also in non-exercised muscles. Thus, the aim of this study was to examine the acute effect of lower and upper body maximal strength loading on upper and lower body explosive strength.
METHODS: Preliminary data of 7 physically active men (age: 24±3, 1RM squat: 120±17 kg, 1RM bench press: 91±12 kg) completed 2 strength training sessions consisting of combined lower (i.e. squat) and upper (i.e. bench press) body maximal strength loading (3×5 followed by 3×3 repetitions at 80% 1RM, for both exercises) was analysed. The session started with either squat (SQ+BP) or bench press loading (BP+SQ). Squat and bench press mean propulsive velocity (MPV) was assessed during the loading as well as in a separate explosive strength assessment (3 repetitions with 60% 1RM) prior to the first loading (T0) and immediately after the first (T1) and the second loading (T2).
RESULTS: No between-condition difference in MPV during the BP and SQ was observed ($p > .05$). Bench press MPV at T1 was only statistically reduced in BP+SQ (BP+SQ: -13.6±9.3%, $p < .001$ and SQ+BP: -5.1±5.6%, $p = .282$), while squat MPV was statistically reduced at T1 in both sessions (SQ+BP: -10.2±4.4%, $p < .001$ and BP+SQ: -7.1±4.0%, $p = .007$). No further decrease was observed between T1 and T2 in both bench press (SQ+BP: -9.7±12.9%, $p = .237$ and BP+SQ: +3.7±17.0%, $p = 1.000$) and squat (SQ+BP: +1.0±6.6%, $p = 1.000$ and BP+SQ: -1.8±14.0%, $p = 1.000$). The decreased bench press MPV at T2 was statistically significant in both sessions (SQ+BP: -14.4±13.4%, $p = .011$ and BP+SQ: -11.5±7.2%, $p = .038$), while squat MPV at T2 only decreased in SQ+BP (SQ+BP: -9.4±5.4%, $p = .033$ and BP+SQ: -8.5±10.3%, $p = .066$).
CONCLUSION: Our preliminary data indicate that upper body high-intensity muscle contractions impair both upper and lower body explosive strength performance, while lower body strength loading does not induce fatigue in the upper body. Whether the reduction in lower body explosive strength after preceding upper body strength loading is due to central or systemic factors remains to be investigated. However, practitioners should be aware of a reduced lower body movement velocity after a preceding upper body maximal strength loading.
References
1. Dragutinovic B, Feuerbacher JF, Jacobs MW, Bloch W, Schumann M. Acute Effects of Concurrent High-Intensity Interval Cycling and Bench Press Loading on Upper and Lower-Body Explosive Strength Performance. International journal of sports physiology and performance. in press.

**VELOCITY-BASED TRAINING RESULTS IN LESS ACUTE FATIGUING EFFECTS ON JUMP AND SPRINT PERFORMANCE COMPARED TO FAILURE-BASED RESISTANCE TRAINING: A RANDOMIZED CONTROLLED CROSSOVER TRIAL**

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INTRODUCTION: Professional team sport is characterized by the interchange of short high-intensity activities and longer low-intensity periods. Strength, power and speed are considered key determinants of success in team sports (Bragazzi et al., 2020; Faude et al., 2013; Suchomel et al., 2016; Yáñez-García et al., 2019). However, the high density of competitions makes the integration of resistance training (RT) very difficult. Due to the short time between competition games and due to the high amount of team training sessions, strength training sessions are therefore often placed in the preparation phase to prepare players for the upcoming demands during the season (Silva et al., 2015). If no further or only insufficient RT sessions are offered after the preparation phase, the performance level will gradually drop again during the course of the season and the risk of injuries increases. This randomized controlled crossover trial investigated whether an acute difference exists between velocity-based RT with maximal10% velocity loss (VL10) and traditional 1RM-based RT to repetition failure (TRF) on jumping and sprinting performance immediately following (POST0) and 24h post (POST24) RT.
METHODS: 15 recreational team sport athletes (23.1±3.5 yr; 1.80±0.06 m; 79.1±7.9 kg , Squat (SQ): 114,8±24,5 kg; Hip-Thrust (HT): 171,1 ± 26 kg) were investigated in this study. The participants could be classified as highly advanced resistance trained males. The subjects completed a load and volume matched VL10 and TRF, in a randomized order with 7 days break in between. Repeated sprint (5x15m), countermovement jump (CMJ) and drop jump (DJ) were measured pre, immediately post and 24h post both RT sessions. Further, heart rate (HR) and lactate were analyzed during the RT sessions.
RESULTS: Statistics revealed significant time*mode interaction effects for CMJ, DJ and 5x15m (rANOVA p≤ 0.001; ηp2≥0.63). Instantly post RT, sprint, DJ and CMJ were less negatively affected (p≤0.03; SMD≥|0.40|) by VL10 vs. TRF. Sprint and CMJ were already recovered 24h post RT and showed no significant differences between TRF and VL10 (p≥0.07; SMD≤|0.21|). At 24h post RT, DJ was still reduced during TRF, but already recovered during VL10 (p=0.01; SMD=|0.70|). TRF resulted in higher lactate, heart rate, and perceived effort compared to VL10 (p≤0.019; ηp2≥0.27; SMD≥|0.68|).
CONCLUSION: Compared to TRF, VL10 seems to be a less demanding RT method and therefore a promising alternative for team sport athletes during in-season training. Future research should focus on implemented VL10 during the regular season in high-level team sport athletes.

## Oral presentations

### OP-BM07 Biomechanics and jumping I

**CONCURRENT VALIDITY OF ISOKINETIC LEG PRESS AGAINST SQUAT JUMP POWER-FORCE-VELOCITY PROFILES**

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Power-force-velocity profiles expose the sports performance parameters maximum force (F0), speed (v0), power (Pmax), and slope of the F-v relationship (SFV)1. However, unless cohorts are highly jump-experienced3, recent research reports a lack in P-F-v parameter reliability2. Coordinatively less demanding, better standardizeable leg press P-F-v profiles alleviate reproducibility challenges3, but poor agreements to the functional and likely external more valid jump profile raise the question of its suitability as a substitute measure. Here, we compared the performances of vertical squat jump and horizontal leg press P-F-v profile outcomes for the first time in a cohort where all derived parameters can be recorded reliably3.
METHODS: Thirteen male ski jumpers performed a squat jump test on a force plate (CTP Contemplas) followed by an isokinetic leg press test (IsoMed, D&R Ferstl), separated by 20 min. The tests consisted of jumps of five loads from 0% to 80% of body mass or bilateral leg extensions at 0.1, 0.3, 0.7, and 1.2 m·s-1 (ROM: 80° - 130°). Concurrent validity of F0, v0, Pmax, and SFV was obtained using regression validity analysis4 including proportional bias assessments5.
RESULTS: The squat jump (r2≥.96) and the leg press profiles (r2≥.96) revealed highly linear force-velocity relationships. However, the leg press F-v slope was steeper than the squat jump slope, and the F-v parameters did not correlate (F0: r=.48; v0: r=.22; Pmax: r=.69; SFV: r=-.26). F0 was higher in leg press than squat jump P-F-v tests (p<.001), whereas v0 was lower in leg press than squat jump P-F-v tests (p<.001). Significant proportional bias was found for F0: p<.001 and Pmax: p<.001. The typical error in the estimate was for F0: 2.01 N·kg-1, v0: 0.30 m·s-1, Pmax: 1.75 W·kg-1, and for SFV: 0.35 N·s·m·-1·kg-1.
CONCLUSION: Although squat jump and leg press P-F-v profiles revealed linear relationships, they caused different estimations of F0, v0, Pmax and SFV. Hence, multijoint tasks of the lower limb might be coordinatively too complex to be amenable to a single holistic P-F-v assessment. These discrepancies might be explained by biomechanical (e.g. acceleration phases, joint motions and force distributions, punctum fixum – punctum mobile) or neuronal factors and influence F0 and Pmax outcomes depending on performance. The outcomes can differ substantially between approaches as shown by the typical error.
References
1. Morin et al., Int J Sports Physiol Perform 2016
2. Lindberg et al., PLOS ONE 2021
3. Fessl et al., Int J Sports Physiol Perform 2022
4. Hopkins et al., Sport Sci 2010
5. Statistical Consulting Group. https://stats.oarc.ucla.edu/spss/faq/how-can-i-compare-regression-coefficients-between-two-groups/ (03-29-2022)

### SINGLE LEG SQUAT TEST REVEALS WHAT DROP JUMP TEST MISSES, DYNAMIC VALGUS TENDENCY EXAMINATION WITH ARTIFICIAL INTELLIGENCE IN ADOLESCENT SOCCER PLAYERS

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INTRODUCTION: The major part of knee injuries and ACL ruptures in sports occurs in dynamic knee valgus position, which means that the knee tilts to the medial side of the body. Usually, this position appears at the landing phase of the jump, during quick direction shift, jumping and squatting. As a consequence of valgus stress the ligaments of the knee are overloaded and overstretched, furthermore above-threshold stimulus they would be ruptured. Movement pattern screening tests can prevent the injury, as revealing the malalignment in the athletes' movement. Instead of FMS and LESS tests the Microsoft Kinect Azure camera can define accurately the major joint of human body and report the movement of lower-limb segments. The Single Leg Squat (SLS), Single Leg Jump (SLJ) and Drop Jump (DJ) as movement pattern screening tests can provide multifunctional feedback about the current status of the athletes.
METHODS: Twelve (Group A; 14.08±0.99 y, 58.91±8.08 kg, 172 ± 9.05 cm) and ten (Group B; 14.7 ± 0.82 y; 61.8 ± 9.28, 174.3 ± 7.31) healthy adolescent soccer players were involved in this study. Group A previously received some special lower-limb corrective exercise on their strength training. However, Group B received traditional strength training exercises. Lower limb performances were examined with Kinect Azure camera during SLS, SLJ and DJ tests. Test results were compared to each other. The knee lateral-medial movement was examined in relation to hip-ankle frontal plane line. The positive numbers mean varus direction, meanwhile the negative numbers mean valgus direction movement.
RESULTS: Average knee positions during SLS; Group A: 0.35±1.32 cm (R) and 0.54±1.18 cm (L), Group B: 0.85±1.19 cm (R) and 0.34±1.1 cm (L). SLJ; Gr A: 1.09±11.27 cm (R) and 1.18±1.45 cm (L), Gr B: 0.58±1.12 cm (R) and 0.72±1.21 cm (L). DJ; Gr A: 4.63±1.53 cm (R) and 5.86±1.77 cm (L), Gr B. 4.26±1.11 cm (R) and 5.03±1.32 cm (L). The differences between group A and B were significant in each case. Based on the Pearson correlation coefficient strong correlation has been found between SLS and SLJ test (r=0.832). However, between SLS and DJ (r=0.296) and SLJ and DJ (r=0.248) weak correlation has been found.
CONCLUSION: It seems that the SLS, SLJ and DJ tests are suitable for dynamic knee valgus screening. Group A showed significantly better results on each movement tests compare to Group B, where no specific lower-limb corrective exercises have given. There was a strong correlation between single leg tasks (SLS-SLJ), however there is no or just weak correlation between single leg tasks (SLS-SLJ) and drop jump test. To conclude beside DJ and LESS test, single leg exercises are recommended when examining athletes' performance. Kinect camera could be a simple, quick and reliable tool for measuring the athlete's current lower limb status.

### ONE-LEGGED VERTICAL JUMP PERFORMANCE IN FEMALE VETERAN VOLLEYBALL PLAYERS IS NOT FACILITATED BY ONE-LEG BALANCE

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INTRODUCTION: It has been shown that the power-velocity potential is a mechanism contributing to vertical jump performance during two-legged counter-movement jumps (CMJ) (1). It can be argued that during one-legged CMJs where the center of mass' (CoM) base of support is reduced, a higher postural balance control would be required. This study aimed at investigating the effect of one-leg balance in the ensuing one-legged vertical jump performance of female veteran volleyball players (VVP). We hypothesized that a higher one-leg balance would facilitate a more vertical displacement of the CoM, thereby creating more favourable force and power conditions of lower leg musculature during jumping.
METHODS: Twenty seven active (ACT: 50±4 years) and 39 non-active (NACT: 51±5 years) female VVP participated in the assessment of one-leg balance during two quiet stance trials with eyes open and of 20 sec duration, while standing barefoot with either left or right leg on a vertical F/P (Wii Biovision, 1000Hz). They also performed two one-legged CMJs per leg and the best trial was chosen. The average of left and right leg in both balance and jump trials was used for analysis. Off-line, the center of pressure (CoP) data was analyzed (Δt=1-16 sec) and one-leg postural balance was determined by the CoP path length, while maximum power and jump height parameters were calculated. Multiple linear regression analyses were used to test if one-leg postural balance and group would be associated with one-legged vertical jump performance.
RESULTS: No significant (P>0.05) differences were found either in one-leg balance (ACT: 69±17, NACT: 75±18 cm) or maximum power (ACT: 17.2±2.2, NACT: 16.1±2.7 W/kg) and jump height (ACT: 3.7±1.4, NACT: 3.5±1.6 cm). Results from the regression analyses showed that a higher one-leg balance in either the ACT or NACT VVP was not significantly associated with a higher maximum power (F(3, 62): 0.99, P:0.405, R2: 0.046) or higher jump height (F(3, 62): 0.54, P:0.661, R2: 0.025).
CONCLUSION: Our results show that one-leg balance did not affect the VVP's ability to perform more efficiently in the one-legged vertical CMJ, thus not confirming our hypothesis. The challenged neuromuscular coordination within the muscle-tendon units of the lower extremities during CMJ (1) may limit the transfer of balance ability to jumping performance. Volleyball training consists of numerous jumps that are executed towards multiple directions and with frequent transitions from horizontal to vertical CoM displacement. These conditions seem to elicit task-specific adaptations in the neuromuscular control of vertical jump performance in female VVP that probably restrain the contribution of one-leg balance.
REFERENCES:
1) Nikolaidou et al., R Soc Open Sci, 2017

### BIOMECHANICAL DIFFERENCES OF GENERAL JUMPS AND VOLLEYBALL SPECIFIC JUMPS ON HARD FLOOR AND TWO SAND TYPES

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INTRODUCTION: Beachvolleyball is one of the most successful competitive sports in germany besides indoor. Even though kinematic and kinetic differences between indoor and sand condition for different jump types could be proven (1,2), the influence of sand type on those jumps and on injury potential is unknown (3,4). Hence, the aim of this study is to investigate biomechanical variables for the hard floor condition and two sand types differing in degree of hardness.
METHODS: 18 young elite volleyball players (1m/17w) were analyzed. Six different jump conditions including volleyball specific jumps (block, 3 spike forms) as well as standard jumps (CMJ with/without arms) were analyzed on the three grounds. Kinetics and kinematics

were acquired synchronously using insole plantar pressure measurements and IMU-based motion capturing. Kinetic variables include stance time, maximal force and rate of force development (RFD) at takeoff for each limb. Jump height and maximal force for the landing phase were calculated. Kinematic variables include maximal knee flexion angle at takeoff and landing as well as knee flexion at IC.
RESULTS: Kinematic and kinetic differences on the three grounds were not consistent between general and volleyball specific jump types. There was no difference of contact times in the general jumps between grounds, but the closing time in all three spike jump conditions was reduced by 10% in both sand conditions. Contact time of the leading leg didnt differ. The longer contact time of the providing leg goes along with a deeper knee flexion angle of about 15% which wasn't shown in the general jumps. Secondly RFD for both limbs was highest on the hard sand in the general jumps, but highest in hall for the spike jump conditions. Thirdly jump height reduced on the sand conditions in the general jumps by about 3 cm and in all spike jump conditions by about 10 cm. Fourthly players tended to land equally on both legs in the general jumps, but landed primarily on the providing leg after the spike jump on all the grounds. In all jumps maximal forces in the landing phase was highest on hard floor. In contrast in all jump conditions maximal force of the leading leg in the take-off phase was highest in the hard sand condition and lowest in the soft sand condition. Consequently, differences between sand type for take-off was highest.
CONCLUSION: Our results show that general jumps are limited to indicate kinetic and kinematic differences in spike jumps between the three grounds. Furthermore, it has been shown that sand type may have a great influence on maximal force and RFD, but not on knee flexion angle and flight time. Since high maximal forces and high RFDs in the take-off phase might be a risk factor for chronic knee pain in volleyball players (5), further studies should examine the influence of sand type on movement mechanics.
1. Tilp et al., 2008
2. Arianasab et al., 2016
3. Knobloch et al., 2008
4. Bahr et al., 2003
5. Richards et al., 1996

## Oral presentations

### OP-MH12 Metabolic fitness

#### INFLUENCE OF SLEEP QUALITY AND TIME ON FAT METABOLISM AND LEPTIN LEVELS IN PHYSICALLY ACTIVE YOUNG ADULTS

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INTRODUCTION: A lower fat oxidation at rest (BFox) is associated with a poorer quality of sleep [1]. Only one-night sleep restriction does not influence maximal fat oxidation (MFO) during exercise, but it remains unknown if this restriction maintained over time may affect MFO. The aim of the study was to observe the association between the sleep quality and duration, and the maximal fat oxidation during exercise and blood leptin concentrations in healthy adults.
METHODS: Eighty physically active participants (30 women) 18 to 40 years old were included in this study. Height was measured using height measuring instruments. To evaluate body composition (body weight, fat mass, and fat-free mass) a bioimpedance was used. Pittsburgh sleep quality index (PSQI) scale was used to assess the sleep quality. Indirect calorimetry at rest and during MFO exercise test was measured using the open-circuit gas analyzer (Jaeger MasterScreen). Fasting blood sample for leptin analysis was taken from the antecubital vein and analyzed using the MILLIPLEX® Map kit "Human Metabolic Hormone Magnetic Bead Panel Immunoassay". Simple linear regression models were conducted to examine the independent association of sleep quality with fat metabolism and plasma leptin concentrations. We also conducted multiple linear regression models to test these associations after adjusting by cofounders
RESULTS: We observed no association between sleep latency score and MFO (P>0.05) but we observed an inverse association after including sex and age in the model (all P<0.035). An inverse association was detected between sleep duration score with MFO (P=0.03) even when age was included in the model (P=0.022), but this association disappeared when sex, FMI and VO2max were included (P>0.076). We showed an inverse association between sleep latency with MFO relativized to the lean total mass (MFO-LTM) and leg lean mass (MFO-LLM) (P<0.012), even when the model includes cofounders (P< 0.048). MFO-LTM and MFO-LLM showed an inverse association with sleep duration score in unadjusted model (P<0.019), even when was adjusted by age (P<0.033), but it disappeared when sex, FMI and VO2max were included in the model (P>0.105). PSQI global score was negatively associated with MFO-LTM and MFO-LLM (P<0.041), also when were adjusted for age (P<0.043), but not when adjusted for sex, FMI and VO2max (P>0.138). A direct association was found between PSQI global score with leptin (P=0.037), even when age, sex and FMI were included in the model (P<0.028), but not when was included VO2max (P=0.234)
CONCLUSION: Results suggest that maximal fat oxidation during exercise could improve directly by the quality and quantity of sleep. In fact, it has been reported previously that insomnia or trouble sleeping is associated with obesity, which could be regulated by a reduction in leptin hormone, which suppresses appetite and increase fat oxidation.
[1] Jurado-Fasoli L, et al. Sci Rep. 2020 12;10(1):4598.
Grants: 1) PID2019-110063RA-I00. 2) PID2020-120034RA-I00. 3) LI19/2

#### ASSOCIATION BETWEEN INSULIN RESISTANCE AND FAT OXIDATION KINETICS IN HEALTHY YOUNG ADULTS

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INTRODUCTION: Despite the importance of the fat oxidation capacity in metabolic flexibility, which is usually impaired in obese people, and, therefore, its possible impact on insulin resistance, it is unknown how insulin resistance could affect the fat oxidation kinetics (FOK). Therefore, the aim of the present study was to investigate the relationship between insulin resistance and resting fat oxidation (RFO), maximal fat oxidation during exercise (MFO), FatMax (intensity at which MFO is observed) and FOK in apparently healthy young adults.

METHODS: 70 participants (n=26 females; 22.72 ± 4.41 years; Body Mass Index=25.81 ± 5.61 kg · m-2) were enrolled in this cross-sectional study. Fasting glucose and insulin were analyzed in plasma. Body composition was measured by bioimpedance. Different variables related to insulin resistance (HOMA1-IR, HOMA2-IR, HOMA2-%β, HOMA2-%S, HOMA-β and QUICKI) were calculated. RFO and MFO were determined by indirect calorimetry with a gas analyzer, using an incremental exercise protocol of 3-minute steps (15-30W) until RER=1.0 in a cycle ergometer for MFO. Then, after a 5-minute resting period, peak oxygen uptake (VO2peak) test with 1-minute steps (15-30W) was performed until exhaustion beginning at maximum watts of MFO test. A sinusoidal model was used to characterize FOK (dilatation, translation, and symmetry) and to determine the FatMax and MFO during exercise. Linear regression analyzes were performed.
RESULTS: HOMA2-IR was directly associated to MFO (p=0.010) and FatMax (p=0.020), even adjusting for age and sex, body fat or VO2peak in both (p<0.01 in all, p<0.02 in all, respectively). HOMA2-%β was positively associated to RFO (p=0.016), even adjusting for age and sex or VO2peak (p<0.015 in both), MFO only when was adjusted for body fat or VO2peak (p<0.015 in both), and FatMax only when was adjusted for VO2peak (p=0.046). HOMA2-%S was inversely associated to RFO (p=0.041), even adjusting for age and sex or VO2peak (p<0.05 in both), and MFO only when was adjusted for body fat or VO2peak (p<0.03 in both). QUICKI was inversely associated to MFO (p=0.043), even adjusting for body fat or VO2peak (p≤0.03 in both). No significant associations between insulin resistance and fat oxidation kinetics were found (p>0.05).
CONCLUSION: Insulin resistance is directly associated with RFO, MFO and FatMax. However, insulin resistance is not associated with fat oxidation kinetics during exercise. Thus, insulin resistance, due to the inability to use glucose as an energy source, could promote a higher peak of fat oxidation at rest and during aerobic exercise. In fact, due to resistance to this hormone, lipolysis is not inhibited, and this could increase the release of free fatty acids, which could favor fat oxidation. Nevertheless, future research is needed to clarify the association between insulin resistance and fat oxidation kinetics, comparing healthy people and patients with type 2 diabetes mellitus.

### GLYCOLYTIC BEHAVIOR AS A DETERMINING FACTOR IN OLDER FEMALES' MAXIMAL FAT OXIDATION

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INTRODUCTION: The capacity to oxidize fat (FATox) has an impact beyond the oxidative pathway because of its indirect role in lactate production due to the GPR81 action (1), and its association with metabolic flexibility (2). Moreover, recent studies confirm this condition also in chronic exposure to lactate (3). Since there is little knowledge about the metabolic behavior in older women, the present study aims to analyze the relevance of glycolytic behavior in two groups split by Maximal Fat Oxidation (MFO), which are of greater relevance in a population of women over 60.
METHODS: Twenty-four women (67.13±5.31yrs) performed a submaximal incremental cycling test (10W every 315) to the second ventilatory threshold, with gas analysis by indirect calorimetry. FATox and CHOox were calculated by applying the equations of Frayn (1983), with determination of the MFO and peak of CHO (CHOoxpeak). To identify the MFO groups, a neutral band of ±1 was determined about the median (5.01 g/min/kgFFM), being the low MFO group (<4 g/min/kgFFM) and the high MFO group (>6 g/min/kgFFM). Study approved by the scientific ethics committee of the University of Valencia (H105715353921).
RESULTS: Data showed significant between groups differences in Powerpeak (p<0.01), Minpeak (p<0.01) and BLapeak (p=0.01). Other variables such as rFATmax did not reach significance (p=0.14), as well as MinMFO (p=0.47), and CHOox values both at its peak point (p=0.21) and at MFO (p=0.27), showing non-existent differences with respect to the MFO groups.
CONCLUSION: Data confirms BLapeak between MFO-groups differences, despite lactate values were higher in the high-MFO group, unlike indicates the existing literature (3). Since our BLa outcomes were analyzed only post-test, we might assume that the low CHOox rates and power through the test, together with the final BLapeak, might reflect also low lactate outcomes at the MFO point in these women, as suggested by San Millan et al. (3). Moreover, recently a direct association with higher lactate values in those women who obtained a higher MFO was observed (2), indicating that those women who preserved the oxidative pathway, had better maintenance of the glycolytic pathway. Noteworthy, the biggest differences were found with respect to the Powerpeak, confirming the strong association between Powerpeak and fat oxidation in the preliminary phases of this study (2), similarly to the differences found in Minpeak where the highest MFO group is, in turn, the one that performed a longer test. Future studies should analyze the behavior at intensities closer to the maximum in this population to know if these differences are maintained or vary in these markers of interest as well as analyze the lactate behavior in MFO intensities.
References:
1. San-Millán & Brooks. Sports Medicine; (2017) 48(2), 467–479
2. Blasco-Lafarga, et al. Front Phy; (2022) 0, 657.
3. San-Millán, et al. (2022) Front Nutr 0, 197.
4. Frayn. J Appl Physiol Respir; (1983) 55(2), 628–634

### HIGHLY REDUCED ACTIVITY FOR 3 WEEKS IMPAIRS MOOD PROFILE WITHOUT AFFECTING KYNURENINE PATHWAY METABOLITES IN THE BLOOD OF HEALTHY YOUNG INDIVIDUALS

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INTRODUCTION: Low physical activity is one of the major health risk factors and it may also induce acute and long standing mood disturbances. Kynurenine pathway metabolites have been shown to associate with mood state and also respond to physical exercise. The aim of the present study was to reveal how plasma markers of kynurenine metabolism change in response to two 3-week phases of the intervention – severely limited activity followed by resumed activity plus additional physical exercise – in young healthy individuals.
METHODS: Twenty-four healthy individuals (7 females) aged 25.6 ± 5.6 years volunteered to 6 weeks of intervention. During the first 3 weeks, activity was highly reduced using only forearm crutches for ambulation with one leg suspended (INACT), The following 3 weeks consisted of resumed activity plus additional supervised training sessions (mix of resistance and high intensity interval training, 3 to 6 sessions per week; ACT). At baseline and after both INACT and ACT, blood was collected for subsequent UPLC-MS/MS analysis of eight kynurenine pathway metabolites (Tryptophan, L-kynurenine, KYNA, QUIN, 3HK, Picolinic acid, Niacin, 3-Hydroxy anthranilic acid). Questionnaires for activity (IPAQ), anxiety/depression (HADS) and profile of mood states (POMS, 65 items) were assessed at the same occasions. Activity was monitored with activity bracelets.

RESULTS: During INACT, activity was reduced ~7-fold on average (IPAQ score from 2200 to 300 MET min/week), and increased to ~4000 during ACT; average daily step count was ~1200 during INACT and ~7400 during ACT. During INACT, depression score on HADS scale tended to increase (3.3 to 5.5; p=0.067), while anxiety score did not change; however, HADS anxiety score was reduced with ACT compared to after INACT (p=0.01).
On POMS scale, depression (5.7 to 11.7; p=0.025), fatigue (4.8 to 9.5; p=0.001), confusion (4.8 to 7.0; p=0.029) increased, vigor decreased (18.7 to 15.9; p=0.045) and total mood disturbance (14.0 to 33.4; p=0.020) increased with INACT. Intriguingly, those subjects who developed mood disturbance with inactivity, were more active before the intervention according to their IPAQ report (p<0.05). All POMS scale scores fully restored to baseline with ACT.
None of the eight kynurenine pathway metabolites in the plasma changed significantly with either INACT or ACT. Some subjects developed depression according to HADS scale (mild – 1 case, moderate – 1 case, severe – 2 cases), by the end of INACT, but such developments were not reflected in the concentration of any of the kynurenine pathway metabolites.
CONCLUSION: Severe voluntary restriction of activity for 3 weeks had substantial negative, but transient, impact on mood state in young healthy individuals. These changes were not accompanied by alterations in blood concentrations of kynurenine pathway metabolites.

# Oral presentations

## OP-PN36 Micronutrients

### EFFECTS OF VITAMIN D DEFICIENCY ON THE ACUTE RESPONSE OF ARTERIAL STIFFNESS TO MODERATE-INTENSITY ENDURANCE EXERCISE IN HEALTHY ADULTS

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INTRODUCTION: Cardiovascular disease (CVD) is a disease that causes deaths worldwide. It is estimated that 17.9 million people died from CVD in 2019 (1). The previous study has shown that vitamin D deficiency is associated with CVD and arterial stiffness. Increased pulse wave velocity (PWV) is an indicator of arterial stiffness and a major risk factor for CVD. The peripheral PWV (pPWV) is measured by body limb pulse wave and we used a finger to toe to measure pulse wave velocity (ft-PWV). It is known that moderate-intensity endurance exercise has a positive effect on vascular function (2). The primary objective of this study was to understand the effect of vitamin D status on pPWV following moderate-intensity endurance exercise in healthy adults and the relationship between vitamin D levels and pPWV.
METHODS: Fifty male participants were divided into the 25-hydroxyvitamin D (25(OH)D) sufficiency group (n=28, 25(OH)D ≧50 nmol/L) and deficiency group (n=22, 25(OH)D <50 nmol/L). The acute maximal exercise was performed using an incremental cycling test to exhaustion. The relative exercise intensity was set at 60% VO2peak, and the rotation speed was maintained at 60 revolutions per minute for 120 minutes of continuous riding on a stationary bicycle. And the pPWV and blood pressure (BP) were obtained at rest and 0, 15, 30, 45, 60 minutes after moderate-intensity endurance exercise. The pPWV and BP variables were analyzed with a two-way analysis (ANOVA). Significant interaction and main effects were followed up with post hoc comparisons t-test analysis. Bivariate correlations between 25(OH)D levels and PWV were determined with Pearson product-moment analysis. The accepted level of significance was p <0.05.
RESULTS: The total 25(OH)D concentration from 28 participants classified in the sufficiency group was 60.21 ± 6.75 nmol/L and the total 25(OH)D concentration from 22 participants classified in the deficiency group was 40.28 ± 7.50 nmol/L. T-test analysis revealed that 25(OH)D deficiency group had higher pPWV at post-15 minute (5.41 ± 0.93 vs 4.84 ± 0.75 m/s), post-30 minute (5.30 ± 0.77 vs 4.84 ± 0.75 m/s), post-45 minute (5.56 ± 0.93 vs 5.05 ± 0.68 m/s) than the sufficiency group. In addition, the pPWV decreased significantly from baseline to post-0, 15minute in the sufficiency group. Systolic BP decreases significantly from pre-exercise to post-15, 30, 45 minute in sufficiency group. Diastolic BP was no significant time effect and group effect. The 25(OH)D levels were significantly associated with pPWV at post-15, 30, 45 minute.
CONCLUSION: In this study, we found that adults with sufficient 25(OH)D could have a better vascular function after moderate-intensity endurance exercise. People with sufficient vitamin D status had better vascular regulation and could provide the body with the oxygen needed for endurance exercise.
1. World Health Organization. https://reurl.cc/dXaqjq
2. TrevorJ, K. et al., Med Sci Sports Exerc 53(3), 597-605. (2021)

### EFFECT OF B-COMPLEX SUPPLEMENTATION ON PROFESSIONAL FOOTBALL PLAYERS

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INTRODUCTION: The use of supplements in professional sport is still a controversial subject; there is a discussion on the advisability of their use regarding the improvement of performance, as well as on the definition of ad hoc ranges that should be different from those of the normal population, which guarantee that there are no deficits and therefore possible pathologies; for example, the RDA of vitamin C guarantees not to have scurvy, but the goal of nutrition applied to the sport should guarantee an optimal value not only to preserve from possible pathological states.
METHODS: 18 Italian professional soccer players being part of a Serie A team received a vitamin B (composition) supplement (B-Dyn®, Metagenics, Milan, Italy ) for 40 days; iDXA, BIA and a battery of biochemical-clinical analyses were performed at the initial time t0 (pre-season preparation), at time t1 (after 40 days) and at time t2 (after 3 months), to evaluate both the quantity of some vitamins (B9, B12 and D) and also the possible effect on the measured parameters of the supplementation.
RESULTS: iDXA and BIA parameters did not show any remarkable change; although the values of vitamin B9 and B12 (value) were within the normal range, the integration intervention recorded an increase which then decreased by interrupting the integration (value); between the values considered the hematocrit shows a significant increase at time t2 (value), as well as the reticulocytes; the VES also shows a similar trend. The other parameters do not show statistically significant changes except for the plasma values of zinc and vitamin D, which both show a decreasing trend over time.

CONCLUSION: In our opinion, although on a limited sample, this work can be a starting point to re-evaluate integration in professional sports. Evaluating a person who does not practice high-level physical activity, supplementation, in particular of vitamin B9 or B12, would not be justified, in this case, it is; on the contrary, it should probably be kept for the whole season or for longer periods (at least 3 months); the delayed improvement of hematocrit values and granulocytes (value linked to hematopoiesis) it might be justified by the fact that hematopoiesis is affected after a longer period of integration. Unfortunately, it is not easy to act on professional athletes during the season, therefore a larger sample and a control group would be useful in subsequent studies.

### VITAMIN D INSUFFICIENCY AMONG INDIAN ATHLETES AND ITS ASSOCIATION WITH CYP2R1 (RS10741657) POLYMORPHISM.

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INTRODUCTION: Vitamin D insufficiency negatively impacts the health and training efficiency of athletes. The growing prevalence of vitamin D deficiency worldwide might be a combined outcome of dietary inadequacy, less exposure to sun, and genetic predisposition. Variations in CYP2R1 gene have been linked by several studies to vitamin D serum concentration. Especially, the rs10741657(G) allele has been associated with lower vitamin D status and thus a potential cause for Vitamin D insufficiency. Although more than 76% of Indians suffer from vitamin D deficiency, currently there are no studies on Vitamin D levels in Indian Athletes and understanding the genetic predisposition to lower vitamin D status. Thus, the aim of this study was to check for an association between CYP2R1 polymorphism and Vitamin D levels of athletes participating across different sporting category.
METHODS: 91 Indian Elite and sub-elite athletes (Male:44 Female:47) participating in different sports categories (Weightlifting (29), Badminton (31), Athletics (14), Rowing (17)) aged 18.61 (SD=4.2) years were included in the study. The blood sample was collected for laboratory analysis. PCR-RFLP of SNP on CYP2R1 (rs10741657) was carried out and vitamin D levels were checked using the ELISA kit method. Chi-square analysis was done to understand the distribution of allele and genotype frequency among gender & sports categories. To find the association between the genotype and vitamin D status ANOVA and Independent sample t-test were carried out.
RESULTS: Majority (92.3%) of the participants were vitamin D insufficient. Vitamin D deficiency was highest among weightlifters and athletics groups (100%), irrespective of gender, followed by female rowers (88%), and Badminton players (64.5%). The genotypic frequency for Wild, Heterozygote and Mutant was 21%, 40% and 39% respectively. The average Vitamin D levels across the Wild, Heterozygote and Mutant genotypes were 27.39 ng/mL, 13.39 ng/mL and 12.41 ng/mL, respectively and it was found significantly different.
CONCLUSION: Vitamin D deficiency is highly prevalent among the athletes in the study. This deficiency may be due to the higher prevalence of alternate allele CYP2R1 polymorphism. Thus, making the genetic makeup a key player in determining the Vitamin D status of athletes.

### HOW CAN SWIMMER'S NUTRITION IMPROVE THE PERFORMANCE: A SYSTEMATIC REVIEW

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INTRODUCTION: Although the nutrition problems of swimmers has been well documented in the literature, still insufficient nutrition existed in swimmers. The aim of this study is therefore to explore how to deal with the problem of insufficient nutrition supplement in swimmers to improve the performance of the athletes.
METHODS: This systematic review was conducted under the guidance of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria. PubMed, Web of Science, EBSCO and CNKI (Chinese databases) were searched for papers published after 2014. A total of 47 papers were included, and the results of the evidence on age, nutritional criteria, athletic ability and nutrition in the study population were retrieved for systematic evaluation.
RESULTS: Consistent evidence shows that most swimmers currently skip breakfast, with excessive calorie intake in dinner. As for the macronutrients, the problems of both insufficient carbohydrate and fat supplement and excessive protein (especially animal protein) intake exist in swimmers. For the micronutrients supplement, vitamin A, vitamin B1, vitamin B2, vitamin C, vitamin PP, vitamin E, Calcium, Zinc, Potassium and Magnesium are generally insufficient, but Sodium supplement tends to be excessive. The main focus of research on nutritional supplement is on Creatine, Branched-chain amino acids, L-carnitine and Lycopene.
CONCLUSION: Unbalanced energy intake in three meals a day, insufficient carbohydrate and fat supplement and excessive protein intake, lack of certain micronutrients and the improper use of nutritional supplement are the main problems that need to be solved to the performance of swimmers.

### EFFECTS OF DIFFERENT VITAMIN D LEVELS ON BONE MASS AND TURNOVER MARKERS IN FEMALE ADOLESCENT FOOTBALL PLAYERS: A ONE-SEASON STUDY.

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INTRODUCTION: Vitamin D (Vit D) is a hormone that plays an important role in bone development (Holick 2003). In fact, levels of serum 25-hydroxyvitamin D (25(OH)D) above 30 ng/mL are recommended to maximize calcium absorption and bone mineralization (Holick et al. 2011). To our knowledge, there is only one study that analysed the association between Vit D and bone health finding no correlation between these parameters in female adolescent football players (Brännström et al. 2017). Thus, the aim of this study was to evaluate the influence of different 25(OH)D concentrations on bone health changes during a season in this population.
METHODS: A total of 22 female football players were divided into two groups according to their 25(OH)D concentrations: 11 in deficient/insufficient 25(OH)D group (IVD; <30 ng/mL; 12.6±0.6 y), and 11 in sufficient 25(OH)D group (SVD; ≥30 ng/mL; 12.6±0.6 y). Subtotal body and lumbar spine bone mineral content (BMC), and mean legs areal bone mineral density (aBMD) were measured by dual-energy X-ray absorptiometry (DXA, QDR-Explorer, Hologic Corp). Bone mineral apparent density (BMAD) for the whole body and lumbar spine was calculated using Katzman and Carter equations (Carter, Bouxsein, and Marcus 1992; Katzman et al. 1991). Electrochemiluminescence immunoassays were used to analyse bone biomarkers (procollagen type I N-terminal propeptide, osteocalcin, and C-terminal cross-linked telopeptide) and 25(OH)D. All variables were registered at the beginning and the end of the football season. Serum calcium was measured by colorimetric assay. Analysis of variance for repeated measures was performed to examine body composition differences within players

with IVD and SVD between the beginning and the end of the season and to analyse group by time interactions for normally distributed variables. Mann-Whitney U and Wilcoxon signed-rank tests were used for those that did not show normal distribution.
RESULTS: The increase in legs aBMD and lumbar spine BMAD was higher in players with SVD than those with IVD (n2p were 0.277 and 0.237; p<0.05). Only players with SVD significantly improved whole body BMAD from the beginning to the end of the season (r was 0.63; p=0.001). Both players with IVD and SVD significantly increased subtotal body and lumbar spine BMC (p<0.05). No significant between- and within-group differences were found for bone biomarkers parameters (p>0.05). Moreover, serum calcium levels were reduced in both groups (p<0.05).
CONCLUSION: SVD might cause an extra increase of aBMD and BMAD parameters in female adolescent football players. Moreover, it seems that different serum 25(OH)D concentrations do not directly affect turnover markers in this population.

# Oral presentations

## OP-SH06 Psychology and education

### VALIDATION OF THE CANADIAN ASSESSMENT OF PHYSICAL LITERACY (CAPL-2) FOR GERMAN AND POLISH CHILDREN

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Introduction
In recent years physical literacy as a prerequisite of participation in physical activity has attracted researchers' attention worldwide. To measure physical literacy the Canadian Assessment of Physical Literacy, second edition (CAPL-2) with the four domains of Motivation and Confidence, Physical Competence, Knowledge and Understanding, and Daily Behavior is a valid and reliable instrument to assess physical literacy in children. The aim of our study is to translate CAPL-2 (Longmuir et al., 2018) into German and Polish language, adapt it to German and Polish context and to test the measurement properties on German and Polish children 8-12 years old.
Method
CAPL-2 consists of a questionnaire to assess the Knowledge and Understanding and Motivation and Confidence domains. The Daily Behavior domain is assessed from one self-report item of weekly physical activity included in the questionnaire and objectively from step counts during one week. To measure the Physical Competence domain three physical tests are applied. In a first stage the CAPL-2 questionnaire was translated into German and Polish language according to the TRAPD approach (Harkness, 2003), pilot tested and the final two versions of the questionnaire and the final German manual description was produced. So far, the German version of the questionnaire was tested on 113 children (girls=56, mean age=10.77, SD=1.3) and the Polish version on 181 children (girls=94, mean age=11.6, SD=1.1). 71 German children (girls=35, mean age=10.8, SD=1.4) completed CAPL-2 assessments.
Results
The analyses until now show acceptable split-half reliability for the Motivation and Confidence domain. For the total CAPL-2 questionnaire the Mann-Whitney-Test shows no significant differences between the German (M=32.84; SD=5.87) and Polish (M=31.58; SD=5.91) children. The data revealed statistically significant differences in the domain Knowledge and Understanding (p=.000; r=.33) and the item of weekly physical activity (p=.028; r=.14) between the two samples.
Discussion
Following similar procedures adopted in the other CAPL-2 validation studies, confirmatory factor analyses will be performed on full samples of approximately 500 German and 500 Polish children. CAPL-2 total and domain scores will be computed for all children and separately across gender and age groups. The comparison of CAPL-2 scoring of the two samples will show to what extent the different cultural backgrounds and educational systems support the promotion of physical literacy.
References
Harkness, J. (2003). Questionnaire Translation. In J. Harkness, F. van de Vijver, & P. Mohler (Eds). Cross Cultural Survey Methods (pp. 35-56). Hoboken, NJ: Wiley.
Longmuir, P.E. et al. (2018). Canadian Assessment of Physical Literacy second edition: A streamlined assessment of the capacity for physical activity among children 8 to 12 years of age. BMC Public Health, 18, 1047. doi: 10.1186/s12889-018-5902-y

### THE DEVELOPMENT AND VALIDATION OF DEPENDENCE AND CRAVING MEASURES SPECIFIC TO ATHLETES WHO USE ANABOLIC-ANDROGENIC STEROIDS

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Background: Anabolic-androgenic steroid (AAS) dependence is estimated to affect approximately 30% of people who use AAS. Presently, measures to assess and diagnose AAS dependence are adapted from scales specific to other forms of drug misuse (e.g., alcohol) and these measures have issues with internal consistency and breadth of construct capture. Alongside this, there are currently no measures to assess AAS craving, which represents a potentially important antecedent to AAS dependence. Therefore, the aim of this study was to develop and provide evidence of validity for measures of AAS dependence and AAS craving.
METHODS: Data were collected from male and female strength athletes who use AAS across two samples (nsample 1 = 206; nsample 2 = 103). Sample 1 completed the new measures alongside instruments assessing theoretically related constructs (Doping Moral Disengagement, Doping Self-Regulatory Efficacy Scale, craving items from the Wisconsin Smoking Withdrawal Scale, AAS adapted Diagnostic and Statistical Manual for Mental Disorder 5th Edition), whereas Sample 2 just completed the new instruments.
Results: Exploratory and Confirmatory Factor Analyses (CFA) were used with data from Sample 1 to determine the factorial structures of the AAS Dependence Scale (AASDS) and AAS Craving Scale (AASCS), as well as the item sets for both measures. The AASDS consists of 15-items across five first-order factors that are represented by one second-order factor. The AASCS consists of 16-items across four first-order factors that are represented by one second-order factor. Evidence supporting the concurrent, convergent and discriminant validity of scores obtained with both scales was provided through their associations with the theoretically related variables. CFA with the data from Sample 2 confirmed the factor structures for both scales.

Conclusions: The AASDS and AASCS are proposed as valid and reliable measures of AAS dependence and AAS craving for use in research with strength athletes who use AAS.

### THE VALIDATION OF AN ORIGINAL CRITERIA-REFERENCED TESTS BATTERY FOR THE ASSESSMENT OF K-8 STUDENTS' FUNDAMENTAL MOTOR SKILLS AND ITS INTEGRATION INTO THE PEDAGOGICAL TEACHING-LEARNING SEQUENCE

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INTRODUCTION: A key role of quality school physical education (PE) is to enable children to learn and master motor skills. The assessment of fundamental motor skills (FMS) therefore becomes essential. Limitations of existing measurement tools include being designed exclusively for clinical and sport contexts, having age restrictions (3 - 10 years old) and not emphasizing, as much as it should, pedagogical purposes of PE learnings. Accordingly, we developed an original battery of 24 representative tests for the evaluation of students fundamental psychomotor (20) and sociomotor (4) skills.
Objective: To assess feasibility, validity and reliability of these 24 FMS tests of the battery.
METHODS: Following established standards for the development of psychomotor tests, we identified the skills to be assessed, developed assessment parameters by focusing on the performance process (quality) rather than the product, and determined the tests procedures. Other experts evaluated the face and content validity of this battery. Testing took place in 7 schools (N = 1584 students). Each test was administered to targeted age groups students (2nd, 5th and 8th grade) to assess the test's feasibility and to refine evaluation parameters. This process was repeated following modifications of testing procedures aimed at improving psychometric properties. Inter-rater reliability and construct validity (more precisely, concomitant validity) were assessed with Pearson correlations, Kappa statistics, Pearsons chi-squared statistics and Cramers V symmetric measurements.
Results: After the first test administration and the first feedback from PE teachers on test parameters, we modified instructions to improve clarity and adjusted the estimated time of administration for some grade levels and the training of raters. Following the 2nd and 3rd school's visits and modifications of testing procedures, acceptable to good indices of inter-rater reliability (Pearson $\chi 2$ = 93,536-136,894; Kappa = 0,654-0,836) and construct validity (Pearsons Khi-square $\chi 2$ = 98.942-148.775; linear by linear association $\chi 2$ = 72.144-89.226; Cohens Kappa = 0.696-0.798 and Cramers V symmetric = 0.806-0.850) were found for final versions of the tests.
Conclusions: Our study shows that the development of this criteria-based test battery following a rigorous methodological process was complex and time intensive (over 5 years). Nevertheless, the statistical analyses led to an appropriate validity and intra-rater reliability. We are continuing to investigate the ability of this criteria-based test battery to identify known group differences. Also, a process of establishing standardized measuring procedures is already in place. This test battery could become a standard measuring tool for assessing the FMS related to the PE learning outcomes, either for diagnostic, formative or summative purposes, within different teaching-learning scenarios of the French school curricula in New Brunswick, Canada.

### EFFECT OF FIVE WEEKS PARTICIPATION IN THE DAILY MILE ON COGNITIVE FUNCTION IN PRIMARY SCHOOL CHILDREN

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INTRODUCTION: The Daily Mile is an extremely popular school-based physical activity intervention which is currently being implemented in ~14,000 schools in ~80 countries Worldwide. However, the longer-term effects of participation in The Daily Mile on cognitive function in young people are unknown; whilst the evidence from other physical activity initiatives is mixed. Furthermore, it is suggested that changes in physical fitness may moderate changes in cognitive function, given the positive association between fitness and cognition in young people. Therefore, this study examined the effect of five weeks of participation in The Daily Mile on cognitive function and physical fitness in young people.
METHODS: In a quasi-experimental study, two classes were assigned to an intervention group, who completed The Daily Mile every day for five weeks (n=44), or to a control group who continued with their habitual activities for five weeks (n=35). Cognitive function was assessed by a battery of computerised tests, consisting of a Stroop test (executive function), Sternberg paradigm (working memory) and Flanker task (attention). Physical fitness was assessed as distance run on the multi-stage fitness test (MSFT). Baseline and follow-up measurements were completed 48-h before the first, and 48-h after the last, training session respectively. Data were analysed via ANCOVA, examining between group differences at follow-up whilst controlling for baseline values (reported as mean and [95% confidence intervals]).
RESULTS: Response times on the complex level of the Stroop test were faster at follow-up in the intervention group compared to the control group (intervention: 1357 ms [1280, 1400 ms]; control: 1463 ms, [1410, 1523 ms], p = 0.048). There was no effect of The Daily Mile on the simple level of the Stroop test, Stroop test accuracy, or any aspect of performance on the Sternberg paradigm and Flanker test (all p > 0.05). However, physical fitness (MSFT distance) was greater at follow-up in the intervention group compared to the control group (intervention: 880 m, [820, 940 m]; control: 740 m, [680, 800 m], p = 0.002).
DISCUSSION:
Five weeks of participation in The Daily Mile enhanced executive function (as evidenced by faster response times on the complex level of the Stroop task) and physical fitness (as evidence by a greater distance run on the MSFT), when compared to the control group. However, there was no effect on working memory or attention. The findings of the present study suggest that even a relatively short duration implementation of The Daily Mile (five weeks; i.e., over a school half term) has the potential to enhance cognitive function in children, which has implications of schools and policy makers due to the potential beneficial effect on academic achievement.
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**EFFECTS OF TWO CONTROLLED PHYSICAL EXERCISE PROGRAMS ON WORK ABILITY, JOB SATISFACTION AND ANXIETY IN THREE SEDENTARY COMPANIES: A PILOT STUDY**

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INTRODUCTION: Anxiety is a feeling associated with fear that is related to lifestyle. Moreover, recent studies indicate that it is not only the physical activity itself that brings benefits to work capacity, but also highlight how beneficial it can be to perform it with co-workers. The scientific literature has not yet found the appropriate components of the various intervention programs in order to understand the general state of the question. The objective of this study was to assess the effect of two supervised physical exercise interventions in the workplace on work capacity, job satisfaction and self-perceived anxiety.

METHODS: A pre-experimental study was conducted on workers with sedentary occupations from three different companies and sectors: (1) Renewable energy engineering; (2) Insurance and (3) Infrastructure and services. The participants of the first two were administered a supervised physical exercise program at their corporate headquarters in Madrid (PRODET: n=12; mean age 43.21±7.04 and n=16; mean age 46.59±5.01, respectively). The third company carried out another physical exercise intervention in a single corporate headquarters in Madrid (HASAVI; n=18; mean age 39.25±9.83). A pre- and post-test intragroup analysis was performed on work capacity, job satisfaction and perception of anxiety.

Results: The PRODET program in the company (1) found a significant improvement in work capacity in relation to requirements (p=0.033; ?2=0.24) and an increase in psychic vitality (p=0.037; ?2= 0.23). In this company, a significant increase was found in the overall score of the work capacity index (p=0.045; ?2=0.20). The program also improved the perception of satisfaction in relation to remuneration and benefits (p=0.016; ?2= 0.19), the perception of satisfaction related to the quality of production (p=0.013; ?2=0.21) and the total score of job satisfaction (p=0.016; ?2=0.19). There was also a decrease in trait anxiety (p=0.039; ?2=0.22). No statistically significant differences were observed in the change of values from pre to post in any other company and program (p>0.05).

Discussion: These findings coincide with the results reported by other authors while studies with lower methodological quality found greater effects. Also, recent investigations have focused their interventions on graduate employees, given the presumed ease of access in these organizational contexts. This suggests the existence of considerable barriers for conducting quality interventions in the field of physical activity in the workplace. The PRODET supervised physical exercise program could influence work capacity and job satisfaction in general.

Bibliography:

Selye H. The stress of life. Nueva York: McGraw-Hill; 1956.

Jakobsen MD, Sundstrup E, Brandt M, Jay K, Aagaard P, Andersen LL. Physical exercise at the workplace prevents deterioration of work ability among healthcare workers: cluster randomized controlled trial. BMC Public Health. 2015;15

## Oral presentations

### OP-SH12 Coaching Challenges

**THE INTRINSIC VALUES OF BEING A PARENT COACH IN YOUTH HANDBALL: A 9-MONTH LONGITUDINAL QUALITATIVE STUDY**

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Introduction

In Norway, the number of children and adolescents involved in organized sports has grown steadily over the past several decades. Hence, a growing number of parents are coaching their own children. This trend appears to have increased over the past decades. Indeed, it has been estimated that 58 million man-hours are performed in organized sports every year. Because so many parents are involved in coaching their own children, research is warranted to provide insight into why parents choose to stay involved both on and off the court. Therefore, the purpose of the present study was to use a longitudinal qualitative design to gain in-depth insights into parent-coaches' intrinsic values of being a significant adult in youth Norwegian handball.

Methods

Three parent-coaches (n=2 males; n=1 female; all volunteer coaches) who were coaching female handball players (aged 12-13 years) participated in this study. Three focus group interviews (carried out in September, January, and May) were conducted as semi-structured interviews in appropriate settings during a 9-month competitive season. A semi-structured interview guide was developed with the intention of exploring how the participants thoughts and experiences about the intrinsic values of being a parent-coach in youth handball. Thematic analysis was used to analyze the data.

Results

After completion of the thematic data analysis, an overarching theme for the purpose of the study stood out – Enjoyment through being a parent-coach in youth handball. Four different main themes complimented and constituted within the study's overarching theme: (a) the privilege of being a parent-coach; (b) personal growth as a coach; (c) creating progress and mastery experiences; and (d) personal contribution to beneficial socialization processes and friendships between teammates. From the in-depth analysis, results revealed that the sub-themes excitement and variation, from play to performance, and positive feedback stood out under main theme 1. Under main theme 2, the sub-themes receiving support, feeling a sense of autonomy, and use of humor stood out. Under main theme 3, the sub-themes team achievement, personal skills, and performing together stood out. Finally, under main theme 4, the sub-themes team membership, friendships within the team, and personalized team-sport stood out.

Conclusion

The values underlying parent-coaches' thoughts, attitudes, and behaviors are of utmost importance. Our findings showed that the three parent-coaches experienced great enjoyment while staying involved both on and off the court. Additionally, the three parent-coaches expressed feelings of privilege because they appreciated the opportunities of personal growth as a coach, creating experiences of mastery

and progression, and being part of the process of socialization of young handball players. Further research is warranted to understand the role of parent-coaches in organized youth sports.

### LONGITUDINAL EFFECTS OF DIETARY SUPPLEMENT AND MEDICATION USE ON FUNCTIONAL AND MORAL ATTITUDES TOWARDS DOPING

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Background: Dietary supplement (DS) use has been associated with more favourable doping attitudes (Backhouse et al., 2013; Hurst et al., 2019). However, research to date has been limited to cross-sectional designs. Alongside this, researchers have not differentiated between functional/moral doping attitudes or examined potential effects of medication use on doping attitudes. As such, the aim of this study was to examine the longitudinal reciprocal relations between DS/medication use and functional/moral doping attitudes.
METHODS: Data were collected from male (n = 105) and female (n = 100) student-athletes competing in a range of team and individual sports at three time points across a competitive season. At each time point, participants completed a questionnaire assessing DS/medication use and functional/moral doping attitudes.
Results: Three-wave-cross-lagged panel analysis was used to examine the reciprocal causal effects of DS/medication use and functional/moral doping attitudes. For muscle-building supplements (e.g., protein, creatine), we detected significant weak positive cross-lagged effects from muscle-building supplement use to functional doping attitudes and from functional doping attitudes to muscle-building supplement use between T1 and T2 and T2 and T3. For moral attitudes, significant negative weak-to-moderate effects from muscle-building supplement use to moral doping attitudes were found between T1 to T2 and T2 to T3. No significant effects were detected from moral doping attitudes to muscle-building supplement use. For health and well-being (e.g., vitamins and minerals) and weight-loss (e.g., fat burners, laxatives) supplements, no significant cross-lagged effects were detected for either doping attitude. For medications (e.g., aspirin, paracetamol), we detected significant weak negative cross-lagged effects from medication use to moral doping attitudes and significant weak positive effects from moral doping attitudes to medication use. No significant cross-lagged effects were detected between medication use and functional attitudes.
Conclusions: Representing the first reported research to test the longitudinal effects of DS/medication use on doping attitudes, our findings provide the strongest support yet for a causal link between DS/medication use and favourable attitudes towards doping. Further, muscle-building supplement use appears to be a greater risk factor for doping than other forms of DS use. Our findings also provide some support for effects of attitudes on DS/medication use.
Backhouse SH, Whitaker L, Petróczi A. Gateway to doping? Supplement use in the context of preferred competitive situations, doping attitude, beliefs, and norms. Scandinavian Journal of Medicine & Science in Sports. 2013;23(2):244-52.
Hurst P, Kavussanu M, Boardley I, Ring C. Sport supplement use predicts doping attitudes and likelihood via sport supplement beliefs. Journal of Sports Sciences. 2019;37(15):1734-40.

### ATHLETES USING SPORT SUPPLEMENTS MAY BE MORE LIKELY TO DOPE BECAUSE OF A MORE FAVORABLE DOPING ATTITUDE, A GREATER SOCIAL PRESSURE TO DOPE, AND A PERCEIVED EASE IN WHICH TO DOPE

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Introduction
The use of sport supplements (e.g., creatine, caffeine, and nitrate) is highly prevalent amongst athletes. In the past decade, a body of evidence has shown that sport supplement use may be related to the use of prohibited performance enhancing substances (i.e., doping). The aim of this study was to examine whether the relationship between sport supplement use and doping is mediated by the theory of planned behavior constructs (i.e., attitudes, subjective norms, and doping perceived behavioral control).
Methods
Competitive athletes (N = 443, 46% female, age = 27.0 ± 8.6 years old, years competing = 8.3 ± 3.5) were recruited via social media and completed measures of sport supplement use, doping attitudes, doping subjective norms, doping perceived behavioral control, and doping intention.
Results
Zero-order correlations indicated that sport supplement use was moderately and positively associated with doping attitudes (r = 0.20), subjective norms (r = 0.22), perceived behavioral control (r = 0.22) and intention (r = 0.21). Associations between doping attitudes, subjective norms, perceived behavioral control and intention were large and positive (r range = 0.49 to 0.78). Parallel mediation analysis indicated that sport supplement use was not directly related to doping intention (b = 0.10, 95% CI = -0.22 to 0.42) but instead was indirectly related via doping attitudes (b = 0.23, 95% CI = 0.11 to 0.36, effect size = 0.11), doping subjective norms (b = 0.26, 95% CI = 0.08 to 0.43, effect size = 0.13), and doping perceived behavioral control (b = 0.53, 95% CI = 0.34 to 0.76, effect size = 0.50). Contrast analyses reported no differences for indirect effects for each mediator ($p > 0.05$). Overall, the model accounted for 61% of the variance on doping intention ($F(4, 438) = 171.75$, $p < 0.01$, $R = 0.78$).
Discussion
Our data suggest that athletes who use sport supplements report stronger intentions to dope because of a more favorable doping attitude, a greater social pressure to dope, and a perceived ease in which to dope. For those aiming to in prevent doping in sport, interventions should aim to target attitudinal change towards doping, perceptions of the accepted practice of doping, and decrease perceptions of control.

### POTENTIAL RISKS OF EARLY SPECIALIZATION AND HIGH TRAINING VOLUME AMONG ELITE YOUTH FOOTBALL PLAYERS IN CHINESE SCHOOL FOOTBALL

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INTRODUCTION: With China's commitment to promoting youth football in schools, more and more players engage in more frequent, intensive and organized sports training from a young age despite the controversy over early specialization (ES). Supporters claim that ES

allows players gain advantages in the competition, better training resources and career opportunities, but some literature on youth sports link ES with burnout and injuries. Therefore, this research aims to investigate the correlation between the training volume and ES level of elite Chinese youth players and potential risks of ES.
Method:
A cross-sectional survey study was used. Players who participated in the National School Football Winter Camp were invited to fill out a questionnaire that included the data of ES, sports volume, injury history, and burnout (n=178 children, n=88 boys and n=90 girls).
RESULTS: Confirmatory factor analysis obtain a good overall fit of the model (CMIN/DF=2.016; CFI=.927; RMSEA=.076; GFI=.943; RMR=.041). The internal consistency of the questionnaire were satisfactory (Cronbachs α=.73). The results have shown that 80.3% of the players is high-ES, while 2.8% is low-ES and 16.9% is moderate-ES. Almost all the players (96%) played one sport more than eight months of the year, most of them (75.8%) spent more than twice of the time on organized sport than leisure activities, and 30.3% of them trained exceeding average weekly hours per week based on age in years. In response to the burnout scale, the M±SD values were 1.48±0.65 for emotional/physical exhaustion, 1.64±0.66 for reduced sense of accomplishment, and 1.27±0.55 for sport devaluation. Binomial logistic regression showed the odds of reporting an injury were higher for high ES players compared to players categorized as low and moderate ES (OR=3.046; CI=1.155-8.03; p=.024). It was also higher for high ES players compared to players categorized as low and moderate ES (OR=2.451; CI=1.071-5.61; p=.034) when reporting more injuries. The MANOVA tests showed differences for: (a) burnout by the level of early specialization (F=2.72, p=.046), especially showed significant difference for sport devaluation by the level of early specialization (F=4.99, p=.027); (b) reduced sense of accomplishment by the sports volume (training one sport more than eight months of the year), (F=5.901, p=.016); and (c) emotional/physical exhaustion by the sports volume (the time spent in organized sports is more than twice than leisure activities), (F=8.17, p=.005).
CONCLUSION: The following conclusion can be stated from our findings: (i) high level of ES will increase the odds of injury and lead to sport devaluation; (ii) Excessive training volume is associated with an increased probability of reduced sense of accomplishment; and (iii) Notably, paucity of leisure activities will increase the odds of emotional/physical exhaustion.

**THE EFFECTS OF THE USE OR NON-USE OF LEAGUE STANDINGS AND PLAYOFFS ON PARTICIPATION RATES IN A CHILDREN AND YOUTH SOCCER CONTEXT**

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Introduction
Whether or not to use league standings and playoffs (LSPO) in children and youth sports has been a recurring topic for fiery debates. In order to stimulate long-term sports development, enjoyment and continued participation, the Swedish Football Association decided that from 2017 the use of LSPO will be abolished until the year the children turn 13.
Method
In order to study the effect of the use or non-use of LSPO on the participation rate, register data from a specific childrens and youth football context (school class football) were analyzed. This context has the advantage that the conditions have in general been constant several decades until 2017, when keeping official scores, league standings and playoffs were removed for all age groups (7-12 years; Preschool-Grade 5) with the exception for the oldest group (13 years; 6th grade). This makes it possible to study the phenomenon over time in a natural environment and compare groups with each other while at the same time taking reasonable control of confounding factors without intervening or manipulating the groups.
School class football is a phenomenon run by a voluntarily sport club where approximately 3000-3500 children and youths participate annually. In school class football it is the single class that makes up the team and competes against other classes from different schools in the municipality. It is optional for classes to sign up and it is also up to the individual child to participate. The schools are not responsible for their participating classes. Rather, the teams are coached by volunteering parents. School class football is subject to competitive engineering (CE) as rules are modified in several ways (e.g., playing on smaller fields, using smaller goals and footballs, girls and boys playing together, always at least two boys and two girls on the pitch).
Results
Results shows that the participation rate before the removal of LSPO (2015-2017) increased slightly (<1%; from n= 3044 to 3063; n = 19), while a clear increase (20%; from n = 3063 to 3689) could be noted after the removal of LSPO (2017-2021). The increase was particularly noticeable among the girls after the removal of the LSPO (41%; from n = 1102 to 1550). While the increase among the boys was only modest (9%; from n= 1961 to 2139) and in correspondence with the municipality population increase (7 %) in this age group.
Discussion
The results indicate that the removal of league standings and playoffs increases the participation rate of groups of individuals who are usually not considered as competent as other participants. One of the reasons for this may be that a more caring and mastery oriented climate is created where coaches, athletes and parents to a greater extent care that everyone thrives and have fun instead of focusing on winning matches and getting to the playoff.

## Oral presentations

### OP-MH20 Health and fitness in children

**EFFECTS OF 12-WEEK RESISTANCE TRAINING ON NEUROMUSCULAR AND BODY COMPOSITION CHANGES IN PUBERTAL CHILDREN**

RUAS, C.V.1,3, RATEL, S.2, NOSAKA, K.1, GARNIER, Y.2, PINTO, R.S.3
*1 - EDITH COWAN UNIVERSITY, AUSTRALIA; 2 - UNIVERSITÉ CLERMONT AUVERGNE, FRANCE; 3 - FEDERAL UNIVERSITY OF RIO GRANDE DO SUL, BRAZIL*

INTRODUCTION: Children have become less physically active in the last decade, and their muscle force and power levels are lower when compared with the children in ~40 years ago (1). The decrease in physical activity levels seems to have been accentuated due to the COVID-

19 pandemic (2), and dynapenia (i.e., loss of muscle force and/or power) due to muscle disuse is now common in children (3). Thus, effective resistance training (RT) interventions are necessary to increase children's maximal and explosive muscle strength. The present study investigated the effects of 12-week RT on neuromuscular parameters and body composition in pubertal children.
METHODS: Twelve (7 boys and 5 girls) untrained pubertal children (13.4±0.9 y; Tanner stage 3.4±0.6) performed a structured full body RT program consisting of bilateral knee extensions and flexions, bench press, abdominal crunch, back extension, lateral pull-down, elbow flexion, and upright row (60 - 90 minutes a session) twice per week on non-consecutive days; exercises per session for 12 weeks with increasing volume and intensity. Bilateral KE one-repetition maximum test (1-RM) was performed before, post-6 and post-12 weeks of the program. Outcome measures included maximal voluntary isometric contraction (MVIC) torque and rate of force development (RFD) of the knee extensors (KE), electromyographic (EMG) activity of vastus lateralis and rectus femoris muscles (root mean square during MVIC), muscle thickness (MT) and echo intensity (EI) of the whole quadriceps muscle assessed by B-mode ultrasonography, and body composition by dual-energy x-ray absorptiometry. Changes in these measures before and after the training were analyzed by repeated measures ANOVAs and paired t-tests.
RESULTS: KE 1-RM increased (P<0.01) from pre-training (29.1±24.4 kg) to post-6 (48.8±39.4 kg) and post-12 weeks of RT (83.0±65.6 kg). MVIC torque increased (P<0.01) from baseline (134.6±31.6 Nm) to post-training (166.8±47.6 Nm), but RFD and EMG did not change after training (p>0.05). MT increased (p<0.01) from pre- (63.8±9.8 mm) to post-training (78.3±9.1 mm), and EI decreased (p<0.01) from pre- (39.4±8.5 A.U) to post-training (28.5±5.6 A.U). The decrease in EI represents increase in quadriceps muscle quality. Total body fat-free mass (FFM) increased (p=0.01) after the training (39.2±6.5 kg) from the baseline (38.2±7.1 kg), but no changes in body fat percentage, thigh FFM, bone mineral density and content were found (p>0.05).
CONCLUSION: The 12-week RT was effective for increasing MVIC torque (16.3±17.5%) and MT (18.8±5.5%) of the knee extensors in untrained pubertal children. It appears that the risk of paediatric dynapenia can be reduced by the regular RT program, and importantly, the children of the present study enjoyed the resistance exercises and indicated that they wanted to continue the program.
REFERENCES
1) Faigenbaum et al., Curr Sports Med Rep, 2019
2) Wenner M., Nature, 2022
3) Faigenbaum & MacDonald, Acta Paediat, 2017

### PRETERM BIRTH IS ASSOCIATED WITH IMPAIRED PHYSICAL FITNESS IN PRESCHOOLERS: A CROSS-SECTIONAL STUDY

MARTÍNEZ-DE-QUEL, Ó.1, MARTÍNEZ-ZAMORA, M.1, ESTEBAN-DÍEZ, I.2, VALENZUELA, P.L.3

*<1> COMPLUTENSE UNIVERSITY OF MADRID. <2> SAN PEDRO HOSPITAL, RIOJA SALUD. LOGROÑO. <3> RESEARCH INSTITUTE OF HOSPITAL 12 DE OCTUBRE. MADRID.*

INTRODUCTION: Preterm birth has adverse consequences in health outcomes later in life. Mounting evidence shows that prematurity is associated with a lower physical fitness in middle childhood, adolescence and adulthood [1]. However, whether these effects are already visible since early childhood remains unknown. We aimed to compare the physical fitness of preterm preschoolers with that of age-matched children born at term.
METHODS: Children aged three to six years old and born preterm (<35 weeks) were recruited from the Neonatal Intensive Care Unit of San Pedro Hospital (Logroño, Spain), and age-matched children born at term (>37 weeks) were included as a control group. A variety of physical fitness indicators (body mass index, waist circumference, upper and lower limbs strength, agility, balance, cardiorespiratory fitness and flexibility) were assessed with the PREFIT battery [2] and the adapted sit and reach test. Demographics and physical activity levels were measured through the PrePAQ questionnaire. Between-group differences were analyzed by one-way ANCOVA adjusting for age, sex, and any other demographic variable differing between groups.
RESULTS: A total of 98 preterm children (gestational age 32.4 ± 2.3 weeks, age 5.1 ± 0.8 years, 45% female) and 74 controls (gestational age 39.9 ± 1.0 weeks, age 4.8 ± 0.9 years, 47% female) were evaluated. Despite similar physical activity levels (p>0.05), preterm children showed an overall poorer physical fitness compared to controls. Specifically, preterm children had a lower handgrip strength (26.4 ± 2.0 vs 7.5 ± 0.2 kg, p<0.001), lower-limb muscle strength (standing long jump: 75.9 ± 2.0 vs 85.2 ± 2.3 cm, p=0.003), agility (4 x 10-m test: 17.6 ±0.2 vs 15.8 ± 0.2 sec, p=0.001), cardiorespiratory fitness (PREFIT 20-m shuttle-run test: 3.2 ±0.2 vs 3.8 ± 0.2 min, p=0.005) and flexibility (adapted sit and reach: 14.6 ± 0.6 vs 17.6 ± 0.6 cm, p=0.001). Conversely, preterm children and controls showed similar results in balance, waist circumference and body mass index.
CONCLUSION: Prematurity seems to impair physical fitness since early childhood, which might support the need for promoting preventive strategies (e.g., exercise interventions or physical activity programs in schools).
References:
[1] Clemm, H.H., et al. Exercise capacity after extremely preterm birth: development from adolescence to adulthood. Annals of the American Thoracic Society, 2014.11(4): p.537-45.
[2] Cadenas-Sánchez, C. et al. Physical Fitness Reference Standards for Preschool Children: The PREFIT Project. Journal of Science and Medicine in Sport, 2019. 22(4): p.430–37

### THE EFFECT OF AN ACTIVE BREAKS INTERVENTION ON PHYSICAL HEALTH, COGNITIVE PERFORMANCE AND CLASSROOM BEHAVIOUR: RESULTS FROM THE I-MOVE STUDY

MASINI, A.1, MARINI, S.2, CECILIANI, A.2, BARONE, G.2, LANARI, M.3, GORI, D.1, BRAGONZONI, L.2, TOSELLI, S.1, STAGNI, R.4, BISI, M.C.4, SANSAVINI, A.5, TESSARI, A.5, DALLOLIO, L.1

*UNIVERSITY OF BOLOGNA*

INTRODUCTION: Active Breaks (ABs) intervention involve short bouts of moderate to vigorous physical activity (MVPA) conducted by the appropriately trained teachers and delivered during or between curricular lessons1. The aim of the I-MOVE study was to evaluate the effect of an ABs intervention on physical health and cognitive functioning in primary school children.
METHODS: Two groups were considered: The Active Breaks group (ABsG) performed the I-MOVE protocol three times a day and the control group (CG) continued with normal lessons. The COVID-19 pandemic led to certain design changes in the study so during the lockdown, the ABs protocol was conducted through distance learning. Cognitive performance was assessed using working memory test and physical health was monitored through Actigraph accelerometers, motor fitness test and anthropometric evaluation. Classroom behaviour was monitored using an "ad Hoc questionnaire".

RESULTS: The percentage of children in the overweight/obesity category increased in CG and decreased in ABsG (CG pre:43.6% post:46.2% vs ABsG pre:28.4% post:25.9%, p=0.02). The 6 minutes Cooper test was significantly different between-group with adjustment for baseline values (ABsG change:1.77±136.03 vs CG change:-156.42±187.53; p<0.05). For the standing long jump no statistically, significant differences were found between the two groups over time. Working memory performance increased significantly more ABsG (change:1.30±1.17) than in CG (0.96±1.20), p<0.05. Actigraph results show that the weekly time spent in MVPA and minutes spent in vigorous and moderate PA increased in both groups with no statistically significant difference between groups, only ABsG increased in light PA. The time spent in sedentary behaviour significantly increased both in ABsG and CG, +1208.29±1077.07, p=0.001 respectively, but without significant differences from baseline to follow-up when comparing the groups. Almost the entire sample of children wanted to continue with the intervention in the following year. Children reported improvements in their quality of school life including feeling better in class 75.40% and in school 82.50% when using active breaks. There were also improvements in their time on task behaviours: 52.90% reported they work easily in class, 58.80% reported they can stay seated easily, 52.90% said they could listen more clearly, and 59.60% said they learned better and were more focused after ABs. The same results were confirmed by the teachers.
CONCLUSION: The program has proven to be very effective on the childrens cognitive and cardio-fitness performance, anthropometric measures and classroom behaviour. As the intervention presents these positive effects, its implementation in schools can have a positive, sustainable and long-term impact on childhood health.
References:
1Calella P, Mancusi C, Pecoraro P, et al. Classroom active breaks: a feasibility study in Southern Italy. Health Promot Int. 2020;35(2):373-380

## 15:00 - 16:15

## Invited symposia

### IS-PN07 Metabolomics in sports and exercise science

#### METABOLOMICS IN APPLIED SPORT SCIENCE RESEARCH

OWENS, D.

*LIVERPOOL JOHN MOORES UNIVERSITY*

In the applied sports setting, new methods to profile athletes with some predictive power are constantly sought. Whether this be injury prediction, recovery status or maximizing performance. For example, large scale projects have been set up to identify genetic genomics-based biomarkers in athletes with an adequate predictive power (Pitsiladis et al., 2016). However, profiling the genome of athletes is only the tip of the iceberg as the proteome and transcriptome also influence the phenotype of the athlete. As well as the aforementioned 'omics' approaches, metabolomics is an exciting discipline as unlike genes and proteins, metabolites are the direct outcome of biochemical reactions, thus can be insightful and reliable factors in physiological profiling of athletes.
In this symposium presentation, an overview of studies that describe how metabolomics is being utilised in applied sport science studies will be given. A spotlight will be put on data from two exemplar studies from the presenter's research group that have profiled i) endurance and ii) strength and power athletes. To balance use case for metabolomics in applied sports scenarios, attention will be paid to limitations of the technique with suggested do's and don'ts of applied sports metabolomics research.
In summary, this symposium presentation will demonstrate how metabolomics can reveal novel insights allowing practitioners to develop appropriate interventions to influence performance and recovery whilst raising critical considerations for study design.
References
Pitsiladis YP, Tanaka M, Eynon N, et al. Athlome Project Consortium: a concerted effort to discover genomic and other "omic" markers of athletic performance. Physiol Genomics. 2016;48(3):183–190. PubMed ID: 26715623 doi:10.1152/physiolgenomics.00105.2015

#### CAN METABOLOMICS REVEAL NOVEL METABOLITES AND METABOLIC PATHWAYS ASSOCIATED WITH MUSCLE HYPERTROPHY?

BAUMERT, P.

*TECHNICAL UNIVERSITY OF MUNICH*

Resistance training is an attractive and low-cost intervention to increase muscle mass and function in various populations including athletes and elderly. Several studies show that resistance training not only increases muscle size and strength but also additionally improves glycaemic control (Yang et al., 2014), and increases glucose uptake (Colberg et al., 2016) as well as insulin sensitivity (Ibañez et al., 2005), suggesting metabolic adaptations. However, whilst mTORC1 has been identified as a key mediator of the protein synthesis, which increases post resistance exercise and during chronic overload, there are still many gaps in our understanding of the metabolic adaptations following muscle hypertrophy.
Thus, I will firstly present own data about the effect of muscle growth stimulation on metabolic changes in differentiated murine skeletal muscle stem cells in vitro and in hypertrophied mouse muscles in vivo. I will then put my results into the context to the limited published literature (e.g. Fazelzadeh et al., 2016) and I will present a systematic review of metabolic changes in muscle hypertrophy for the first time as part of a symposium. In this regard, I will explain the outcomes and that the identification of pathways associated with muscle hypertrophy is more important to advance this new field than only detecting changes of individual metabolites. Lastly, I will discuss the limitation of metabolomics analysis in muscle tissue and, as a consequence, the current incomplete coverage of global metabolic changes during muscle growth. The objectives of this presentation are to facilitate the understanding of the omics-based systems approach for gaining a comprehensive insight in metabolic adaptation following muscle hypertrophy, and to elicit debate of the future direction of this field, how discoveries of novel biomarkers will help to develop efficient training regimes for athletes.

**METABOLOMICS FOR IN VITRO AND IN VIVO EXERCISE SCIENCE**

LAUTAOJA, J.

*UNIVERSITY OF JYVÄSKYLÄ*

Exercise-like electric pulse stimulation (EL-EPS) of differentiated skeletal muscle cells, i.e., myotubes, evokes contractions that mimic intra- and extracellularly many of the physiological responses produced by in vivo exercise1. Besides EL-EPS, other in vitro exercise models, such as pharmacological compounds2 and myotube stretching3, exist. Strength of the in vitro exercise models is exclusive examination of the muscle cells without the interference of other cell types. This is not the case with in vivo studies. Overall, both in vivo and in vitro approaches are valuable tools in skeletal muscle and exercise research.
Different omics approaches, such as metabolomics4,5, are commonly used to examine exercise-induced changes in vivo. However, the number of in vitro EL-EPS metabolomics studies is small6,7. Additionally, although nutrition is known to have a great impact on exercise performance in vivo8, this aspect has remained understudied in vitro7,9.
We applied low-frequency EL-EPS under high- and low-glucose conditions to understand how myotube contractions and carbohydrate availability affect the C2C12 myotube, media and cell-free media metabolomics7. We observed contraction-induced uptake of glucose and release of lactate, acetate, 3-hydroxybutyrate and branched-chain fatty acids. Others have studied the effects of high- and low-frequency EL-EPS6 and stretching10 on the C2C12 myotube and media metabolomes, respectively. These studies demonstrated that high-frequency EL-EPS induced greater responses on the myotube metabolome than low-frequency EL-EPS, at least after short-term stimulation6 and that the cessation of the myotube stretching promoted myotube atrophy observed as increased media amino acid content10.
Metabolic disturbances promote exercise-induced adaptations in vivo and these responses can further be augmented by carbohydrate restriction8. When we cultured myotubes in low-glucose conditions, both the cells and the media were almost completely depleted from glucose after EL-EPS. This was not the case in high-glucose conditions. Interestingly, many of the contraction-induced responses observed in the myotube and media metabolomes were of lower magnitude in low-glucose conditions. This demonstrates that EL-EPS does not replicate all the in vivo responses to skeletal muscle contractions. That being said, in vitro exercise models improve constantly. For example, 3D muscle cell models and optimization of the cell microenvironment (e.g., hypoxia, nutrition and media flow) are being developed. Finally, it is important to keep in mind when interpreting in vitro data that the origin- and donor-specific characteristics of the skeletal muscle cell lines influence the obtained results11.

1. Nikolić et al. 2017
2. Carter & Salomon 2019
3. Ren et al. 2021
4. Sakaguchi et al. 2019
5. Schranner et al. 2020
6. Hoshino et al. 2020
7. Lautaoja et al. 2020
8. Hargreaves & Spriet 2020
9. Farmawati et al. 2013
10. Ilaiwy et al. 2016
11. Abdelmoez et al

## Invited symposia

### IS-EX01 JSPFSM-ECSS exchange: Benefit of Maternal Exercise and Physical Activity on Childrens Health

**THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY IN PREGNANCY AND CHILD HEALTH: AN EPIDEMIOLOGICAL PERSPECTIVE**

MATSUSHITA, M.

*TOKAI UNIVERSITY*

World health organization guidelines on physical activity and sedentary behaviour recommend an active lifestyle for pregnant women. These guidelines are based on cohort studies targeting maternal and fetal health outcomes, such as low birth weight of the offspring, preterm births, and a variety of child health. I will provide an overview of East Asian and Japanese birth cohort studies. Physical inactivity during pregnancy is prevalent. To provide more practical recommendations, physical activity assessment requires several unidentified information such as 1) practical exercise intensity information, 2) type of physical activity such as commuting, chores, leisure, and sports, and 3) the influence of pre-pregnancy physical activity are necessary. Cohort studies considering the above information are still lacking. Wearable sensors using ICT technologies may potentially benefit future cohort studies.

**PLACENTAL SUPEROXIDE DISMUTASE 3 MEDIATES BENEFITS OF MATERNAL EXERCISE ON OFFSPRING HEALTH**

KUSUYAMA, J.

*TOHOKU UNIVERSITY*

INTRODUCTION: Poor maternal diet increases the risk of obesity and type 2 diabetes in offspring, fueling the worldwide epidemic of these diseases. Recent animal studies have shown that maternal exercise improves the metabolic phenotype of offspring in adulthood, including improved glucose tolerance and liver function (1). Here, we demonstrated the molecular mechanisms responsible for these critical effects of maternal exercise on glucose metabolism in offspring. METHODS: 8-weeks-old C57BL/6 female mice were fed a chow or high-fat diet and housed in cages with (trained) or without (sedentary) running wheels for 2 weeks before breeding and during gestation. Offspring were sedentary and chow-fed. RESULTS: Maternal exercise improved glucose metabolism and liver function, characterized by glucose tolerance test, hepatocyte glucose production, RNA-sequence of the liver in adult offspring. Beginning at embryonic day 13.5, maternal exercise increased expression of the tricarboxylic acid cycle and fatty acid oxidation genes in offspring liver, and increased DNA demethylation at promoters of these hepatic genes. Next, we identified a novel maternal exercise-induced AMP-activated protein ki-

nase(AMPK)/isocitrate dehydrogenase/alpha-ketoglutarate/ten-eleven translocation (TET) methylcytosine dioxygenases axis in offspring liver controlling DNA demethylation. Primary hepatoblasts treated with serum from trained dams, but not sedentary dams or trained non-pregnant females stimulated this signalling pathway, suggesting the effects of maternal exercise on offspring stem from a placenta-derived serum factor(s). Proteomics of serum and RNA-sequence of the placenta from trained dams identified this factor as superoxide dismutase 3 (SOD3). Recombinant SOD3 treatment of mouse and human hepatoblasts increased AMPK-TET signalling and hepatic gene expression. The effects of maternal exercise to increase liver AMPK-TET signal, alter liver DNA methylation and gene expression, and improve offspring glucose tolerance in vivo were ablated in placenta-specific Sod3 KO mice. By utilizing the transcriptome of the placenta and reporter analysis of Sod3 promoter, we demonstrated that maternal exercise-induced expression of vitamin D receptor (VDR) and vitamin D signalling mediate placental Sod3 expression, and normal vitamin D levels are necessary for the beneficial effects of maternal exercise on offspring liver gene expression. Finally, SOD3 was increased in serum and placenta from highly physically active pregnant women. CONCLUSION: SOD3 is an exercise-induced, placenta-derived protein that improves glucose homeostasis via epigenetic changes in offspring liver, defining a novel mechanism for the beneficial effects of exercise on metabolic health (2). These findings may lead to novel therapeutic approaches to limit the transmission of metabolic disease to the next generation. REFERENCES: 1) Kusuyama et al., Nature Metabolism, 2020 2) Kusuyama et al., Cell Metabolism, 2021

**MATERNAL OBESITY AND EXERCISE; EVIDENCE AND ISSUES**

ELLIOTT-SALE, K.

*MANCHESTER METROPOLITAN UNIVERSITY*

Pregnancy has been identified as a risk factor for the development of obesity, with long lasting consequences for both maternal and child health that last years/decades. As such, managing maternal obesity is of major public health interest. The pregnancy and postpartum periods are 'teachable moments' due to the heightened awareness about health and positive attitude towards lifestyle interventions. However, there are also a number of barriers to maintaining a healthy lifestyle during this time, which makes weight management difficult. Understanding these barriers and developing mitigation strategies is essential for the design and delivery of successful exercise-based interventions. I will (i) provide an overview of current exercise-based interventions for weight management during and following pregnancy and (ii) suggest future research directions. At present, physical activity interventions that provide choice and support and involve women in their design seem to be most successful at influencing body mass and markers of health.

## Oral presentations

### OP-PN13 Ergogenic Aids I

**BEETROOT JUICE SUPPLEMENTATION DOESN´T AFFECT TO VERTICAL JUMP PERFORMANCE IN COMPETITIVE FEMALE VOLLEYBALL PLAYERS.**

LÓPEZ-LEÓN, I., MORENO-LARA, J., MUÑOZ-LÓPEZ, A., RICO, E., GUZMÁN-NEBRO, J.A., SÁNCHEZ-OLIVER, A.J., MUÑOZ-LLERENA, A., DOMÍNGUEZ, R.

*UNIVERSITY OF SEVILLE*

INTRODUCTION: Volleyball is characterized by explosive efforts and it demands agility, jumps, and blocks for athletes. Jumping ability is one of the key elements of volleyball performance (1). Vertical jumps are related to blocking, spiking, and serving abilities (2). Sports supplements that include nitrate (NO3-) rich beetroot juice (BJ) (3) has been suggested as an ergogenic aid in sport. Based on the absence of studies analysing the possible ergogenic effect of BJ on female volleyball players, this study aimed to analyse the effect of BJ on vertical jumps in female competitive volleyball players.
METHODS: 11 competitive female volleyball players with more than six years of experience who competed in the second Spanish national league (age: 22.45 ± 3.13 years; weight: 72.25 ± 7,1 kg; height: 175.64 ± 6,7 cm) participated in this study. 150 minutes before each testing session, the players ingested a total 140 mL of BJ (~12.8 mmol NO3-), or 140 mL of a NO3depleted BJ as placebo (PLA), on a radomised assignment. The players executed three different types of vertical jumps: countermovement jump (CMJ), block jump (BJ), and attack/spike jump (AJ). Between-group differences were analysed using a Studen t-test. The effect size (ES) was used for qualitative assessment. We set the statistical significance level at $p<0.05$.
RESULTS: There were no significant between-groups differences in any of the vertical jumps: CMJ (30.95 ± 2.27 vs 30.67 ± 2.83 cm; $p = 0.638$; ES = 0,11 [-0,79 - 1,00]), BJ (31.72 ± 2.52 vs 31.93 ± 2.87 cm; $p = 0.721$; 0,07 [-0,96 – 0,81]), and AJ (40.25 ± 4.60 vs 39.31 ± 4.42 s; $p = 0.324$; ES = 0,20 [-0,69 – 1,09]).
CONCLUSION: BJ supplementation has been suggested as an ergogenic aid in explosive (4) and high-intensity efforts (5). Our results did not agree with previous results. Future studies must analyse the effect on other key parameters of this sport as agility or speed. In addition, it´s necessary to analyse the possible effect of a chronic supplementation protocol.
1. L.C. Stanganelli et al. J Strength Cond Res 22, 741–749 (2008).
2. T. Sattler et al. J Strength Cond Res 29 (6), 1486–1493 (2015)
3. R. Maughan et al. Br J Sports Med 52, 439–455 (2018).
4. R. Tan et al. Int J Environ Res Public Health 19 (2), 762 (2022).
5. R. Domínguez et al. J Int Soc Sports Nutr 15, 2 (2018).

**EFFECTS OF BEETROOT JUICE SUPPLEMENTATION ON AGILITY IN COMPETITIVE FEMALE VOLLEYBALL PLAYERS**

MORENO-LARA, J., LÓPEZ-LEÓN, I., MUÑOZ-LLERENA, A., GUZMÁN-NEBRO, J.A., RICO, E., SÁNCHEZ-OLIVER, A.J., MUÑOZ-LÓPEZ, A., DOMÍNGUEZ, R.

*UNIVERSITY OF SEVILLE*

INTRODUCTION: Inorganic nitrate (NO3-), which is abundant in some green leafy vegetables and beetroot, is sequentially reduced to nitrite (NO2-) and nitric oxide (NO) following ingestion. Dietary NO3- supplementation has been reported to have ergogenic effects on improving

endurance (1), high intensity (2), and explosive efforts (3). However, the majority of the studies included only male athletes. The objective of this study was to analyse the influence of the acute supplementation with NO3rich beetroot juice (BJ) on the subsequent performance of professional female volleyball players agility ability.
METHODS: 11 female professional (second Spanish national league) volleyball players with an experience higher than six years competed in the second Spanish national league (weight: height: 175.64 ± 6,7 cm; 72.25 ± 7,1 kg; age: 22.45 ± 3.1 years) articipated in this study. The study followed a randomised double-blind cross-over design. Before each testing session, the players ingested 140 mL of NO3rich BJ (~12.8 mmol NO3-) or a NO3depleted BJ (PLA), 150 minutes before. The players executed the 0-5-0 agility test and a modified T-test in each session. We assessed the differences between BJ and PLA using a Student t-test. The effect size (ES) was also calculated. We set the statistical significance as $p<0.05$.
RESULTS: There were no significant differences between BJ and PLA for the 0-5-0 test (2.92 ± 0.16 vs 2.85 ± 0.17 s; $p = 0.046$; ES = 0.41 [-0.49 – 1.31]) nor the modified T-test (6.37 ± 0.28 vs 6.25 ± 0.35 s; $p = 0.320$; ES = 0.36 [-0.53 – 1.26]).
CONCLUSION: Acute supplementation with NO3rich BJ was not effective in increasing performance in the agility ability of female volleyball players. The absence of significant differences could be attributed to a gender effect due to a reduction of NO2- to NO blunted, based on a greater oxidative skeletal muscle phenotype than males (4). Therefore, future studies are necessary to detect possible differences in response to NO3- in females compared to males.
1. R. Domínguez et al. Nutrients, 9 (1), 43 (2017).
2. R. Domínguez et al. J Int Soc Sports Nutr 15, 2 (2018).
3. R. Tan et al. Int J Environ Res Public Health 19 (2), 762 (2022).
4. K.A. Wickham, L.L Spriet. Appl Physiol Nutr Metab 44, 915-924 (2019).

### SODIUM CITRATE OR SODIUM BICARBONATE INGESTION? A COMPARISON OF GASTROINTESTINAL SYMPTOMS AND BLOOD ALKALOSIS.

URWIN, C., SNOW, R., CONDO, D., SNIPE, R., WADLEY, G., CONVIT, L., CARR, A.

*DEAKIN UNIVERSITY*

INTRODUCTION: Ingestion of either sodium citrate (SC) or sodium bicarbonate (SB) can induce blood alkalosis, some gastrointestinal symptoms (GIS), and exercise performance improvement (1). However, direct comparisons of these supplements to-date have been limited and equivocal (REFS). Investigating the timing and magnitude of blood alkalosis and GIS responses to SC and SB supplementation may allow more evidence-based recommendations to athletes as to how and when these supplements may be used prior to exercise. This study aimed to compare the recommended dose of SC (500 mg.kg-1 BM) and SB (300 mg.kg-1 BM) supplementation for induced blood alkalosis (blood pH and [HCO3-]) and GIS (number and severity).
METHODS: Using a repeated-measures, double blinded, cross-over design, 16 healthy and active male (n = 8) and female (n = 8) completed two experimental testing sessions, with 500 mg.kg-1 BM SC or 300 mg.kg-1 BM SB ingested in gelatine capsules alongside a carbohydrate-rich meal over a 15 min period. Forearm venous blood samples were collected and immediately analysed for blood pH and [HCO3-] at baseline, immediately after ingestion, and then every 30 min for 300 min post-ingestion. GIS questionnaires were completed at the same time-points (2). Time-course and session value (i.e. peak and time to peak) comparisons of SC and SB supplementation were performed using linear mixed models.
RESULTS: Peak blood pH and [HCO3-] were similar for SC and SB ($p = 0.729$, 0.308), as were delta blood pH and [HCO3-] ($p = 0.654$, 0.478). Blood [HCO3-] was ≥ 6 mmol.L-1 above baseline from 180-240 min post-ingestion for SC, significantly later than for SB (120-180 min, $p < 0.001$). GIS were mostly minor, and peaked 80-90 min post ingestion for SC, and 35-50 min post ingestion for SB. There was no significant differences for the number or severity of GIS reported ($p > 0.05$ for all parameters).
CONCLUSION: When comparing SC and SB, similar blood alkalosis and GIS was observed post-ingestion with regards to peak and total values. However, the time-course of these responses did differ, as had previously been suggested (3). Specifically, for SC (500 mg.kg-1 BM), blood alkalosis peaks and GIS subside by 180-240 min post-ingestion. For SB (300 mg.kg-1 BM), the same occurs by 120-180 min post-ingestion. For both supplements, the most frequently reported GIS were bloating, belching and flatulence, although all were relatively infrequent and of minor severity. Therefore, to maximise alkalosis and minimise GIS, our findings suggest SB should be ingested 2-3 hours prior to exercise, and SC 3-4 hours prior to exercise.
References
(1) Carr et al., Sports Med, 2011
(2) Gaskell et al., IJSNEM, 2019
(3) Peacock et al., RSM, 2021

### DIETARY INORGANIC NITRATE AS AN ERGOGENIC AID: AN EXPERT CONSENSUS DERIVED VIA THE MODIFIED DELPHI TECHNIQUE

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INTRODUCTION: Dietary inorganic nitrate is a popular nutritional supplement, which augments nitric oxide bioavailability and may enhance exercise performance. Despite considerable research exploring the effects of dietary nitrate during exercise, there is currently no expert consensus on how, when and for whom this compound could be recommended as an ergogenic aid. Additionally, there is no consensus on the safe administration of dietary nitrate as an ergogenic aid.
METHODS: In this study, we used the modified Delphi technique to establish the views of 12 expert panel members on the use of dietary nitrate as an ergogenic aid. Over three iterative rounds (two via questionnaire and one via videoconferencing), the expert panel members voted on 222 statements relating to the use of dietary nitrate as an ergogenic aid. Consensus was reached when > 80% of the panel provided the same answer (i.e., yes or no). Statements for which > 80% of the panel cast a vote of insufficient evidence were categorised as such and removed from further voting. These statements were subsequently used to identify directions for future research.
RESULTS: The 12 panel members contributed to voting in all three rounds. A total of 39 (17.6%) statements reached consensus across the three rounds (20 yes, 19 no). In round one, 21 statements reached consensus (11 yes, 10 no). In round two, seven further statements

reached consensus (4 yes, 3 no). In round three, an additional 11 statements reached consensus (5 yes, 6 no). The panel agreed that there was insufficient evidence for 134 (60%) of the statements, and were unable to agree on the outcome of the remaining statements.
CONCLUSION: This study outlines the current expert consensus on dietary nitrate as an ergogenic aid, which may be of value to athletes, coaches, practitioners and researchers. Findings suggest that the effects of dietary nitrate are reduced in individuals with higher aerobic fitness (V̇O2peak > 60 ml/kg/min) and therefore aerobic fitness should be taken into account when considering use of dietary nitrate as an ergogenic aid. It is recommended that athletes hoping to benefit from dietary nitrate supplementation should consume 8–16 mmol nitrate acutely or 4–16 mmol/d nitrate chronically (with the final dose ingested 2–4 hours pre-exercise) to maximise ergogenic effects. From a safety perspective, athletes may be best advised to increase their intake of nitrate via vegetables and vegetable juices. Acute nitrate supplementation up to ~ 16 mmol is believed to be safe. However, the safety of chronic nitrate supplementation requires further investigation. The expert panel agreed that there was insufficient evidence for most of the appraised statements, which highlights the need, and considerable scope, for additional research in this area.
*KM and SP are joint senior authors

**EFFECT OF NITRATE SUPPLEMENTATION AND HYPOXIC TRAINING ON OXIDATIVE STRESS AND NITRIC OXIDE METABOLISM IN ENDURANCE ATHLETES**

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INTRODUCTION: Hypoxic exercise was shown to increase the oxidative stress through overproduction of reactive oxygen species (ROS). But, chronic aerobic exercise training decrease the oxidative stress at rest and post- exercise by improving the antioxidant enzymatic efficiency. However, little is known regarding the effects of several weeks of HIIT performed in hypoxia on the oxidative stress and antioxidant systems. In other hand, nitrates supplementation is a strategy used to improve exercise performance when microvascular perfusion may be one of the limiting factors. The benefits of nitrates supplementation rely partly on the increases in nitric oxide bioavailability and in subsequent muscular microvascular perfusion. Moreover, NO has antioxidant properties and thus nitrate supplementation may modulate the OS resulting from high-intensity exercise in hypoxia. The goal of this study was therefore to assess the effects of nitrate supplementation during HIIT performed in normobaric hypoxia on oxidative stress and antioxidant systems.
METHODS: 30 subjects trained in endurance were randomised in 3 groups: hypoxic training + nitrate supplementation (HNO); hypoxic training + placebo (HPL); normoxic training + placebo (NPL: control, CON). Participants completed 4 weeks with 3 sessions per week performed in hypoxia or in normoxia. Participants ingested nitrates or placebo 2h30/3h before the beginning of each session. Blood tests were done at rest in pre- and post-intervention (i.e., one week before the training period and one week after). Antioxidant enzymes activity (SOD; GPX; catalase), NO metabolites (NOx), ferric reducing antioxidant power, myeloperoxidase activity (MPO), advanced oxidation protein products (AOPP), Malondialdehyde (MDA), nitrotyrosine and uric acid were measured in plasma
RESULTS: In post-training, nitrates (p=0.07) and NOx (p=0.06) were higher in HNO, compared to CON group. HNO increased both nitrates (p=0.1, +32%) and NOx (p=0.09, +33%) from pre- to post-intervention, whereas HPL and NPL did not. GPX increased during the training period (time effect p=0.025) independently of the group. However only CON group significantly increased GPX (p=0.017, +20%), while HPL and HNO groups did not change. Similarly, MDA increased during the training period (time effect p=0.0003). Both HNO (p=0.001, +60%) and CON groups increased (p=0.023, +30%) while HPL did not change.
CONCLUSION: Our results confirm in trained subjects that normoxic HIIT increases GPX as already observed in untrained subjects. The addition of hypoxia blunts this increase, maybe by a lower metabolic stimulus during hypoxic sessions. Hypoxia seems limit the MDA increase observed in CON group and could result to lower mitochondrial ROS generation during hypoxic sessions. The increase in MDA in HNO group is intriguing; however, nitrate supplementation could allow develop higher power during hypoxic sessions. The reported low effects of supplementation on OS markers may come from the moderate circulating increase in NOx.

## Invited symposia

### IS-AP06 Flywheel resistance exercise: rationale, current evidence, and practical applications

**ACUTE AND CHRONIC PERFORMANCE CHANGES WITH FLYWHEEL RESISTANCE EXERCISES**

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The concept of flywheel training has been developed in the recent past with the first evidence supporting its efficacy as a conditioning method dating back to the early 1990's (Colliander and Tesch, 1990). Flywheel training was initially studied and implemented to mitigate the negative effects of the absence of gravity on astronauts during space travels (Norrbrand et al., 2008). Later, practitioners understood the advantages offered by this methodology and they started to use flywheel training for the performance development of athletes (Maroto-Izquierdo et al., 2017).
Previous studies have described the mechanical advantages of these devices and attempted to clarify the neurophysiological mechanisms, morphological adaptations and training effects induced by flywheel exercise (Beato and Dello Iacono, 2020; Norrbrand et al., 2008). In detail, flywheel exercise is characterized by the combination of both concentric and eccentric contractions, which offers neural patterns and mechanical responses that have important implications for both acute changes and chronic adaptations (Beato et al., 2019; Petré et al., 2018).
While the acute enhancement of athletic performance using traditional resistance exercises has been extensively investigated, evidence supporting flywheel exercises for such a purpose is still limited (Cuenca-Fernández et al., 2018; Beato et al., 2020). Preliminary findings suggest implementing flywheel exercises to elicit acute performance enhancement may be a viable alternative to traditional protocols; however, there is no evidence about what conditioning activity (flywheel vs. traditional protocols) may be superior in enhancing athletic performance (Beato et al., 2019). About the use of flywheel training to obtain chronic adaptations, previous evidence reported that significant increases in muscle volume and cross-sectional area (Petré et al., 2018) and in sport-specific parameters can be expected following >6 weeks of training (de Hoyo et al., 2015; Allen et al 2021).

However, the effect of flywheel training is associated with some factors such as training load components, which will determine the specificity of stimuli, as well as, the user's familiarization level, which is important to optimize the effect of the exercises, e.g., when specific eccentric strategies are needed to decelerate the movement at the desired joint angles (Beato and Dello Iacono, 2020). Additionally, from a methodological point of view, the choice of the exercises (e.g., training variation), training intensity, volume, and frequency, provide the desired stress to achieve the sport-specific adaptations in line with the program objectives. Therefore, this presentation aims to better understand the motivations of some adaptive responses (i.e., acute and chronic) and to summarize studies that elucidate how to better implement flywheel technology into strength training protocols.

### MUSCLE ACTIVATION, BIOMECHANICAL LOADING AND HYPERTROPHY WITH FLYWHEEL RESISTANCE EXERCISE

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The gravity-independent flywheel exercise device was first developed for use in space to counteract muscle loss in astronauts during long-duration space flights (Berg and Berg, 1993, Berg and Tesch, 1994), and has been used in many training programs and research studies ever since. The flywheel exercise device allows for varying loading throughout the repetitions, and this talk will cover some of the differences between flywheel resistance exercise and traditional weight training.

Traditional weight training commonly provides constant load and therefore often call for submaximal muscle activation during the eccentric actions, and maximal or near maximal muscle activation around the so called "sticking point" in the concentric actions. During flywheel resistance exercise, the force applied to the strap in the concentric phase is transformed to kinetic energy of the rotating flywheel, and by decelerating the flywheel rotation over a short time in the last part of the eccentric action, it is possible to produce eccentric overload (Fernandez-Gonzalo et al., 2014). The subsequent high muscle activation during the concentric and parts of the eccentric action of flywheel resistance exercise (Pozzo et al., 2006) may promote a more efficient resistance training, rather than being restricted at a submaximal level as in traditional weight training (Norrbrand et al., 2008, Maroto-Izquierdo et al., 2017).

Previous flywheel studies have demonstrated substantial eccentric overload during open-loop knee extensions, and consequently high muscle activation during the eccentric action (Norrbrand et al., 2010). However, eccentric overload was not always apparent in closed-loop leg-extension exercises (Alkner and Tesch, 2004, Norrbrand et al., 2011, Sjöberg et al., 2021), possibly due to that the concentric peak force commonly occurs where muscle mechanics are favourable, i.e. at relatively extended knee and hip angles, whereas the peak eccentric force is produced in the unfavourable flexed position close to the turning point (Sjöberg et al., 2021). Thus, depending on which type of workout that is performed, e.g. body positioning, lever arms, and muscle length will affect the force output throughout the flywheel repetitions.

Furthermore, flywheel resistance training was proven effective counteracting muscle atrophy during 90 days of bed rest (Alkner and Tesch, 2004), induced substantial hypertrophy following only 5-7 weeks of resistance exercise (Seyennes et al., 2007, Norrbrand et al., 2008, Lundberg et al., 2013), and was reported to induce an overall greater hypertrophy response than traditional weight-stack resistance training (Maroto-Izquierdo et al., 2017).

In summary, the present talk will cover the muscle activation and the biomechanical loading during flywheel resistance exercise, and the resulting hypertrophy response following flywheel resistance training.

### FLYWHEEL RESISTANCE TRAINING METHODOLOGICAL APPLICATIONS

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Coaches and practitioners may benefit from a proper combination of important training variables such as loading intensity and training volume in resistance training. What is more, the percentage of velocity loss along repetitions (i.e., velocity-based training) can be helpful to decide the desired fatigue level While there is extensive knowledge on how to implement traditional resistance training exercises on programs. (González-Badillo and Sánchez-Medina, 2010, Pareja-Blanco et al., 2017), only over the last years the methodology know-how of flywheel resistance training devices is being developed.

Different technologies can be used to monitor the loading intensity using flywheel devices (Muñoz-López et al., 2021b). Recently, some research showed progressive overloading while the moment of inertia is increased (McErlain-Naylor and Beato, 2021). Furthermore, there are interesting differences in the overload profile if men are compared to women (Martinez-Aranda and Fernandez-Gonzalo, 2017), highlighting the importance of considering an individualized approach when using flywheel devices. Recent research also applied the velocity-based training approach in these devices (Muñoz-López et al., 2021c; Sabido et al., 2018). In particular, it has been shown that a minimum of 3-4 repetitions are required at the beginning to establish a target training zone. (Sabido et al., 2018). Indeed, the mechanical loss differs from the mechanical output used (Muñoz-López et al., 2021c). Interestingly, the mechanical loss in flywheel devices is more likely curvilinear than linear. For example, executing more than 20 repetitions on the leg extension exercises did not show more mechanical decrements (Muñoz-López et al., 2021c).

Finally, during this talk, I will also cover an important concept surrounding the use of flywheel resistance training devices: the so-called "eccentric overload" (Berg and Tesch, 1998). A recent meta-analysis showed that most of the research using flywheel devices did not prove if an eccentric overload was achieved or not (Muñoz-López et al., 2021b). Usually, practitioners link the eccentric overload training with the simple use of flywheel devices, but it has been proved that it is not mandatory (Núñez et al., 2020). First, a proper definition of the eccentric overload in flywheel devices remains to be defined. Secondly, important methodological aspects such as the familiarization (Tous-Fajardo et al., 2006), the moment of inertia used (McErlain-Naylor and Beato, 2021), the mechanical variable monitored (Muñoz-López et al., 2021b), or the flywheel shaft type (Muñoz-López et al., 2021b) could affect the eccentric overload measurement. In summary, this talk will highlight how to effectively manage important methodological considerations in the daily practice of using resistance training devices based on scientific evidence.

## OP-AP10 Endurance Running

### RELATIONSHIP BETWEEN PHYSIOLOGICAL PARAMETERS AND TIME TRIAL PERFORMANCE OVER 1, 2 AND 3 KM IN WELL-TRAINED RUNNERS

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INTRODUCTION: Middle distance running is unique due to its proximity to sprint running. Athletes competing over these distance display various physiological profiles [1]. Due to increasing anaerobic energy supply and altered muscular demands of high velocity running, differences become more pronounced with distances bordering sprint events [2]. Previous research has focused on comparing physiological measures in different groups of athletes specialized in distinct running distances [3]. However, within-group comparisons of athletes participating over various distances are rare. Therefore, it was the aim of this study to assess the relationship of physiological variables and running performance over 1-, 2- and 3-km time-trials (TT) close to the sprint-endurance divide in a single cohort of athletes.
METHODS: Twenty well-trained male sprinters, middle- and long-distance runners/triathletes performed several laboratory tests (incremental test, ramp test, sprint test, constant load tests) to determine V̇O2max, running economy (RE), fractional utilization of V̇O2max at maximal lactate steady-state (%V̇O2max), maximal fat oxidation (MFO) and maximal lactate accumulation rate (V̇Lamax) [4]. As performance tests, TT over 1, 2, and 3-km were performed on an outdoor track. Relationships between physiological parameters and TT velocity as well as 100-m performance (v100) were assessed by correlation coefficients and confidence intervals (CI).
RESULTS: Participants completed the 100-m and 1-, 2-, and 3-km TT in 12.8 ± 0.8, 173.0 ± 10.6, 383.9 ± 24.7 and 606.0 ± 45.5 seconds, respectively. V̇O2max showed the highest positive relationship with performance over all TT distances ($p < 0.001$) from 1 to 3 km ($r = 0.66$, $r = 0.80$, $r = 0.84$, respectively), while no significant correlation was present with v100 ($r = -0.03$, $p = 0.90$). Despite overall lower correlation coefficient and broader CI, MFO showed similar results. V̇Lamax and RE were positively correlated with v100 and displayed increasingly negative correlation for TT, whereas no significant correlation was found for 1000-m. %V̇O2max was not significantly correlated with TT nor v100.
CONCLUSION: In line with previous research, aerobically determined variables become increasingly relevant with growing running distance [1]. In contrast, anaerobic power expressed as V̇Lamax, has increasingly negative influence on competitions exceeding ~3 min. Hence, running durations of 1.5-3 min seem to represent the divide of sprint and endurance running . Based on these results, practitioners should focus on enhancement of aerobic measures even for distances close to the sprint-endurance divide. Training emphasizing anaerobic power should be progressively reduced with increasing competition duration due to growing negative influence of anaerobic metabolism.
1) Haugen et al. (2021) Sports Med
2) Gastin (2001) Sports Med
3) Svedenhag & Sjödin (1984) Int J Sports Med
4) Quittmann et al. (2020) J Sci Med Sport

### INTERVAL TRAINING SESSION DESIGN, INTENSITY CONTROL AND THE EFFECTS ON ACCUMULATED TIME ABOVE 90% VO2MAX

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INTRODUCTION: The accumulation of time above 90% of VO2max (t>90%VO2max) has been suggested as a potentially important stimulus for endurance adaptation [1]. Multiple factors of methodological (e.g. session design) and physiological (e.g. anaerobic threshold in % of VO2max) nature can be the reason for the large variation in t>90%VO2max observed in recent studies [2,3]. Therefore, this study aimed to investigate how two different interval sessions with two methods of controlling intensity influenced time accumulated above 90% of VO2max.
METHODS: Twelve well-trained cyclists and triathletes (VO2max: 68±6.3 and maximal aerobic power (MAP): 4.9±0.5 W/kg) performed preliminary testing of VO2max, anaerobic threshold and time to exhaustion at MAP. Subsequently, the athletes performed a short interval session (SI) consisting of 3 rounds of 13 repetitions of 30 seconds effort with 15 seconds rest and a long interval session (LI) consisting of 6 rounds of 5 minute efforts with 2.5 minutes rest. Both interval sessions were completed two times. In the fixed condition the intensity was set to 84 [2] and 100% [4] of MAP for SI and LI respectively while an effort-based approach was used for the free intensity condition (i.e. the participants were instructed to aim to achieve the greatest possible average work rate over all intervals). Session RPE was recorded 30 minutes after the end of each session.
RESULTS: The average work rate was greater ($p < 0.01$) in the free (SI: 316±42W & LI: 323±44W) compared to the fixed (SI: 296±42W & LI: 300±43W) condition. In the fixed condition, SI led to grater t>90%VO2max compared to LI ($p < 0.01$ SI: 420±259sec & LI: 178±159sec). However, there was no statistically significant difference ($p = 0.32$) in t>90%VO2max between SI (1130±204) and LI (1016±312). The SI sessions had statistically significantly ($p < 0.01$) higher ending blood lactate concentrations compared to LI in both the fixed (SI: 5.83±1.86 & LI: 4.68±1.56) and free (SI: 8.57±2.03 & LI: 7.73±2.19) conditions. Finally, there was no statistically significant difference ($p = 0.28$) in the session RPE between the SI and LI but the free intensity was rated harder ($p < 0.01$) compared to the fixed.
CONCLUSION: While the fixed intensities led to differences in t>90%VO2max between the SI and LI sessions, the effort-based approach resulted in no such differences which demonstrates the importance of details in the design of exercise sessions. Although using the effort-based approach made both SI and LI sessions harder (i.e. as demonstrated through lactate and session RPE), which must be accounted for in daily training practice, and likely requiring experienced athletes, the method may provide a better way of intensity control when comparing different exercise sessions.

### EFFECT OF PERFORMANCE LEVEL ON CHANGES IN ECONOMY DURING PROLONGED RUNNING

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INTRODUCTION: Running economy (RE) is an important determinant of endurance running performance [1]. Although RE is known to be sensitive to fatigue during prolonged running [2,3], the pattern of this deterioration may be mediated by training status, which currently remains unexplored. The aims of this study were to quantify the changes in RE during a prolonged run and compare changes between sub-populations of male endurance runners.
METHODS: Thirty-four well-trained distance runners (maximal oxygen uptake (VO2max) 62.7±7.3 ml/kg/min; 10km time 35:57±4:24) completed two treadmill trials separated by 5-10 days. The first trial involved an incremental test to determine lactate threshold (LT) and VO2max. The second trial involved a 90 min run at the speed corresponding to LT (sLT). Respiratory gases were collected at 15 min intervals for 5 min, and blood lactate (BLa) was measured at 15, 60, and 90 min. Subsequently, two subgroups of 12 athletes were identified based on 10km race time as high-performers (HP; 10km <33:00, VO2max 70.0±5.0 ml.kg-1.min-1) and low-performers (LP; 10km 38:00-45:00, VO2max 56.7±4.4 ml.kg-1.min-1) A two-way repeated measures ANOVA with Bonferroni post-hoc corrections was used to detect changes over time and between groups, and effect sizes (ES) were calculated as Cohen's d. Significance was defined as $p<0.05$.
RESULTS: The athletes ran at 14.3±1.5 km/h, corresponding to 79.8±2.9 % of VO2max, and mean RE was 212.6±12.0 and 220.6±13.7 ml/kg/km at 15 and 90 min, respectively. Compared to the 15 min time-point, RE remained unchanged at 30, 45 and 60 min but was significantly elevated after 75 min (1.8±2.6%, $p=0.003$, $d=0.30$) and 90 min (3.6±2.9%, $p<0.001$, $d=0.57$). Between 15 and 90 min, the respiratory exchange ratio (RER) remained unchanged (0.92±0.03 vs 0.91±0.03), but BL increased from 1.7±0.3 to 2.5±0.6 mMol/L ($p<0.001$, $d=0.62$). The two subgroups did not differ in RE after 15 min (HP: 214.3±10.6 ml/kg/km, LP: 212.1±10.0 ml/kg/km), and although the difference in RE change after 75 min wasn't significant, there was a large effect of performance level on it (HP: 1.5±2.7, LP: 3.3±2.6%, $p=0.06$, $d=0.81$). The between-group difference in RE change at the 90 min time-point was also not significant (HP: 3.7±2.0, LP: 5.0±3.6%, $p=0.29$, $d=0.44$).
CONCLUSION: During a 90 min run at sLT, RE remains stable until 60 min before deteriorating significantly in well-trained male runners. BLa also increases as the exercise progresses, whereas RER remains stable. The performance level of endurance runners didn't significantly influence changes in RE between the two groups, although a moderate effect was reported. More data is required to clarify the possible differences depending on performance level.
1. Joyner (2008); 2. Brueckner et al. (1991); 3. Kyrolainen et al. (2000)

### SEX DIFFERENCES IN PERFORMANCE FATIGABILITY DO NOT AFFECT THE HALF-MARATHON PACING STRATEGIES OR PERCEIVED EXERTION IN RECREATIONAL TRIATHLETES

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INTRODUCTION: Many factors have been shown to affect the pacing adopted by athletes during endurance events, such as perceived exertion and performance fatigability[1]. Alterations in muscular function after a prolonged running race have already been reported[2], with greater impairment of muscle contractile properties as the distance increases[3]. Moreover, sex differences have been reported in both pacing[4] and the maximal voluntary isometric contraction (MVIC) force decrease after long-distance races[5]. During triathlons, athletes run after swimming and biking and pacing is affected by the previous portions of the race[4]. Therefore, the purpose of the present study was to investigate the effects of MVIC force loss during a triathlon race on the sex differences in pacing strategies and rating of perceived exertion (RPE) during running. We hypothesize that a decrease in MVIC force would be correlated to a positive pacing and a faster increase in RPE.
METHODS: Seventeen recreational triathletes, 8 females (F; age: 43.3±10.4 y) and 9 males (M; age: 46.6±7.8 y) were tested in an official triathlon race (1.9 km swim, 90 km bike and 21.1 km run). Knee extensors MVIC force was assessed at pre-race (Pre) and immediately before the running section (T2) and the strength decrease from Pre to T2 (ΔS) was calculated. Pacing data were obtained by individual GPS tracking devices. The RPE (CR-10 scale) of each triathlete was collected at 15 equal-distant points during the half marathon. Non-parametrical statistical analysis was performed to assess between and within sex groups differences in MVVIC, ΔS, pace and RPE.
RESULTS: Higher absolute MVIC force at Pre (M: 491.4±120.9 N; F: 357.9±83.0 N) and T2 (M: 381.1±93.3 N; F: 310.9±74.1 N) were found in M compared to F ($p<.05$), but F showed a lower ΔS (M: -23.1±1.6 %; F: -15.3±2.6 %; $p<.001$). No sex differences were observed in the average running speed (M: 362.7±88.5 s/km; F: 383.8±58.9 s/km; $p=.736$), and speed decrement from the 8th km (M: from 331±55 s/km to 387±59 s/km; F: from 347±55 s/km to 409±59 s/km) with an overall positive pacing strategy. RPE increased from the 16th km to the end of the race (from 7±2 to 9±1 in both M and F; all $p<.05$) with no difference between sexes.
CONCLUSION: Despite a larger decrease in the MVIC force of the knee extensors prior to running, M showed similar decrease in speed or increase in RPE to F throughout the following half-marathon. These results suggest that the pacing strategy adopted by athletes during triathlons is dependent on the complex interplay of physiological and psychological factors that can contribute to fatigability and thus to overall performance.
References:
[1] Millet (2011)
[2] Konings (2018)
[3] Temesi (2021)
[4] Wu (2015)
[5] Temesi (2015)

**PHYSIOLOGICAL CHARACTERISTICS OF WORLD-CLASS KENYAN RUNNERS – MAXIMAL AEROBIC CAPACITY AND RUNNING ECONOMY**

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INTRODUCTION: Kenyan middle and long-distance runners have become a major research interest over the past years and even more recently with the new flood of world records in such events since 2016 [1-3]. Such performances depend on three main physiological factors: an athletes' maximal oxygen uptake or VO2max; their ability to sustain a high percentage of that VO2max for long periods of time; and an athletes' ability to move efficiently at submaximal speeds, representing a good running economy [4,5]. While the first two factors respond to training, technological advances such as new running shoes can improve running efficiency [3,6]. The aim of this study was to measure the VO2max and running economy on a lab treadmill in world-class Kenyan distance runners at two different intensities. We then compared this data to the literature in an attempt to explain the recent flurry of world records.
METHODS: Seven world-class male Kenyan runners (age: 22.7 ± 3.2 years; weight: 59.9 ± 4.8 kg; height: 174 ± 5 cm) who had an official mean personal record for the half-marathon of 59:30 ± 0:48 min:s, and a 10 km personal best of 27:33 ± 0:41 min:s) were recruited and completed maximal and submaximal laboratory-based tests (adidas AG, Herzogenaurach, Germany). Assessments included a maximal rate of oxygen uptake test and submaximal steady state running economy trials on a treadmill related to both marathon (75% vVO2max) and 10km pace (90% vVO2max) during three separate visits.
RESULTS: The measured VO2max of the world-class runners was 75.9 ± 3.5 mL/kg/min which can be classified into the top range of values found in previously published literature for a similar population, which overall ranged from 60.7–85.3 mL/kg/min with an average of 71.9 mL/kg/min [7,8]. The submaximal running economy showed large inter-subject variability and at 75% vVO2max was 192.3 ± 8.1 mL/kg/km or 54.5 ± 2.0 mL/kg/min, and at 90% vVO2max was 184.1 ± 10.1 mL/kg/km or 61.9 ± 3.3 mL/kg/min, both of which are in the middle of the range of previously reported values for a similar population [9].
CONCLUSION: This study found the obtained physiological values from world-class runners to be in line with those already published suggesting the recent improvements leading to a new flood of world records might not be physiological, but other factors such as novel shoe designs may play an important role in terms of running economy as previously suggested [3,10].
REFERENCES:
1. Tucker et al., Int J Sports Physiol Perform, 2015
2. Jones et al., J Appl Physiol (1985), 2021
3. Muniz-Pardos et al., Sports Med, 2021
4. Joyner et al., Sports Med, 2019
5. Foster et al., Sports Med, 2007
6. Conley et al., Phys Sportsmed, 1981
7. Weston et al., Med Sci Sports Exerc, 2000
8. Muniz-Pardos et al., Curr Sports Med Rep, 2018
9. Lucia et al., Appl Physiol Nutr Metab, 2006
10. Rodrigo-Caranza et al., Sci Rep, 2021

## Oral presentations

### OP-MH15 Exercise and training in patient populations

**THE EFFECT OF RESISTANCE TRAINING ON THE MUSCLE STRENGTH AND OVERALL MACROSCOPIC AND MICROSCOPIC QUALITY OF SKELETAL MUSCLE TISSUE IN HYPOGONADAL MEN**

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INTRODUCTION: Hypogonadism in men is considered a clinical syndrome manifesting with low testosterone levels (TT), associated with a decline in muscle mass, muscle strength, increased adiposity, and visceral obesity, altogether leading to various alterations in the metabolism of these patients. The overall muscle atrophy during hypogonadism is particularly important, as it is one of the major contributors to normal physical function. However, there is still a lack of studies dealing with the effect of regularly performed physical activity on hypogonadism. The study aimed to examine the effect of a 12-week resistance training programme on body composition, muscle strength and skeletal muscle cell parameters in hypogonadal men, and determine their skeletal muscle tissue quality both, on the macroscopic and microscopic levels.
METHODS: In the study, we compared the effect of resistance training (RT) on hypogonadal patients without hormonal therapy (HP: n=6; age:48.41±6.38 years; body weight: 95.25±13.90 kg; TT level =7.9±1.75 nmol/L), and treated hypogonadal patients (HPT: n=8; age:43.00±3.19 years; body weight: 99.09±26.53 kg; TT level= 12.85±3.44 nmol/L), with control group of eugonadal males (EM: n=8; age:49.31±5.84 years; body weight: 85.97±7.49 kg; TT level =15.81 ±3.99 nmol/L). Within 12 weeks subjects performed RT twice a week. The training program consisted of 6 exercises at an intensity from 60-80% of 1RM. Body composition was measured by DXA and muscle strength was measured by predicted dynamic leg press 1RM from multiple repetition maximum. To compare the effect of 12-week training on the skeletal muscle composition, percutaneous muscle biopsies from Vastus Lateralis were performed both, before and after the intervention. Immunohistochemical analyses (IHC) were used to determine the muscle morphology variables of slow-twitch (type I) and fast-twitch (type II) cross-sectional area (CSA), myonuclear number and satellite cell (SC) density.
RESULTS: A significant increase in lean mass was observed both, in HP ($p<0.05$) with an average increase of 2.73 kg, and HPT ($p<0.05$) group. HM also showed a trend to increase muscle mass on average by 2.27 kg ± (d=0.53). Muscle strength of lower limbs increased in all three groups ($p<0.01$). When subjects were merged, a negative correlation between TT and body mass ($p<0.01$) and a positive correlation

between TT and lean mass (p<0.05) was found before and after the intervention, in both groups The increase in CSA, myonuclear number and SC was in all groups after the intervention.
CONCLUSION: In conclusion, the study proved significant improvement in muscle strength and positive changes in muscle mass regardless of the overall levels of testosterone. There were also positive changes on the microscopic level of the skeletal muscle tissue. The outcomes might be useful for their clinical relevance in the hypogonadal males treatment
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**CORRELATION BETWEEN DIFFERENT MEASURES OF EXERCISE CAPACITY AND QUALITY OF LIFE IN COPD**

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INTRODUCTION: Airflow obstruction and impaired exercise capacity are the main clinical characteristics of chronic obstructive pulmonary disease (COPD). It is unclear whether physiological impairments are reflected by functional impairments in daily life or other aspects of health status and dyspnea evaluation. In this prospective cross-sectional study, we explored the relationship between different measures of exercise capacity, and symptoms and quality of life (QoL) in patients with COPD.
METHODS: 42 patients with moderate to severe COPD participated. Measures of exercise capacity included: oxygen consumption (VO2) at the anaerobic threshold (AT) and at peak exercise (peak VO2) during a maximal cycle ergometer test; endurance time (ET-hiCWR) at a high intensity constant work rate (70% of peak work-rate (WR) achieved in the maximal test); the time constant for VO2 kinetics (tau) in a moderate intensity constant WR exercise test; and 6-minute walk distance (6MWD). Patient reported outcome measures (PROMs) of health impairment were obtained by: St. George Respiratory Questionnaire (SGRQ), divided into 3 domains (symptoms, activity, and impacts) scored 0 to 100 (higher score = worse impairment), from which a total score was calculated; and Baseline Dyspnea Index (BDI), a 24 item multidimensional measurement of dyspnea during daily activities. Correlations between measures of exercise capacity and PROMs were calculated by Spearmans test.
RESULTS: 36 patients with COPD (23 males, FEV1 = 43±10%pred.) completed all evaluations. No correlation was found between pulmonary function at rest and PROMs. Peak VO2 correlated with SGRQ total score (r=-0.507, p= 0.002) and domain scores, and with BDI (r=0.619, p=0.0001). 6MWD correlated with the activity domain score of SGRQ (r= -0.517, p=0.013). No other correlations were found between 6MWD, tau, ET-hiCWR, AT and SGRQ total or domain scores or BDI score.
CONCLUSION: In a cohort of patients with moderate to severe COPD, peak VO2 was the only measures of exercise capacity that correlated with PROMs of QoL and dyspnea. 6MWD, tau, ET-hiCWR and AT were not significantly correlated to PROM scores. These results shed light on the relationship between metrics related to the physiological responses to exercise and the quality of life in COPD patients.

**A 12-WEEK CONCURRENT TRAINING INTERVENTION IMPROVED MUSCLE DYSFUNCTION BUT NOT SYSTEMIC OXIDATIVE STRESS AFTER 1 YEAR OF TRAINING CESSATION IN OLDER PEOPLE WITH COPD.**

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INTRODUCTION: Skeletal muscle dysfunction is a major problem in patients with chronic obstructive pulmonary disease (COPD), affecting both ventilatory and non-ventilatory muscles (1). Muscle dysfunction is characterized by a decreased proportion of type I muscle fibers and oxidative enzyme capacity and a reduced exercise tolerance (2). Concurrent training combining power-oriented resistance training (RT) and high-intensity interval training (HIIT) has been shown to improve both muscle dysfunction and systemic oxidative stress in the short term (3), however, the long-term effects remain poorly known. This study aimed to assess the effects of a 12-week concurrent training program composed of power-oriented RT and HIIT on physical performance, quality of life, pulmonary and neuromuscular performance, and systemic oxidative stress in older adults with COPD after 1 year of training cessation.
METHODS: A total of 29 older adults with COPD were randomly divided into intervention (INT; n=14) or control (CON; n=15) groups, of which 21 completed the 1-year detraining follow-up (INT, n=8; CON, n=13; 76.9±6.8 years). Primary outcomes were Short Physical Performance Battery (SPPB), health-related quality of life (EQ-5D-5L), vastus lateralis muscle thickness (MT; ultrasonography), peak oxygen volume (VO2peak) and peak work rate (Wpeak) (incremental cardiopulmonary exercise test), rate of force development (RFD; force platform), leg press maximum power (Pmax; force-velocity relationship) and systemic oxidative stress and antioxidant activity (protein carbonylation and malondialdehyde levels, and catalase activity, respectively). Assessments were performed at baseline and 1 year after completion of training. Mixed model repeated measures ANOVA with Bonferroni's post hoc tests was used.
RESULTS: INT group improved SPPB (Δ=1.0 point; p<0.05), quality of life (Δ=0.07 points; p<0.05), MT (Δ=0.06 cm; p<0.05), VO2peak (Δ=1.3 ml·kg-1·min-1; p<0.05), Wpeak (Δ=10.3 W; p<0.05), RFD (Δ=834 N·s-1; p<0.05) and Pmax (Δ=62.2 W; p<0.05) while no changes were observed in the CON group (all p>0.05). No changes in systemic oxidative stress were observed in either group in the long term (all p>0.05).
CONCLUSION: Twelve weeks of concurrent training were enough to improve physical performance, quality of life, exercise tolerance and neuromuscular performance but not systemic oxidative stress in older adults with COPD after 1 year of training cessation.

## Oral presentations

### OP-PN23 Hypoxia II

**EFFECTS OF PRE-TERM BIRTH ON THE CARDIO-RESPIRATORY RESPONSES TO HYPOXIC EXERCISE IN CHILDREN**

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INTRODUCTION: Pre-term birth is associated with numerous long-term physiological sequelae which appear to impair exercise capacity. However, preliminary evidence suggests a cardio-protective effect of pre-term birth on hypoxia-induced physiological impairments. Further

evidence is required to corroborate this theory, and there is as yet no data to investigate the relationships between prematurity, hypoxia and exercise capacity in children. Therefore, the aim of this study was to assess the cardio-respiratory responses to an incremental exercise test in pre-term children, relative to their full-term counterparts, under normoxic and hypoxic conditions. The pre-term children were hypothesised to display a lower exercise capacity in normoxia than a full-term control group, and this difference was hypothesised to be attenuated in hypoxia.
METHODS: Fourteen prematurely-born (PREM) (Mean ± SD; gestational age 29 ± 2 weeks; age 9.1 ± 0.6 years), and fifteen physical activity-matched full-term children (CONT) (gestational age 39 ± 1 weeks; age 9.5 ± 0.9 years) visited the laboratory on three occasions. They first performed a baseline lung function test (spirometry), and then underwent two incremental exercise tests to exhaustion in normoxia (FiO2 = 20.9%) and normobaric hypoxia (FiO2 = 13.2%) on a cycle ergometer. Gas exchange, capillary oxygen saturation and haemodynamic parameters were continuously recorded using a metabolic cart, fingertip pulse oximetry and impedance cardiography, respectively.
RESULTS: Forced vital capacity ($p = 0.971$) and forced expiratory volume in one second ($p = 0.428$) were similar between groups. However, PREM demonstrated a lower peak expiratory flow rate than CONT (3.46 ± 0.89 vs. 4.24 ± 0.95 L/min; $p = 0.031$). Peak power output was higher in normoxia than hypoxia (103 ± 17 vs. 77 ± 18 W; $p < 0.001$), with no difference between CONT and PREM (94 ± 23 vs. 86 ± 19 W; $p = 0.154$). Peak oxygen uptake was significantly higher in normoxia than hypoxia in CONT (50.8 ± 7.2 vs. 43.8 ± 9.9 ml/kg/min; $p < 0.001$) but not in PREM (48.1 ± 7.5 vs. 45.0 ± 6.8 ml/kg/min; $p = 0.137$; interaction $p = 0.044$). Higher peak heart rate (187 ± 11 vs. 180 ± 10 bpm; $p = 0.005$) and lower stroke volume (72 ± 13 vs. 77 ± 14 ml; $p = 0.004$) were observed in normoxia relative to hypoxia in CONT, with no such differences observed in PREM ($p = 0.218$ and $p > 0.999$, respectively).
CONCLUSION: Pre-term children demonstrated greater expiratory flow limitations despite no differences in vital capacity. A hypoxia-induced decrease in peak oxygen uptake was only apparent in the full-term group, suggesting that pre-term birth (and/or associated neo-natal treatments) could protect against the negative effects of hypoxia on exercise capacity. This is a promising finding for prematurely-born individuals wishing to engage in physical activity at altitude. Further research is however required to consolidate these findings, and to identify the limiting factors to normoxic and hypoxic exercise capacity in this population.

## ACUTE PERFORMANCE, PHYSIOLOGICAL, AND PERCEPTUAL CHANGES IN RESPONSE TO REPEATED CYCLING SPRINT EXERCISE COMBINED WITH SYSTEMIC AND LOCAL HYPOXIA IN YOUNG MALES

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INTRODUCTION: Studies have shown that sprint training in combination with systemic or local (i.e., with blood flow restriction, BFR) hypoxia is an effective training method to improve sport-specific physical performance compared with the same training in normoxia. Since systemic and local hypoxia create different intrinsic stimuli, it is important to determine the performance, physiological, and perceptual changes in response to these conditions to gain insights into the adaptive mechanisms and to maximize training-induced adaptations. Thus, this study investigated motor performance fatigue (i.e., decrease in peak and mean power output) and the associated physiological adjustments (e.g., muscle oxygen saturation (SmO2) and muscle activity) during repeated cycling sprint exercise in local and systemic hypoxic as well as normoxic conditions. Moreover, perceived fatigue and its potential determinants (i.e., effort and physical strain perception) were quantified.
METHODS: Fourteen active males (24.2±2.0yrs, 80.9±10.0kg, 1.8±0.1m) participated in a randomized cross-over study. Subjects performed repeated cycling sprints (i.e., six intervals of 10s with 30s rest in between) in normoxia (NOR), systemic normobaric hypoxia (14.4% O2, HYP), and with BFR (40% of individuals' arterial occlusion pressure). Mean and peak power output, SmO2 of vastus lateralis as well as muscle activity of vastus medialis and lateralis were assessed during each interval. Percentage decrement score (Pdec) was calculated to quantify motor performance fatigue. Perceived fatigue, effort perception, and perceived physical strain were also queried immediately after each interval. SmO2 was normalized to the data recorded at rest over 30s prior to exercise. Before and immediately after exercise termination, peripheral blood lactate concentration (BLC) and oxygen saturation (SpO2) were recorded. Data were analyzed with repeated measures ANOVAs (time×condition).
RESULTS: Pdec for mean and peak power output was higher in HYP and BFR compared to NOR (all $p<.009$). SmO2 increased over the course of exercise in NOR and was higher compared to the BFR condition only in set 6 ($p<.001$). Muscle activity was not different between conditions. In the BFR condition, muscle activity of vastus medialis was reduced in set 5 and 6 compared to set 1 and 2 (all $p<.033$). Perceived fatigue, effort perception, and perceived physical strain progressively increased without differences between conditions. In parallel with lower SpO2, greater BLC was observed in HYP immediately after exercise compared to BFR and NOR (all $p<.001$).
CONCLUSION: HYP and BFR resulted in an exacerbated motor performance fatigue development but did not differentially influence perceived fatigue, effort and physical strain perception as well as muscle activity compared to NOR during 'all-out' repeated cycling sprint exercise. The lower oxygen availability in HYP and BFR might have impaired the contractile function of muscles resulting in a reduced repeated sprint ability performance.

## THE EFFECT OF COMBINED ARM AND LEG EXERCISE TRAINING IN HYPOXIA ON PHYSICAL PERFORMANCE, AND BIOMARKERS OF CHRONIC FATIGUE IN BIATHLON JUNIOR ATHLETES

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INTRODUCTION: Biathlon is a complex sport discipline, that in addition to a high endurance capacity and efficient skiing technique, demands accurate shooting performed directly after intense exercise. Scientific evidence suggests that hypoxia training increases exercise performance and high altitude acclimatization. The physiological mechanisms responsible for these benefits include improvements in cardiovascular hemodynamics, oxygen transport and beneficial changes in immune system. The aim of the present study was to examine the acute effect of endurance training under normobaric hypoxia on physical functioning and biomarkers of muscle fatigue in biathlon junior athletes.
METHODS: Twelve biathlon junior athletes (aged 16.4 ± 2.1 years) completed a 3-week training programme in normobaric hypoxia (HypTr) (FiO2=15.2 %). HypTr sessions consisting of an arm cycling exercise with an intensity of 150.0 ± 34.0 Watts (SkiErgo Cocept 2 USA) and running intervals (13.0 ± 1.0 km/h) (Matrix Jeager HP, Cosmos, Germany) with intensity calculated individually for each athletes. Spiroergometry and biomarkers of muscle fatigue were performed before and after the end of the training protocol.
RESULTS: An increase in maximal oxygen uptake (55.6 ± 8.8 vs. 58.5 ± 8.5 mL/kg/min) and the absolute power output during arm exercise test (257.0 ± 63.5 vs. 272.5 ± 60.2, $p<0.01$) were observed in response to exercise training in hypoxia. HypTr has significant effect on hemo-

globin (F=5.0 p<0.05), myoglobin concentrations (F=4.8 p<0.05), creatine kinas activity (F=7.4 p<0.01) and transforming growth factor β levels (F=8.2 p<0.01). Training in hypoxia has little effect on antioxidant status with a favourable changes in proinflammatory cytokines levels.
CONCLUSION: Exercise training in normobaric hypoxia had a significant positive effect on the physical performance and concentration of the specific fatigue biomarkers, therefore it may play a crucial role in the physiological adaptive mechanisms in biathlon junior athletes.

## COMPARISON OF THE AUTOMATIZED AND THE OPTIMIZED CARBON MONOXID (CO) REBREATHING METHOD MEASURING HAEMOGLOBIN MASS

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INTRODUCTION: A high haemoglobin mass (Hbmass) is a prerequisite for a high maximum oxygen uptake and hence, a high endurance performance. The most commonly used method to measure Hbmass is the optimized carbon monoxide (CO) rebreathing method (oCO) that is athlete-friendly and highly reproducible [1]. Recently, a new automated CO rebreathing method (aCO) was introduced [2]. The aCO method uses the same CO dilution principle as the oCO method, but there are some small methodological differences. Until now estimated Hbmass has never been compared between the new aCO method and the oCO method. The aim of this study was therefore, to quantify the difference between Hbmass estimated with the oCO with capillary blood samples (procedure oCOc) and the aCO method with venous (procedure aCOv) or with capillary blood samples (procedure aCOc).
METHODS: 18 healthy subjects (9 male, 9 female) participated in the study. Hbmass was estimated with both CO rebreathing METHODS: The oCO method was based on the standard protocol (procedure oCOc) [1], with minor modifications [2]. The aCO method, using the automated OpCO system (Detalo Instruments, Denmark), is described by Fagoni et al. [3]. Briefly, subject inhaled CO for 10 minutes in a supine position. Venous (procedure aCOv) and capillary blood samples at the right earlobe (procedure aCOc) were taken simultaneously at the same time points
RESULTS: Overall, Hbmass was different between the three measurement procedures (F = 57.55, p<0.0001). Hbmass was lower (p<0.0001) for the oCOc procedure (737 g ± 179 g lower) than for the aCOv procedure (825 g ± 189 g, -9.3%) and for the aCOv procedure (835 g ± 189 g,-10.6%). There was no difference (p = 0.12) for Hbmass estimated with the aCOv and the aCOc procedures.
CONCLUSION: Hbmass estimations with the oCO method (procedure oCOc) were about 10% lower than for the aCO method (procedures aCOc and aCOv). This difference is relevant and should be taken into account when the oCO method is replaced with the aCO method in a laboratory and individual longitudinal comparisons of the measured Hbmass are important and when comparing Hbmass results of studies using either the oCO or the aCO method. Possible reasons for this difference could come from different calculations for Hbmass including CO flux from blood to myoglobin for the oCO method compared to the aCO method and other influences yet to be discovered.
1. Schmidt, W. and N. Prommer, The optimised CO-rebreathing method: a new tool to determine total haemoglobin mass routinely. Eur J Appl Physiol, 2005.
2. Steiner, T. and J.P. Wehrlin, Comparability of haemoglobin mass measured with different carbon monoxide-based rebreathing procedures and calculations. Scand J Clin Lab Invest, 2011.
3. Montero, D., et al., Erythropoiesis with endurance training: dynamics and mechanisms. Am J Physiol Regul Integr Comp Physiol, 2017.
4. Fagoni, N., et al., Reliability and validity of non-invasive determined haemoglobin mass and blood volumes. Clin Physiol Funct Imaging, 2018.

## NEAR-INFRARED SPECTROSCOPY ASSESSMENT OF SKELETAL MUSCLE OXIDATIVE CAPACITY: METHODOLOGICAL CONSIDERATIONS

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INTRODUCTION: The assessment of skeletal muscle oxidative capacity through near-infrared spectroscopy (NIRS) has gained popularity within the past 10 years. Different approaches have been used by several research groups in terms of exercise modality, intensity and duration of the exercise employed, number of occlusions performed, NIRS signals investigated, muscles assessed, and equations used to correct for blood volume shifts.
This study aimed to compare the use of different NIRS signals with and without blood volume correction equations for the assessment of NIRS-derived oxidative capacity. Additionally, this study explored the simultaneous evaluation of the vastus lateralis (VL) and tibialis anterior (TA) muscles in two groups of young healthy participants of different fitness levels.
METHODS: Thirty-six participants, eighteen chronically trained (CT: 14 males, 4 females) and eighteen untrained (UT: 10 males, 8 females), were recruited for this study. Maximal O2 consumption (V̇O2max) was assessed during a cycling incremental test to exhaustion. NIRS-derived oxidative capacity was assessed at rest, after 20 leg extension movements with ankle weights (1 s extension and 1 s flexion), performing 20 transient arterial occlusions (5 s occlusion every 10 s). Two trials were performed with 2 minutes of rest in between. Muscle oxygen consumption (V̇O2m) was estimated by calculating the slope of each occlusion period from both the deoxygenated hemoglobin signal (HHb) corrected for changes in blood volume following the Ryan [(2), HHbR] and Beever [(1), HHbB] equations, and the oxygen saturation signal (StO2 ). V̇O2m values were then fit using a monoexponential function and the time constant Tau was taken as the measure of muscle oxidative capacity. These analyses were performed in both the VL and TA muscles.
RESULTS: V̇O2max was significantly greater in CT compared to UT (58.2±4.8 vs 43.0±4.9 mL/kg/min, P<0.0001). The goodness of the monoexponential fits for V̇O2m was excellent for all variables investigated (r2 0.94±0.05). Tau estimated from HHbR and HHbB were not different while Tau estimated using StO2 was significantly smaller (27.3±7.1 vs 27.3±7.1 vs 23.2±6.2 s, respectively; P<0.0001). HHbR Tau values were significantly smaller in CT compared to UT in both VL and TA (CT: VL 23.5±5.8 and TA 24.3±4.4 vs UT: VL 31.1±8.3 and TA 29.4±7.3; P<0.0001). No differences were detected between VL and TA within the same group (P>0.05).
CONCLUSION: This study showed that within the same muscle, HHb and StO2 signals result in different Tau values, although different blood volume correction strategies for HHb do not impact Tau. Additionally, no differences were detected across muscles for the same NIRS signals suggesting that the TA muscle is suitable for investigating skeletal muscle oxidative capacity and able to identify fitness level differences.
REFERENCES:
1. Beever AT et al. JAP 2020.
2. Ryan TE et al. JAP 2012.

## OP-BM12 Monitoring

### LONGITUDINAL SWIMMING PERFORMANCE AND TECHNIQUE MONITORING DURING TRAINING BASED ON A SINGLE IMU -A PILOT STUDY TRACKING CHANGES IN STROKE EFFICIENCY AND SPATIO-TEMPORAL PARAMETERS

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INTRODUCTION: Ongoing monitoring of swimmers becomes a coachs major duty, evaluating their performance and providing feedbacks for their improvement [1]. Inertial Measurement Units (IMU) became more readily available in sport to allow performance and technical assessments. Thus, previous applications of such sensors during in-situ swimming training showed their relevance to automatically quantify spatio-temporal metrics [2, 3]. However, these studies were restricted to short period of time, and led to limited insights as regards to training process. The aim of this study was to assess the sensitivity of IMU-derived performance and kinematical variables over the first part of the 2022 season to monitor technical abilities.
METHODS: Four regional swimmers performed 5 monitoring trials (T1, T2, T3, T4, T5). They consist in 4x100m in front crawl at 400m pace starting each 2 minutes with an IMU (Cometa WaveTrack, Italy) on the sacrum. A deep-learning model allowed to compute lap by lap speed (SP), stroke rate (SR), stroke length (SL) and jerk cost (JC) [4]. Smallest Worthwhile Change (SWC) [5] were used to detect changes in metrics for the whole training group. An ANCOVA and SWC were used to assess changes in estimated linear regression coefficients (B0 and B1) between SP and JC to track modification in smoothness and stroke efficiency across the season. Significance was set at $p<0.05$ and meaningful change at 1xSWC.
RESULTS: Meaningful variations over time were found with an increase of JC at T2 (1.29xSWC), a decrease at T4 (-1.18xSWC) and a decrease of SR (-1.45xSWC) coupled with an increase of SL (1.18xSWC) at T5. ANCOVA revealed a significant global interaction effect of B1 ($F(4.27)=5.27$; $p<0.01$) and significant differences in B0 ($F(4)=4.11$; $p<0.01$) according to monitoring trials. It was confirmed by meaningful changes in B1 at T2 (-2.43xSWC), T4 (5.20xSWC) and T5 (-3.10xSWC) and in B0 at T4 (-4.40xSWC) and T5 (4.43xSWC).
CONCLUSION: This pilot work showed that regression coefficients between SP and JC were modified across the training period that allows longitudinal significant data-driven feedbacks on swimming technique. Whereas no meaningful change in performance was quantified, a lower jerk cost associated with same speed was highlighted. This leads to a better swimming efficiency reflected by the increase in regression coefficients. This result may be linked to modification in kinematics reflected by SL increase and SR decrease. Finally, on-field single IMU-based monitoring of swimming can provide useful data for training regulation. Nevertheless, such analysis needs to be expanded to high level swimmers and over a full training season.
1. Hamidi Rad et al. (2020) 2. Ganzevles et al. (2017) 3. Michaels et al. (2016) 4. Ganzevles et al. (2019) 5. Buchheit (2016)

### INDIVIDUALISED BALL SPEED PREDICTION IN BASEBALL PITCHING BASED ON IMU DATA

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INTRODUCTION: The optimal pitching motion displays a sequential activation of body parts, also known as the kinetic chain, in which the pelvis and trunk play an essential role. Enhancing pitching technique through the optimal positioning and timing of proper pitching mechanics can result in a fast and accurate throw and reduce the injury risk [1,2,3]. Therefore, estimating ball velocity based on IMU data can be a step towards assessment of the pitching technique.
METHODS: Twenty-five youth baseball pitchers performed ten fastball pitches with maximal effort. Ball velocity was measured by a radar gun (Stalker Radar, Plano, TX, USA). Two 9-DOF IMUs (MPU-9150, Invensense, San Jose, CA, USA, Accelerometer: 16 g, Gyroscope: 2000 deg/s) were rigidly attached to participant's pelvis and sternum. Peak angular velocity of pelvis (PAP) and trunk (PAT) were calculated by taking the Euclidian norm [4]. We developed three multilevel Bayesian regression models to predict the ball velocity: (I) complete pooling model (Observations), (II) two-level varying-intercept model (Personal) and (III) two-level varying-intercept, varying-slope model (Full). Each model was evaluated by the predictive performance defined as the expected log-predictive density (elpd). Comparing the developed models determines the contribution of the kinematic parameters related to pitching mechanics and pitcher's body height to predictive performance. We used leave-one-out (LOO) cross-validation for a model selection.
RESULTS: The Full model was a preferable model ($R2 = 0.975$), followed by the Personal ($R2 = 0.973$) and the Observations model ($R2 = 0.137$). The Full model was better than the Observations model by 308.3 (SE = 13.5) and better than the Personal model by 5.5 (SE = 3.3) of log predictive probability values.
CONCLUSION: Ball velocity can be estimated with a low accuracy with only IMU data. However, by including an additional level, we introduce the group participation that makes a distinction between pitchers of a different height. This results in a significantly improved predictive performance of the model that includes PAP and PAT on an individual-level when including pitcher's height on a group-level. Therefore, IMUs, that can be easily used in every situation, can provide an input for ball velocity predictions without use of a radar gun. Our results demonstrate the added value of a pitcher's height to predictive performance and use of proposed method represents a potential for predictions of future throwing speed when pitchers grow taller.
REFERENCES:
1) Seroyer et al, Sports Health, 2010
2) Dowling et al, ASB, 2016
3) van der Graaff et al, J. Phys. Fit. Sport. Med., 2018
4) Skejø et al, Sensors, 2020

### CONCURRENT VALIDITY OF THE STRYD POWER METER DURING WALKING AT DIFFERENT SLOPES AND BACKPACK LOADS.

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INTRODUCTION: Mountain rescuers, wildland firefighters and military personnel could be treated as elite athletes because the success of accident rescues might often depend on their physical performance. Therefore, training load quantification is of paramount importance in order to improve physical performance of rescue teams. In recent years, some inertial measurement units have been designed to quantify training load during some physical task, such as running [1]. In this sense, the Stryd device has been validated to measure power output during running [2] but not during walking [3]. Walking, either at different slopes or with load carriage, is one of the main activities that rescue personnel have to face during rescues[3]. Accordingly, the aim of this research was to measure the concurrent validity of the Stryd power during walking at different slopes and with different backpack loads without slope during level walking.
METHODS: Seventeen participants from a mountain rescue team performed 8 walking trials. Each trial consisted of 5 minutes walking at 3.6 km/h at different positive slopes (1%,10% and 20%) and with different backpack loads (0%, 10%, 20%, 30% and 40% of body mass) without slope. During the trials, the internal load indicators of oxygen uptake (VO2), minute ventilation (VE), heart rate (HR) and rate of perceived exertion (RPE) were registered. Concurrent validity of the Stryd's power output was assessed by checking its linearity with the internal load indexes. Pearson´s correlation coefficients (r) were used to evaluate the direction and magnitude of the linear relationships. Significance was set at $P<0.05$.
RESULTS: Results showed significant ($P< 0.05$) positive correlations between power (W) and the internal load indicators (VO2 ml/kg/min r= 0.91; VE L/min r= 0.95; HR r= 0.92; %VO2max r= 0.92; %HRmax r= 0.89 and RPE r= 0.83) during walking at 1%, 10% and 20% slopes. The relative power (W/kg) also showed a significant ($P< 0.05$) positive correlation with these measures (VO2 ml/kg/min r= 0.96; VE l/min r= 0.93; HR r= 0.93; %VO2max r= 0.94; %HRmax r= 0.92 and RPE r= 0.89). During walking with different backpack loads, the results showed positive correlations between power and relative power against all the physiological and perceptive variables measured (range r= 0.52 to 0.75).
CONCLUSION: This is the first research that assessed the concurrent validity of the Stryd Power Meter device during walking. Our findings indicate that measurements of power (W) and relative power (W/kg) provided by Stryd device units show concurrent validity. We suggest that the Stryd device may be useful and valid to measure power in walking activities at different slopes and backpack loads. This project was supported by the Basque Country Government (PRE_2019_2_0102).
[1] R.L. Aubry et al.(2018).J Strength Cond Res.
[2] V. Cerezuela-Espejo et al.(2020).Eur J Sport Sci. DOI:10.1080/17461391.2020.1748117
[3] A. Pinedo-Jauregi et al.(2022).Gait Posture. DOI:10.1016/j.gaitpost.2021.11.041

### DESCRIPTION OF THE THERMAL PATTERN OF 950 ATHLETES USING THERMOGRAPHY TO MEASURE SKIN TEMPERATURE.

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INTRODUCTION: Infrared thermography is a fast technology that allows non-invasive measurement of skin temperature. This tool has been applied in the scientific literature for the control of training workloads and the prevention of injuries, since it allows detecting the body regions that present the greatest risk of injury. This has been shown, especially when thermal asymmetries are used in the analysis (Carmona P. et al. 2020; Corte A. et al. 2019). The objective of this study was to identify and describe the distribution of thermal asymmetries in athletes in order to describe normal values and be able to establish individualized profiles.
METHODS: 950 athletes measured by the same observer were analyzed including only thermography images in a basal state, according to the indications of the Glamorgan protocol (Ammer K. et. al. 2008). The images were taken with a FLIR T530 camera (Flir Teledyne systems, Sweden) and analyzed using the automatic ThermoHuman software (Pema Termo Group, Spain), scientifically validated for this purpose (Requena-Bueno L. et al. 2020). Thermal analysis was performed anonymously, extracting data from 80 regions of interest (ROI) using an artificial vision algorithm and displaying the average, minimum, and maximum temperature results for each ROI. The system automatically compared the ROIs of both sides to obtain the mean asymmetry metric, that is, the difference between the mean temperature of one ROI and its contralateral.
RESULTS: The asymmetry values showed a mean difference of (0.004ºC ± 0.66ºC) in all ROIs. When the ROIs were analyzed individually, the most stable with the least mean asymmetry were: the ROI of the chest (0.007ºC ± 0.16ºC), the trapezius in its frontal view (0.008ºC ± 0.24ºC), the lower back region (0.007ºC ± 0.26ºC) and the vastus medialis (0.003ºC ± 0.27ºC). While the greatest differences were found in the foot in the posterior view (0.37ºC ± 3.73ºC), the wrist in both anterior and posterior views (0.16ºC ± 0.72ºC; 0.09ºC ± 0.65ºC), the shoulder in the posterior view (0.09ºC ± 1.47ºC) and the vastus lateralis (0.09ºC ± 0.40ºC). In addition, the regions with the greatest variability were: the neck (0.03ºC ± 2.10ºC; 0.01ºC ± 2.04ºC) and the foot (0.005ºC ± 2.26ºC; 0.37ºC ± 3.73ºC), both in its anterior and posterior views.
CONCLUSION: A normality profile of athletes using thermography to analyze the skin temperature of the ROIs was established. This allows the comparison of a new athlete with the database of the 950 athletes. In addition, as has been verified with the descriptive analysis of this sample, the ROIs show a degree of similarity very close to symmetry when a large number of evaluations are included, even without knowing the factors of influence. This facilitates the generation of individualized thermal profiles that can improve the understanding and usefulness of thermographic analysis.

### CAN BODILY SELF-CONSCIOUSNESS AFFECT TRAINING IN VIRTUAL REALITY WHEN IDENTIFYING TO AN AVATAR?

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INTRODUCTION: The growing development of Virtual Reality (VR) technologies offers appealing opportunities for athletes to train in simulated environments [1]. Coupled with motion capture, VR grants the possibility to see oneself from a third-person perspective, embodying an avatar, which offers new perspectives for movement training and visualization. However, several aspects of brain perception-action may distinguish interactions in real world and in VR. When manipulating an avatar, a critical aspect is the consciousness of a self, anchored in a physical body, as a construct of multisensory integration [2]. The aim of this study was to evaluate how visuomotor performances evolve from a first person to a third person (avatar) perspective, and to assess the modulating role of bodily self-consciousness.

METHODS: Thirty-one sport students (thirteen females) performed a visuomotor task in virtual reality (VMVR) which consists in hitting as quickly as possible buttons spatially arranged around concentric circles on a vertical board (120x120cm). In the first-person condition (1PP), buttons are successively lit up after being reached by the hand-held VR controllers. In the third-person condition (3PP), the buttons are reached using the hands of an avatar created with motion capture, displayed two meters in front of the participant and following its movements. The task was performed seeing the avatar from the back (0°), or with a viewpoint positioned to the left (-60°) or to the right (60°) to stimulate perspective taking. A questionnaire and specific VR tasks evaluated components of bodily self-consciousness: self-identification, self-location and perspective taking.
RESULTS: A repeated measures ANOVA showed no differences between 1PP and 3PP scores whatever the viewpoint : 0°, 60° or -60° ($F(3,123) = 1.29$, $p = 0.28$), which shows that participants were able to maintain similar visuomotor performances while manipulating the avatar. In addition, we show that participants take full advantage of the far-from-target viewpoint (two meters away) in avatar conditions, reaching lower reaction times for peripheral stimuli in 3PP compared to 1PP ($F(3,123) = 5.98$, $p = 8x10\text{-}4$). A Principal Component Analysis indicated orthogonality between 1PP/3PP response times and measures of self-identification, self-location and third-person perspective, which confirms the lack of impact of bodily-self-consciousness on visuomotor performances when manipulating an avatar.
CONCLUSION: This study demonstrates the ability of a population of young athletes to instantly manipulate a third-person avatar in VR, without interferences due to bodily self-consciousness. The performances obtained facing the avatar's back or by adding a 60° angle - which implies perspective taking and mental rotations, are unaltered. Thus, manipulating an avatar in VR can be used to exploit rich cognitive-motor stimulating environments for athletes training.
REFERENCES:
[1] Ahir K et al., 2020
[2] Blanke O, 2012

## Oral presentations

### OP-AP31 Sports Technology: Development in the digital era

#### VALIDATION OF AN OPEN SOURCE AMBULATORY ASSESSMENT SYSTEM FOR PHYSICAL ACTIVITY MEASUREMENT

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INTRODUCTION: Inertial-based trackers have become a common tool in data capture for ambulatory physical activity assessment and for physical activity promotion. Most commercially available systems use black-box aggregation algorithms, often resulting in data that are locked into proprietary formats and metrics that make later replication or comparison difficult (Brondin et al. 2020). For physical activity and health promotion strategies and interventions the accurate recording and appropriate feedback to the user seems essential for intervention success and data interpretation. The aim of the presented study is to further develop and evaluate an open source ambulatory assessment system that produces data which can be complemented and compared against later. This consists of generic software and open algorithms for capturing physical activity, with a special focus on persons with non-communicable diseases (diabetes, cardiovascular diseases), which can be used for research questions as well as health promotion strategies.
METHODS: The aim of the study is to validate an open-source ambulatory assessment system that consists of an open source smartwatch (Bangle.js), algorithms, and software components (smartphone app) against a reference tool (ActiGraph GT9X). Two validation experiments were performed, one lab-based treadmill study (3, 5, 7 km/h) to define activity cut-offs (light, moderate, vigorous) and step validation in a convenience sample of 16 volunteers (7m, 9w) with a mean age of 45.4 years (±6.8 SD) and one 'in vivo' study with 28 volunteers (14m, 14w) suffering from diabetes or cardiovascular disease with a mean age of 65.6 years (±13.2 SD). All code for the analysis was written in Python and is made available online.
RESULTS: A comparison between data from ActiGraph GT9X trackers and our proposed system reveals the original inertial sensor signals at the wrist strongly correlate (Pearson correlation coefficients for raw inertial sensor signals of 0.97 in the controlled treadmill-walking setting). The obtained classification accuracy for distinguishing between low-moderate or moderate-vigorous activity is 97.5% and 86.7%, respectively under labaratory conditions. The estimated steps from the open-source wrist-based detection approach strongly correlate with the hip-worn ActiGraph output (average Pearson correlation coefficients of 0.81 for minute-wise comparisons of detected steps) in day-long ambulatory data.
CONCLUSION: Recording inertial sensor data in a standardized form and relying on open-source algorithms on these data form a promising methodology that ensures datasets can be replicated or enriched long after the wearable trackers have been decommissioned.

#### RESEARCH ON THE HIGH-QUALITY DEVELOPMENT OF CHINAS SPORTS FITNESS APPS UNDER THE DIGITAL BACKGROUND

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INTRODUCTION: By analyzing the main problems of current Chinas sports fitness apps, exploring the new opportunities for app development under the digital background, and proposing targeted strategies for promoting the high-quality development of Chinese sports fitness apps.
METHODS: literature method, logical analysis method
RESULTS: Dilemma: 1. In China, the user information of sports fitness platform is at risk of leakage , the existence of loopholes in network technology and the lack of corresponding supervision and management mechanisms of platforms may make users privacy stolen by criminals and seriously affect network information security; 2. Platform fitness function is single and homogenization is serious, most platforms compete viciously for their own interests and get more customers by playing price war, 3. The profit model is backward, currently many fitness guidance apps are using implanted advertising or part of the course fees to obtain profits, but this requires extremely high number and loyalty of users ,too much advertising and paid courses will often cause the loss of users.
Opportunity:
1.Policy support: In China, the government has issued a series of policies to help the digital transformation of the sports industry, such as the "National Fitness Plan 2021-2025", which provides endogenous impetus for the development of "digital + sports"; 2. Market prospect:

The epidemic situation in COVID-19 is still grim, home isolation has become the normal state of peoples lives, The public awareness of fitness is increasing day by day, and the "cloud fitness" based on digital technology is very hot. 3. Technical support: digital technology can promote the transformation and upgrading of APP to create a more immersive experience for the audience; 4. Economic foundation: the GDP per capita of Chinese residents is growing year by year, the public demand is changing to a higher level, and sports, as a public service, can meet peoples spiritual, physical and psychological needs and become the first choice for many people.
CONCLUSION: Countermeasures: 1. Improve the platform supervision and management mechanism: use digital technology to upgrade the user information protection system; increase the punishment for leaking user information and other acts, and form a supervision and management circle with government, society and platform as a whole; 2. Improve platform services and functions, and create a sports service platform that meets the fitness needs of different age stages; 3. innovating profit model: accurate advertising times, optimization of paid service course quality, free placement of basic service courses, and free value-added services for loyal customers.

### A JUST-IN-TIME ADAPTIVE INTERVENTION TO ENHANCE PHYSICAL ACTIVITY AFTER INACTIVE PHASES IN CHILDREN AND ADULTS.

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INTRODUCTION: Just-in-time adaptive interventions (JITAIs) are promising technology-based interventions for behavior change (Wunsch et al., 2022). This study aimed to evaluate if a JITAI can enhance physical activity in the subsequent hour depending on whether the JITAI trigger has been answered (JITAI condition) compared to when the trigger was not answered (control condition).
METHODS: Data of the three-week intervention period of the SMARTFAMILY2.0 trial which aimed to promote physical activity in families (Wunsch et al., 2020) was used for analysis. A total of 80 participants with 907 JITAI triggers were included in this study. A JITAI was sent when the participant has been inactive for at least 60 minutes (indicated by accelerometry). Two multilevel models were calculated (outcomes: metabolic equivalents (MET) and step count) using RStudio with measurements (level 1) nested in participants (level 2) under consideration of several covariates (i.e. weekday/weekend, time of the day, adult/child).
RESULTS: Results indicated significantly higher MET and step count in the JITAI condition com-pared to the control condition within-persons (level 1). Participants in the JITAI condition recorded 5.52 higher MET ($\beta = 0.08$, $p = .014$) and 113.16 more steps ($\beta = 0.08$, $p = .022$) in the following hour compared to participants in the control condition.
CONCLUSION: The inactivity JITAI implemented in the SMARTFAMILY2.0 trial indicates promising results concerning physical activity enhancement in the subsequent hour. Here, the inclusion of further factors like the availability of the participant or the inclusion of affective variables into the design of the JITAI might further enhance the effect in future studies.
References
Wunsch, K., Eckert, T., Fiedler, J., & Woll, A. (2022). Just-in-time adaptive interventions in mobile physical activity interventions – A synthesis of frameworks and future directions. The European Health Psychologist.
Wunsch, K., Eckert, T., Fiedler, J., Cleven, L., Niermann, C., Reiterer, H., Renner, B., & Woll, A. (2020). Effects of a Collective Family-Based Mobile Health Intervention Called "SMARTFAMILY" on Promoting Physical Activity and Healthy Eating: Protocol for a Randomized Controlled Trial. JMIR Research Protocols, 9(11), e20534. https://doi.org/10.2196/20534

### HEALTH EFFECTS OF A 12-WEEK WEB-BASED LIFESTYLE INTERVENTION FOR PHYSICALLY INACTIVE ADULTS: A RANDOMIZED CONTROLLED CLINICAL TRIAL

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INTRODUCTION: Physical inactivity has been identified as an important health risk factor, especially for non-communicable diseases. Web-based lifestyle interventions have become of great research interest to promote a physically active lifestyle. Previous research on such interventions indicates health-promoting effects, but further research is needed. Therefore, the aim of the present study was to investigate the health effects of a web-based health program (TK-HealthCoach) offered by a national health insurance fund (Techniker Krankenkasse, TK).
METHODS: The study was designed as a randomized controlled clinical trial in which n = 189 physically inactive adults (48.07 ± 12.01 years, 73.50% females, 25.56 ± 3.66 kg/m2) were included and randomly assigned to a 12-week interactive (TK-HealthCoach) (intervention group) or non-interactive (control group) web-based health program using permuted block randomization. Cardiorespiratory fitness was set as the primary outcome. Musculoskeletal fitness, physical activity and dietary behavior, anthropometry, blood pressure, blood values, and vascular health were defined as secondary outcomes. All outcomes were assessed before and after the 12-week intervention and after a 6- and 12-month follow-up. Complete case (CC) and intention-to-treat (ITT) analyses were performed using robust linear mixed models (RLMM).
RESULTS: CC analysis (n = 96) showed significant time effects for the primary and most secondary outcomes ($p < 0.05$). Significant interaction effects were observed for single secondary outcomes of blood pressure, blood levels, and vascular health ($p < 0.05$), but mainly in favor of the control group. ITT analysis (n = 189) revealed significant time effects for the primary outcome and single secondary outcomes of physical activity, anthropometry, and blood values ($p < 0.05$). There was a significant interaction effect for blood pressure outcomes favoring the control group ($p < 0.05$). No other effects were observed.
CONCLUSION: This study demonstrated that participation in a 12-week interactive or non-interactive web-based health program can induce health effects in physically inactive adults. However, no evidence was found for the superiority of the interactive web-based health program. Thus, more research is needed to clarify the findings of this study within the available evidence on web-based lifestyle interventions.

## OP-BM22 Central and / or spinal drive I

### SPINAL REFLEX MECHANISMS IN ANTICIPATED AND NON-ANTICIPATED ROTATIONAL AND TRANSLATIONAL POSTURAL PERTURBATIONS

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INTRODUCTION: It is assumed that stretch reflex responses are functionally modulated, meaning that reflex reactions to toe-up rotations are counterproductive to regain balance and are therefore suppressed, whereas in translational backward perturbations they have a supporting function and are facilitated (Nashner, 1976). However, previous studies have compared rotations and translations that led to different ankle movements and therefore may evoke the muscle spindles differently. Here, we matched the rotations and translations in terms of the ankle angle properties and additionally analyzed the spinal excitability by means of the H-reflex technique. It was hypothesized that the spinal reflex activity in the anticipated conditions should be decreased in rotations and increased in translations when compared with the equivalent non-anticipated conditions.
METHODS: Muscular responses to external induced anticipated (blocked) and non-anticipated (random) rotations and translations were analyzed by comparing the EMG root mean square signal of the m. soleus within the short-latency response (SLR; 30-60ms after perturbation) in 24 healthy adults. H-reflexes were evoked shortly before (30ms; preparatory setting) and after (45ms; during the SLR) the onset of perturbation. Biomechanical effects of the perturbations were assessed with the maximal ankle angle movement and the time to the maximal ankle angle.
RESULTS: Rotations and translations were shown to induce different muscular activities during the SLR, i.e. noticeably less activity in translations ($p < .001$). In anticipated rotations, the SLR was suppressed ($p = .015$) and H-reflex amplitudes were facilitated ($p = .044$) when compared to the non-anticipated condition. In translations, neither an effect of the stretch reflex response nor the H-reflex could be seen between anticipated and non-anticipated perturbations. Biomechanical effects of the perturbations were not different between rotations and translations and anticipated and non-anticipated perturbations.
CONCLUSION: In line with our hypothesis, muscular activity during the SLR in anticipated rotations were adequately decreased to diminish unnecessary reactions. In contrast, H-reflexes elicited in rotations were increased in anticipated compared to non-anticipated perturbations. It is known that stretch reflex responses and H-reflexes are differently sensitive to the influence of presynaptic inhibition (Morita et al., 1998). However, this cannot explain contradictory behavior of stretch and H-reflex responses as seen in this study. Therefore, it is assumed that the fusimotor system is differently activated in anticipated and non-anticipated postural perturbations and that the muscle spindles have an important role in the feedforward control of postural perturbations.
Morita et al. (1998) J NEUROPHYSIOL
Nashner (1976) EXP BRAIN RES

### EFFECTS OF A PERCUSSIVE MASSAGE ON PASSIVE TORQUE AND REFLEX ACTIVITY OF PLANTAR FLEXOR MUSCLES

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INTRODUCTION: Handheld percussive massage treatment has gained popularity in the therapeutic and athletic communities in the last few years, although evidence of its efficacy is still lacking. A recent study showed that a 5-min handheld percussive massage of the calf muscles increased the ankle dorsiflexion range of motion (Konrad et al. 2020). This may reflect a decrease in muscle stiffness or in the responsiveness of the muscle spindle pathway. The purpose of this study was to investigate the effect of percussive massage on passive torque and reflex activities of the ankle plantar flexors (PF).Handheld percussive massage treatment has gained popularity in the therapeutic and athletic communities in the last few years, although evidence of its efficacy is still lacking. A recent study showed that a 5-min handheld percussive massage of the calf muscles increased the ankle dorsiflexion range of motion (Konrad et al. 2020). This may reflect a decrease in muscle stiffness or in the responsiveness of the muscle spindle pathway. The purpose of this study was to investigate the effect of percussive massage on passive torque and reflex activities of the ankle plantar flexors (PF).
METHODS: Eleven healthy young adults participated to this study [mean (SD); 24 (2)yrs]. Before and after a 5-min handheld percussive massage (TheragunTM Massager pro 4th Gen; PERCU session) or effleurage massage (SHAM session), the maximal amplitude of the Hoffmann reflex (Hmax), maximal M-wave amplitude (Mmax) and tendon tap reflex recorded in the soleus, and the passive torque of PF muscle-tendon unit were measured. Hmax and Mmax were evoked in the soleus by stimulating the tibial nerve (1-ms duration) while tendon tap were triggered by precutting the Achilles tendon with a percussion hammer at 90° ankle angle (Guissard et al., 1988). The passive torque was recorded during ankle dorsiflexion (2.5°/s) from 90° to 60° ankle angle.
RESULTS: The passive torque during ankle dorsiflexion changed neither after PERCU nor CON. Similarly, the Hmax did not change after PERCU [before: 43 (12) % Mmax); after: 40 (19) % Mmax] or SHAM [before: 43 (13) % Mmax); after: 44 (13) % Mmax]. In contrast, the tendon tap reflex amplitude increased after [27(1) % Mmax] compared with before [21(6) % Mmax; $p = 0.02$] PERCU, while no change was observed for SHAM.
CONCLUSION: In the absence of change in passive torque and Hmax, the increase in tendon tap reflex suggests an enhanced muscle spindle sensitivity. This may reflect the thixotropic property of intrafusal muscle fibers (Gregory et al. 1998; Nakajima et al. 2009), providing only a transient effect which should be abolished by muscle contraction. Overall, our results did not demonstrate a salient effect of percussive massage on the plantar flexors neuromechanics.
References
1)Konrad et al. J Sports Sci Med, 2020
2) Guissard et al., Eur J Appl Physiol, 1988

### WIDE-PULSE HIGH-FREQUENCY NEUROMUSCULAR ELECTRICAL STIMULATION DOES NOT INFLUENCE THE H-REFLEX PATHWAY

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INTRODUCTION: Wide-pulse high-frequency (WPHF) neuromuscular electrical stimulation is characterized by high stimulation frequencies (>80 Hz) and long pulse durations (1ms), which preferentially depolarize Ia afferents compared to motor axons (1). Accordingly, some motor units are recruited via the Ia-afferent pathway in the physiological recruitment order (2). However, repetitive activation of the Ia afferent pathway may alter its functioning (3), but it remains unknown whether WPHF transiently modifies presynaptic mechanisms associated with this pathway. This study investigated the effect of a 20-min bout of WPHF on the soleus Hoffmann (H) reflex, and two mechanisms which presynaptically modulate its efficacy to recruit motor units [homonymous postactivation depression (HD) and Ia presynaptic inhibition (PSI)].
METHODS: Twelve healthy young adults (19-25yrs; 3 women) participated to one control session (no stimulation train; CON), and one session during which twenty 20-s WPHF stimulation trains (1-ms pulse duration; 100 Hz; 40-s rest between trains) were applied on triceps surae. The stimulus intensity produced an initial force corresponding to 5% of the participant's maximal force. Before and after the WPHF or the 20-min control period, 20 soleus H reflexes were evoked by stimulating the tibial nerve with an intensity producing an M wave of 10% of the M-wave maximal amplitude (Mmax). HD was assessed by evoking two H reflexes with an interval of 0.5 s. PSI was assessed with the D1 method which consists of conditioning the H reflex by an electrical stimulus of the common peroneal nerve delivered 20 ms prior to the tibial nerve stimulus. Two-way ANOVAs [session (CON vs. WPHF) x time (before vs. after)] were used to analyse the data.
RESULTS: The Mmax amplitude did not change, regardless of the session (p=0.28). The H-reflex amplitude did not differ between sessions before [mean(SD); WPHF: 51(19)% Mmax; CON: 45(21)% Mmax] and after the intervention [WPHF: 45(19)% Mmax; CON: 50(17)% Mmax; p=0.15]. Similarly, HD (p=0.85) and PSI (p=0.23) did change neither in WPHF nor CON session.
CONCLUSION: The lack of change in H-reflex amplitude after WPHF indicates that the efficacy of the synaptic transmission between Ia afferents and motor neurons was not altered. This contrasts with previous work showing a decrease in H-reflex amplitude (4), differences between studies may depend on participants characteristics. The absence of change in HD and PSI suggests that presynaptic mechanisms were not influenced by WPHF (5). Overall, the results suggest that WPHF could be used in rehabilitation to induce a more functional activation of motor units without altering the muscle spindle pathway.
REFERENCES
1.Kiernan et al., J Physiol 558, 341–349 (2004)
2.Collins, Exerc Sport Sci Rev 102–109 (2007)
3.Souron et al., J Physiol 597, 5179–5193 (2019)
4.Wegrzyk et al., Clin Neurophysiol 126, 1400–1412 (2015)
5.Pierrot-Deseilligny & Burke, Cambridge University Press (2012)

### H-REFLEX AND HOMOSYNAPTIC POST-ACTIVATION DEPRESSION MODULATION DURING LOW- AND HIGH-INTENSITY SUBMAXIMAL ISOMETRIC FATIGUING CONTRACTIONS

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INTRODUCTION: One of the possible mechanisms accounting for fatigue is the reflex inhibition of the motoneuron mediated by group III and IV afferents sensitive to by-products of the fatiguing contraction. The H-reflex can serve as a probe to assess a complex interplay between central and peripheral fatiguing mechanisms. H-reflex is also sensitive to previous stimuli, resulting in the decrement of the reflex response, which is attributed to homosynaptic depression of Ia afferents (HPAD). The examination of HPAD represents a tool to gather insight into the integration of central and peripheral mechanisms that regulate muscle output during fatiguing contractions. It has been recently shown, that HPAD is modulated during high intensity (60% MVC) fatiguing intervention (1). However, it is not clear how contraction intensity affects HPAD during fatigue. Thus, the study aimed to investigate the effects of continuous isometric contractions of two intensities on H-reflex and HPAD.
METHODS: Twelve males (age 26.8 ± 8.1 years) were instructed to isometrically contract the plantar flexors, maintaining 25% (CON25) or 65% (CON65) of their MVC until volitional failure. The tibial nerve was stimulated in the popliteal fossa with an electrical stimulator (NeoStim1; EMF Furlan, Slovenia) PRE, during and POST intervention. Ten submaximal paired stimuli (interstimulus interval 8 s) elicited a test (Htest) and a conditioned reflex response (Hcond) 0.5 s later. The EMG signal was collected from the muscle soleus using a 64 channels matrix electrode (GR08MM1305, OT Bioelettronica, Italy). Peak-to-peak amplitudes were extracted from the electrically elicited responses. Data were analysed using repeated measures nested linear mixed effect models.
RESULTS: Hcond was significantly ($P < 0.001$) lower than Htest at PRE (CON25: -37.7%; CON60: -42.6%) and POST (CON25: -36.6%; CON60: -42.4%), resulting in no significant interaction between the effect of time, intervention intensity and previous stimulation on the H-reflex at rest. However, during the fatiguing contraction, there were no statistically significant differences between Htest and Hcond, suggesting a drop in HPAD. Both Htest and Hcond dropped significantly during CON25 intervention by -38.6% and -32.1% respectively ($P = 0.028$; $P = 0.065$) and stayed statistically unchanged during CON60 ($P = 0.573$; $P = 0.66$), resulting in a significant interaction between time and intervention intensity ($P = 0.014$).
CONCLUSION: The results of this study showed that HPAD diminished during muscle contraction compared to rest. However, the drop of both reflex responses (Htest and Hcond) during CON25 suggests that contraction intensity plays an important role in motoneuron output modulation during a fatiguing task. Further analysis of the data from the matrix electrodes is required to gain insight into the effects of fatigue on the modulation of motor unit firing rates.
REFERENCES:
1) Oza et al., Scand J Med Sci Sports, 2019

**ISCHEMIC PRECONDITIONING DID NOT AFFECT CENTRAL AND PERIPHERAL FACTORS OF MOTOR PERFORMANCE FATIGUE AFTER SUBMAXIMAL ISOMETRIC EXERCISE**

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INTRODUCTION: Ischemic preconditioning (IPC) involves repeated, short-term periods of vascular occlusion with subsequent reperfusion and has been shown to increase human performance if applied to the exercising limb prior to physical activity. Studies have found that IPC has an ergogenic effect on a variety of endurance exercise modalities including running, cycling, swimming, and sustained submaximal isometric contractions. The present study was designed to provide further insight into the mechanistic basis for the improved exercise tolerance during submaximal isometric exercise following IPC by investigating key-determinants of motor performance and perceived fatigue.
METHODS: Using a randomized, counterbalanced, single-blinded, sham-controlled, crossover design, 16 males performed an isometric time-to-exhaustion (TTE) test with the knee extensors at 20% maximal voluntary torque (MVT) after an IPC and a sham treatment (SHAM). Those who improved their TTE following IPC performed a time-matched IPC trial corresponding to the exercise duration of SHAM (IPCtm). Neuromuscular function was assessed before and after exercise termination during each condition (IPC, IPCtm, and SHAM) to analyse the impact of IPC on motor performance fatigue and its central and peripheral determinants. Muscle oxygenation (SmO2), muscle activity, and perceptual responses (effort and exercise-induced muscle pain) were recorded during exercise. Motor performance fatigue as well as its central and peripheral determinants were quantified as percentage pre-post changes in MVT (ΔMVT) as well as voluntary activation (ΔVA) and quadriceps twitch torque evoked by paired electrical stimuli at 100 and 10 Hz (ΔPS100 and ΔPS10/PS100-ratio), respectively.
RESULTS: TTE, motor performance fatigue, its determinants, muscle activity, SmO2, and perceptual responses during exercise were not different between IPC and SHAM. However, six participants improved their TTE by >10% following IPC compared to SHAM ($P < 0.001$, $d = 3.23$). Based on effect sizes ($\eta p^2$, d), the time-matched comparisons (IPCtm vs. SHAM) for these 'responders' indicated that motor performance fatigue, its determinants, and SmO2 were not affected, while effort perception seemed to be lower ($\eta p^2 = 0.495$) in the IPCtm condition. The longer TTE in the IPC condition (IPC vs. SHAM) was also accompanied by a lower effort perception ($\eta p^2 = 0.380$) and larger impairments in neuromuscular function, i.e. larger ΔMVT, ΔVA, and ΔPS10/PS100 ($d = 0.71$, 1.0, 0.92, respectively).
CONCLUSION: IPC did neither affect TTE, motor performance fatigue, as well as its central and peripheral determinants, nor muscle activity, SmO2, and perceptual responses during submaximal isometric exercise. However, IPC seemed to have an ergogenic effect in a few subjects, which might have resulted from a lower effort perception during exercise. These results support previous findings that there are 'responders' and 'non-responders' to IPC.

## Oral presentations

### OP-AP32 Youth athletes in team sports

**DIFFERENCES IN BIOLOGICAL MATURITY STATUS AND PREDICTED ADULT HEIGHT BETWEEN SELECTED AND NON-SELECTED PLAYERS: AN INVESTIGATION OF MALE AND FEMALE ATHLETES IN YOUTH ELITE BASKETBALL**

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INTRODUCTION
The influence of biological maturity on talent identification in physically demanding sports is critically debated within both, research and practice. Especially during adolescence, maturity-related performance differences within the same age group may cause greater chances of being selected and promoted for early-maturing athletes (Malina et al., 2019). Though increasing interest is dedicated to maturity-related parameters in talent identification and development in general, evidence of its impact for talent identification in Basketball is still scarce. However, particularly in Basketball, maturity-related indicators (e.g., body height) are considered relevant for performance. Accordingly, the aim of the present study was to analyze differences in the biological maturity status and predicted adult height between selected and non-selected male and female youth basketball players for the German U15 and U16 youth national teams.
METHODS
Male U15 (N=71) and female U16 (N=50) elite youth basketball players were investigated who participated with regional associations squads in a selection tournament for the youth national teams. Just before the start of the tournament, height, weight, biological maturity status (maturity offset, MO; Mirwald et al., 2002), and predicted adult height (PAH, Khamis & Roche, 1994) for each player were assessed. After the tournament, 28 male and 15 female players were selected for the extended squad of the respective youth national teams. Separately for each gender, independent samples t-tests were utilized to analyze differences in the assessed outcomes between selected and non-selected players. Cohen's d served as effect size.
RESULTS
In the male sample, selected players were significantly taller ($p<.01$; $d=0.65$), heavier ($p<.05$; $d=0.44$), and showed significantly higher MO ($p<.05$; $d=0.44$) when compared to their non-selected counterparts. Regarding PAH, selected male players were predicted to get significantly taller than non-selected counterparts ($p<.01$; $d=0.70$). Regarding anthropometric characteristics in the female sample, selected players were taller ($p<.01$; $d=0.70$) while no differences in body weight were present ($p=.08$). Also, significantly higher MO ($p<.01$, $d=0.78$) and PAH ($p< .001$; $d=1.02$) could be observed in selected females.
DISCUSSION
Generally, evident advantages regarding maturity-related parameters in selected male and female players highlight the necessity for their consideration within talent identification procedures. However, future studies are required to allow for more differentiated analyses of the influence of biological maturity on talent selection within elite youth basketball. Among others, the evaluation of benefits of using bio-banded teams within selection tournaments may display a promising approach.
REFERENCES
Malina et al. (2019). Sports Med, 49(11), 1671-1685.
Mirwald et al. (2002). Med Sci Spo Ex, 34(4), 689-694.
Khamis & Roche (1994). Ped, 94(4), 504-507.

### THE IMPACT OF BIOLOGICAL MATURITY, BODY SIZE, AND BODY COMPOSITION IN RELATION TO RELATIVE AGE IN TALENT SELECTION AMONG FEMALE HANDBALL PLAYERS

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INTRODUCTION: Our previous studies have shown that talent selection based on sport-specific tasks is affected by the relative age effects among adolescent handball players. Relatively older players are more likely to be selected than relatively younger ones, which is typically attributed to differences in maturity and body size. In this study we examined the differences in body dimensions, body composition, and biological maturation of selected and not-selected players during a talent selection process in relation to their relative age.
METHODS: Talent selection included N = 264 adolescent female handball athletes who were born in 2008-2009. 106 players were selected for the next stage and 158 were excluded. The selection was based only on sport-specific tasks. The players underwent anthropometric, body composition, and bone age measurements on the day of the selection. Body height was measured with an anthropometer (DKSH Switzerland Ltd, Zürich, Switzerland) to the nearest 0.1 centimetre. Biological age was estimated from bone age with an ultrasound-based device (Sunlight Medical Ltd, Tel Aviv, Israel). Body weight and body composition was determined with an Inbody 720 bioimpedance instrument. We examined relative age effects based on the month of birth in quarter-year intervals (from Q1 to Q8). Differences in maturity, body size and body composition between Q1 to Q8 groups were examined by one-way analysis of variance (with a Scheffe post hoc test), Cohen d was used to compare selected and not-selected groups. We used SPSS 25.0 (IBM) for the statistical analysis.
RESULTS: Selected players were taller than not-selected players (164.7±6.6 vs 161.5±5.5 cm; d=0.54), biologically more developed (13.7±1.1 vs. 13.1±1.0 years; d=0.58) and had larger muscle mass (25.2±3.2 vs 23.5±3.2 kg; d=0.50). When analyzing the results in relation to the relative age groups separately for the selected and not-selected players significant differences between quartiles were evident only for maturity, with older players being more developed than their younger counterparts. There were no differences for body size or body composition.
CONCLUSION: Relative age effects affect selection chances in youth sport. Based on the existing literature, we assumed that the advantage of relative older in talent selection is attributed to differences in maturity, body size, and physical capabilities. Talent selection here was based only on sport-specific tasks and skills. Although there were differences between selected and not-selected players in maturity and body dimensions, the results did not confirm the superior body size and body composition for the relative older players. As expected, relative age groups differed only in maturity, but not in any other measure, suggesting that the advantage of the relative older, and thus more mature, players is not connected to their physical attributes. Rather it seems to affect performance in technical and tactical skills.

### THE IMPORTANCE OF SOCCER-SPECIFIC MOTOR COORDINATION IN ELITE SOCCER ACADEMY PLAYERS' AGILITY TESTING

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INTRODUCTION: The assessment of agility performance is a priority for soccer academy coaches since it fosters training optimization and talent identification. The majority of agility tests used in soccer players evaluation accounts for the physical aspect of agility only. Despite their wide use, these tests do not assess soccer-specific performances. Recently, the introduction of soccer-specific motor coordinative (SSMC) elements e.g., the capacity to manage a ball while sprinting, has been claimed to improve tests sensitivity for performance and maturation. The aim of the present study was to compare the outcomes of a generic agility test with a modified version including soccer-specific skills in a cohort of young elite soccer players.
METHODS: One-hundred forty elite male academy soccer players (U6, n=12; U8, n=28; U10, n=25; U12, n=24; U14, n=24; U16, n=27) participated in the study. Each player performed two tests: standard Illinois Agility Test (IAT) and Modified Illinois Agility test with ball (IATm). All tests were performed after pre-season training, during one regular training session for each category. The execution time for each test was recorded by a single operator through a handled digital stopwatch to the nearest 0.01s. The execution time for each player in each test was averaged among the three trials. The "SSMC gap" was defined as the difference between IATm and IAT execution time. IAT and IATm times were compared through the Repeated Measures ANOVA.
RESULTS: The execution time of IAT and IATm decreased with players' category ($F(5,134)=113.4$, $\eta^2p=0.81$, $p<0.001$), showing performance improvement. A substantial time decrease was noted up to 10 years old, while a lower decrease was found from U10 category on. The SSMC gap also decreased from 25.0 ± 4.9s (U6) to 4.6 ± 1.2s (U16). The SSMC gap for U6 and U8 was significantly higher than the other categories ($p<0.001$, large effect). From U10 category on, no differences in SSMC gap were found (post-hoc p-value $p<0.05$, Cohen's $d<1.94$).
CONCLUSION: The difference between IAT and IATm outcomes (SSMC gap) effectively tracked players' maturation and agility performance. The SSMC gap and SSMCI could provide valuable insights regarding players' skills. Soccer academy coaches should consider the combined use of generic and soccer-specific tests to optimize agility performance assessment at an early age.

### PHYSICAL PERFORMANCE DIFFERENCES IN FEMALE AND MALE GERMAN ELITE YOUTH BASKETBALL PLAYERS ACCORDING TO SELECTION STATUS

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INTRODUCTION
Within talent identification in sports, test batteries assessing physical abilities and skills are commonly used to assist coaches in their efforts to identify promising young players (Johnston & Baker, 2020). For basketball particularly though, there is only limited evidence for the relevance of physical parameters in predicting future performance, especially as it pertains female youth players (Johnston et al., 2018; Mancha-Triguero et al., 2019). Therefore, the aim of the present study was to compare physical performance indicators of selected and non-selected female and male elite youth players competing at the national selection tournament of the German Basketball Federation.
METHODS
The study samples consisted of N = 46 female U16 and N = 68 male U15 elite youth players who were invited to participate in the initial selection tournament for the German youth national basketball teams. In advance of the tournament, players passed a standardized physical performance test battery (10m-sprint, counter movement jump, standing long jump, modified agility T-test). After the tournament, n = 13 female and n = 27 male players were selected for the extended roster of the respective youth national teams. Independent samples t-

tests and associated Cohen's d were calculated for each gender separately to compare the test results between selected and non-selected players.
RESULTS
Considering descriptive statistics, selected players outperformed their non-selected counterparts in all investigated tests (except for male players in the 10m-sprint). Within the female sample, selected players outperformed non-selected players in the 10m-sprint ($p < .05$, $d = 0.68$) and the modified agility T-test ($p < .05$, $d = 0.67$). However, comparisons just failed to reach significance with respect to counter movement jump ($p = .08$) and the standing long jump ($p = .07$). For males, t-tests confirmed significant advantages for selected players in counter movement jump ($p < .05$; $d = 0.49$), while no statistically meaningful advantages were found regarding 10-m sprint ($p = .29$), standing long jump ($p = .15$), and the modified agility T-test ($p = .42$).
DISCUSSION
The present findings show that some of the conducted tests may assist coaches in identifying promising youth basketball players. However, there seem to be gender differences with regards to the abilities that differentiate selected from non-selected players. Thus, while speed abilities seem to be more relevant for identifying talented female basketball players, vertical jumping abilities may be a focus in male players. Future research is needed to examine such gender differences more closely.
REFERENCES
Johnston et al. (2018). Sports Med, 48, 97–109.
Johnston & Baker (2020). Front Psychol, 10, 2925.
Mancha-Triguero et al. (2019). J Sports Med Phys Fitness, 59, 1513-1525.

**YOUTH INTERNATIONAL EXPERIENCE IS A LIMITED PREDICTOR OF SENIOR SUCCESS IN FOOTBALL: THE RELATIONSHIP BETWEEN U17, U19, AND U21 EXPERIENCE AND SENIOR ELITE PARTICIPATION**

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Introduction
Athlete participation in youth international competitions is often regarded as crucial to the attainment of future success. However, the link between participation and performance in sports at youth levels and senior levels is unclear at best. To understand this relationship better we conducted two studies of male football players.
Methods
A total of 1,482 players who had national football team experience at either the U17, U19, U21, or senior levels were included in our studies. These were players from six different nations, distributed across the various playing positions. In Study 1, we examined adult performance at the upper levels of football using a factor analysis and identified the characteristics that define what we termed a 'Super Elite' level, which is the highest level of participation. This outcome measure was used in Study 2 to explore further the link between youth international experience and Super Elite experience via regression models.
Results
In Study 1, the factor analysis suggested that participation in a senior national team, the Champions League, and the Europa League was highly related and could be grouped together as a Super Elite level. In Study 2, our results indicated that youth international experience is a limited predictor of participation at the Super Elite level of football. Participation at the U21 level was the strongest, most consistent predictor of Super Elite level participation. U17 participation was found to be either an insignificant or a negative predictor of subsequent participation in international football. The effect of U19 participation on later participation was partly significant, but weaker than the effect of U21 participation, and depended on national context and playing position.
Discussion
Investments in association-based youth talent identification and selection systems in football may not be useful because such participation does not appear to be a strong predictor of later international elite football participation. Our findings indicate that sport governing bodies need to re-consider their strategies for talent identification and development: before players reach adulthood, fewer resources could be spent on helping a limited number of selected players gain competitive international team experience. This may mean, instead, that the limited economic and human resources that are available should be re-allocated to more local activities that promote recruitment, participation, and development at the grassroots level. Doing so could achieve broader benefits without compromising the development of elite sport.

## Oral presentations

### OP-SH16 Psychology: Motivation

**PRIOR SELF-CONTROL EXERTION AND REPEATED CYCLING SPRINT PERFORMANCE**

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INTRODUCTION: The exertion of self-control has been associated with impaired performance on a number of subsequent physical tasks also requiring self-control, including endurance performance, skill-based tasks, and isometric tasks (Hunte et al., 2021). However, it remains unknown whether repeated sprint exercise performance is negatively affected by the prior exertion of self-control. Therefore, this study explored whether prior self-control exertion reduces subsequent performance on a repeated sprint cycling task and potential mechanisms for these effects.
METHODS: Nineteen physically active males (21.2±2.2 y) completed a repeated sprint cycling task (Wattbike) on two occasions. The repeated sprint exercise task involved 5 x 6 s sprints, with a 24 s passive recovery between each sprint. Prior to the repeated sprint cycling task, participants completed a congruent Stroop task (non-self-control exertion) or an incongruent Stroop task (self-control exertion) for 4 min. Participants RPE and motivation (measured via a Visual Analog Scale) were recorded following each sprint.

RESULTS: Repeated measures ANOVAs (self-control * time) revealed that there was no significant interaction effect for peak power (p = .625), average power (p = .862), distance covered (p = .441), and cadence (p = .984) during the repeated sprint cycling task. Furthermore, there was no significant interaction effect for motivation (p = .960). However, there was a significant main effect of self-control for RPE (p = .030), whereby RPE was higher in the self-control exertion trial (M = 11.32, 95% CI = 10.08, 12.57) compared to the non-self-control exertion trial (M = 10.57, 95% CI = 9.53, 11.60).
DISCUSSION:
The findings suggest that the prior exertion of self-control leads to higher RPE during a repeated sprint cycling task. However, despite the higher perceptions of exertion, there was no difference in performance on the repeated sprint cycling task between the self-control and non-self-control exertion trials.
REFERENCES:
Hunte, R., Cooper, S. B., Taylor, I. M., Nevill, M. E., & Boat, R. (2021). The mechanisms underpinning the effects of self-control exertion on subsequent physical performance: A meta-analysis. International Review of Sport and Exercise Psychology. doi: 10.1080/1750984X.2021.2004610
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### ASSOCIATIONS BETWEEN SELF-REGULATION AND THE ADOPTION OF RECOVERY STRATEGIES IN SWIMMERS

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Introduction
Recovery is an important factor that allows swimmers to limit the training-induced fatigue and achieve continuous performance. Nutrition intake, hydration and sleep constitute primordial elements of the recovery process, as well as cooling strategies (e.g., cold-water immersion [CWI], contrast water therapy [CWT] and whole-body cryotherapy [WBC]), which have positive effects to reduce muscle soreness, improve the quality and quantity of sleep, and enhance performance. The benefits of these recovery strategies are now widely promoted. However, recent studies reported that swimmers' recovery behaviours differ from the actual recommendations. Exploring the specific determinants of self-regulation (i.e., self-control, motivation, self-efficacy) could allow to better understand the adoption of recovery strategies. Hence, we aimed to explore the associations between self-regulation and the adoption of the swimmer's recovery strategies.
Methods
A total of 780 competitive swimmers (41.5% female; age: 33 ± 15 years old) participated in a cross-sectional study. After providing information regarding their expertise and training status, participants were invited to fill in the sport motivation scale (SMS-II) assessing six motivational regulations from the Self-Determination Theory (intrinsic motivation, integrated, identified, introjected, and external regulation of extrinsic motivation, and amotivation). Self-efficacy and self-control were then respectively assessed with the Generalized Self-Efficacy Scale (GSES) and the Self-control scale (SCS). Additionally, participants stated whether they adopt the "recovery foundations" (nutrition, hydration, sleep hygiene) and/or "cooling strategies" (CWI, CWT, WBC). Due to non-normal distributions in the SMS-II, GSES, and SCS scores, non-parametric analyses were performed to compare participants who adopted or did not adopt recovery strategies.
Results
Statistical analyses were performed on 212 participants, excluding those with missing data. Group comparisons showed a higher score of amotivation (p=0.01) for swimmers who did not adopt recovery foundations, while swimmers who adopted recovery foundations had a higher score of intrinsic motivation (p=0.05). We observed tendencies of a higher score of integrated regulation (p=0.06) for swimmers who adopted cooling strategies, and of a higher score of introjected regulation (p=0.06) among swimmers who did not adopt cooling strategies.
Discussion
The results of this study suggest that swimmers who adopt recovery strategies are more intrinsically motivated to swim than those who do not; and that swimmers who do not adopt recovery strategies are more extrinsically motivated to swim. One limitation could be the "trait" measures of self-control and self-efficacy. Future studies could focus on motivation to swim and the formation of beliefs that underpin swimmer's recovery behaviours.

### HEART RATE VARIABILITY AND PRE-EJECTION PERIOD AS PHYSIOLOGICAL MEASURES OF EFFORT ENGAGEMENT DURING THE DEPLETING TASK IN A SEQUENTIAL TASK PROTOCOL

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INTRODUCTION: The strength model of self-control (Baumeister et al., 1998) suggests that the deployment of effort in a first effortful task results in the impairment of performance in a subsequent effortful task. This phenomenon is known as ego-depletion effect. In the past few years, this phenomenon has been criticized due to replication failures or theoretical underpinnings. The aim of the present study was to replicate the ego depletion effect using an adequate sequential task protocol. Since the Model of Neurovisceral Integration, Thayer and Lane (2000) proposed a heart-brain connection; i.e., a direct link between mental effort and the autonomous regulations over the heart. Heart rate variability and pre-ejection period, two measures of the autonomous regulation of the heart can be viewed as biological markers of cognitive resource mobilization. Measuring this resource mobilization could help us to study the link between effort engagement in the depleting task and the size of the ego depletion effect.
METHODS: We used a counterbalanced within-subjects design. Participants completed two experimental conditions (control vs. depleting). We used a modified 30-min Stroop task involving two executive functions (inhibitory control and cognitive flexibility) as the depleting task, a sub-maximal time-to-exhaustion handgrip task as dependent task, and watching a documentary as control task. On session 1, participants (N = 43) familiarized with the depleting task and the dependent task. At sessions 2 and 3, participants performed the control or the depleting task and then the endurance handgrip task. To measure the ego depletion effect, we compared the performance in the endurance handgrip task after the depleting or control task. The evolution of effort engagement during the control and depleting tasks was indexed by the activity of the sympathetic nervous system obtained by heart rate variability and pre-ejection reactivity. Participants perception of pain and effort was recorded every 30 sec during the endurance handgrip task.

Results: We replicated the ego depletion effect. Participants performed worse in the endurance handgrip task after the Stroop task compared to the video task ($p < 0.05$). Participants demonstrated a higher sympathetic activity during the Stroop task than during the video task ($p < 0.001$). Moreover, the sympathetic activity decreased from the beginning to the end of the Stroop task compared to the video task ($p < 0.001$). These results suggest a higher effort mobilization and a decrease over time during the Stroop task.
Discussion: These results confirm that a difficult effortful task is detrimental to a subsequent endurance performance. This study also highlights that the ego depletion effect is accompanied by an effort disengagement over time during the depleting task. Taken together these results show the pertinence of using physiological measures to control effort engagement in sequential task protocols.

## AUTONOMOUS MOTIVATION INFLUENCES ENDURANCE PERFORMANCE VIA EMOTIONAL RESPONSES TO DISRUPTIONS IN GOAL PURSUIT

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Introduction
The degree to which endurance activity is congruent with one's sense of self (i.e., autonomous) is positively associated with endurance performance. This effect has been explained by hedonic and reflective motivational disturbances during the endurance activity. However, it has also been theorized that autonomous motivation leads to more effective emotional regulation, especially when endurance goal pursuit is disrupted, which subsequently leads to superior performance. Two studies examined this hypothesis by focusing on participants' degree of frustration when endurance activities became unexpectedly more difficult.
Method
Study 1 involved 40 participants (45% female, Mean age = 22.65, SD = 2.61) completing a ten-minute cycling task and Study 2 involved 30 participants (40% female, Mean age = 21.63, SD = 1.94) completing an increasingly effortful cycling task until voluntary exhaustion. In both studies, autonomous motivation was measured prior to the task and the task was made unexpectedly more difficult during the trail. In study 1, feelings of frustration were measured at the end of the task and the performance outcome was distance covered. In Study 2, frustration was repeatedly measured throughout the task and the performance outcome was time until task cessation. Mediation analysis (Study 1 & 2) and multilevel modelling (Study 2) were employed to analyse the data.
Results
In study 1, a standardized indirect effect of autonomous motivation on performance via frustration was observed (B = 0.16, 95% CIs = .01 - .32). In study 2, autonomous motivation predicted slower increases in frustration over the course of the trial (B = -.01, p = 0.01). Slower increases of frustration were also characteristic of better performance (B = -.03, p = 0.01). Furthermore, a standardized indirect effect of autonomous motivation on performance via mean levels of frustration was observed (B = 0.24, 95% CIs = .04 - .46).
Discussion
Across two studies, consistent evidence demonstrated that autonomous motivation influences endurance performance via self-regulatory emotional responses to goal disruption. As such, this process should be considered alongside motivational dynamics that explain the performance benefits of autonomous motivation. It is likely that this process occurs because autonomously motivated individuals typically perceive goal disruptions as lower threats to self and adaptively respond to such disruptions.

## I WANT MY TO EXPERIENCE EMOTIONS THAT HELP ME PERFORM BETTER!!! AN INVESTIGATION RE-ANALYSISING OF BBC LAB UK DATA

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Emotions have a profound effect of thoughts and behaviour. Learning effective emotion regulation skills via use of psychological skills could have benefits for behaviour and health. Recent research has demonstrated that delivering psychological online improved performance and lead to adaptive emotional states among a large sample of over 44,000 participants (Lane, Totterdell et al., 2016). The present study uses the same database but focused on meta-beliefs that emotions helped performance, with the logic that interventions designed to regulate emotions should strengthen this relationship.
The online study was developed in conjunction with the BBC Lab UK and fronted by former Olympian Michael Johnson. Using data from 72,204 participants we tested 13 interventions comprising 3 different techniques (imagery, if-then planning, self-talk) that were targeted towards 4 different foci (outcome, task, process, arousal control), with a 13th group who were an active control group (N = 4383), who received instructions from Michael Johnson to play again. A 14th group of participants who voluntarily skipped the intervention video (N = 13265).
Repeated measures ANOVA was used to analyse changes in the intensity of beliefs that emotions helped performance over 4 rounds of competition. The performance measure was an online concentration grid where the goal was to complete as fast as possible, and beat an opponent matched against their time in the practice round. Baseline data was gathered in Round 1 and after which participants were grouped and then followed one of 12 interventions or a control. A 14th group comprised participants who skipped the instructional video. Participants then completed Round 2, with the same intervention followed again and then completed Round 3. ANOVA results indicated that participants who skipped the intervention reported lower meta-beliefs that emotions helped performance from the outset. Of the interventions, interventions that focused on improving skill, that is giving instructional information, had the weakest effect and were similar effect to skipping the interventions. In contrast, interventions that focused on managing emotional arousal, focusing on process goals and achieving an outcome goal had the strongest positive effects. In addition to Lane, Totterdell et al. (2016), findings from the present study emphasise the utility of focusing interventions on emotional arousal. Findings from the present study are showing that are useful in developing meta-emotional beliefs that emotions help performance. Further, the present study shows insight into developing a scalable method teaching and assessing the effects of brief video delivered interventions.

### UCLMUÉVETE PROJECT: USE OF GAMIFICATION AND DIGITAL APPLICATIONS TO PROMOTE ACTIVE BREAKS ON UNIVERSITY WORKERS

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INTRODUCTION: Occupational risk prevention programs targeting unhealthy habits are increasing in interest because they do not only improve workers health but also reduce absenteeism and increase productivity (Fazen et al., 2020). To do so, these programs usually target physical inactivity (PIA), sedentary lifestyles, social isolation, or stress. However, cost-effectiveness of these programs at are still unclear. Programs based on active breaks within the occupational time are promising approach because they increase physical activity (PA) levels of workers and break long-time sitting behaviour. On the other hand, digital applications and gamification seem to increase adherence to newer behaviours by providing social support, group cohesion and commitment (Haque et al., 2020; Mamede et al., 2021. Thus, combining these three elements in a healthy occupational program (#UCLMuévete) might result in a high cost-effectiveness that increase productivity and reduce absenteeism of internal clients (Grimani et al., 2019). Aims: This work aimed to 1) pilot-test the effectiveness of the #UCLMuévete program on university workers health, productivity and work relationships; 2) to analyse the practice adherence to this program.
METHODS: #UCLMuévete is a mixed quasi-experimental project that includes a 2-months pilot intervention. This project has been developed according to the TIDieR guideline and reporting checklist. The pilot intervention was applied at the University of Castilla-La Mancha by the time this abstract was submitted to the ECSS 2022. A total of 71 university workers voluntarily participated in this project. Participants were gathered into teams and received the indications of perform one active break every working day. Three types of active breaks were delivered to the participants under the gamification methodology using a app. So, anytime a participate completed the active break its team got a point. The team with the highest score at the end of the challenge won different rewards. The data collection was conducted before and after the 2-months intervention. The variables measured were (1) health parameters: cardiorespiratory fitness level, lower body strength, body composition; (2) productivity parameters measured through Heart Rate Variability, a variable that provides information of stress; (3) parameters related to work relationship; and (4) practice adherence.
Expected results: Significant improvements are expected to be observed in (1) cardiorespiratory parameters, lower body strength levels, and body fat; (2) productivity; (3) work relationship; and (4) practice adherence. In addition, a positive association between productivity and worker health is expected.
Conclusion: #UCLMúevete might increase university workers productivity by increasing their health through an innovative program that includes a gamification methodology and active breaks. TIDieR guidelines facilitate this project can be expanded to other sports organizations

## Oral presentations

### OP-MH21 Health and adolescents

### THE EFFECTS OF DIFFERENT CORE STABILITY TRAINING ON TRUNK STABILITY AND ATHLETIC PERFORMANCE IN ADOLESCENT FEMALE BASKETBALL PLAYERS

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INTRODUCTION: Trunk position is not only related to the performance of the physical fitness but important for the balance, stability and helping to progressively build fitness levels and improve athletic performance. This study aimed to investigate the effects of trunk stability and athletic performance after 2 types of core muscle training in adolescent female basketball players.
METHODS: Fifty-one of the top four elite female basketball players (age: 14.76± 1.84yrs, BMI: 21.41± 1.96 kg/m2) in the high school basketball league in Taiwan, were randomly assigned to control, TRX and Swiss ball groups using the total ranking of the pre-test scores. All were free from musculoskeletal injuries, vestibular dysfunction, and concussion within three months before the experiment and during data collection. All participants performed a progressive program consisting of 3*8 sessions twice-a-week unstable core muscle training for 8 weeks during the pre-season. Participants engaged in a total workout of 60 minutes with 10 minutes warm-up, 40 minutes main exercises (3*8 sessions: 40-second workout with 20-second rest between each exercise), and 10 minutes cool-down. The plank test for core muscle ability, jumping, speed, agility, and the ankle proprioception test were evaluated in one week before and after the training.
RESULTS: The score of the plank test increased in both TRX and Swiss ball groups, yet no significant difference was observed between the two groups. In terms of athletic performance, no significant change among the three groups after decreasing training volume converts into core muscle training.
CONCLUSION: Both TRX and Swiss ball training can increase core muscle ability without regressing athletic performance. Moreover, core muscle training could help players gain improved power transmission ability and also prevent injury. Thus, we suggested that adding core muscle training, instead of doing original/traditional training, would be an effective strategy for injury prevention.

### RELATIONSHIPS BETWEEN LOAD, WELLNESS AND INJURY IN ELITE JUNIOR AUSTRALIAN FOOTBALL: IT MAY NOT BE THE LOAD BUT HOW WELL YOU COPE THAT MATTERS.

GASTIN, P.

*LA TROBE UNIVERSITY*

INTRODUCTION: Elite junior Australian football players experience high loads across levels of competition and training [1]. High loads have been linked to the risk of injury, either in a linear or curvilinear (U-or J-curve) fashion [2]. Few studies have adjusted for variables that may influence the load-injury relationship such as how well players respond or cope with the physical and mental stresses of their sport [3]. The purpose of this study was to investigate the relationships between player load, wellness and injury. We hypothesised that player wellness would mediate and/or moderate the load-injury relationship.
METHODS: Data were collected and analysed from 280 Australian football players from nine under-18 state league clubs across one season. Internal load was measured via session rating of perceived exertion (sRPE) for training and competition. Week and month-based

absolute and relative load measures were then calculated. Player wellness was reported three times per week for sleep duration and ratings (1-5) of sleep quality, fatigue, soreness, stress and mood. Principal Component Analysis factor loadings were used to identify distinct covariates (6 components, 17 load and wellness variables). Injury was defined as 'any injury leading to a missed training session or competitive match', with only new injuries included in the analysis. Associations between covariates and injury risk (yes/no) were determined via logistic Generalised Estimating Equations.
RESULTS: Univariate analysis indicated that load was associated with injury in the form of a non-linear relationship. Further, wellness as a composite measure, as well as individual factors of stress, soreness and fatigue demonstrated direct relationships with injury. Modelling indicated evidence of mediation where increased soreness amplified the relationship between stress and injury, while increased sleep duration reduced the relationship. A significant interaction term between load and wellness on injury was found (OR= 0.76 95% CI 0.62 to 0.92, P<0.01), indicating the regression weight of load on injury varied as a function of wellness (i.e., wellness acting as a moderator, with poor wellness at high loads further increasing the risk of injury). Including wellness as a mediator or moderator in the analysis suggests that injury risk increases substantially at a 1-week load of 3750 au and beyond.
CONCLUSION: Internal measures of training and competition load are associated with injury risk. This relationship is further influenced by player subjective wellness and sleep, which when poor can amplify the risk of injury at high loads. There is also evidence that higher stress is linked with injury and that soreness and sleep can mediate this relationship. Efforts to monitor and manage load and to support positive adaptive responses may reduce the risk of injury, with perceptions of stress, soreness and sleep relevant in this cohort.
References: [1] Lathlean et al, JSCR 2018; [2] Lathlean et al, IJSPP 2019; [3] Lathlean et al, IJSPP 2020.

**ASSOCIATION BETWEEN WORKING MEMORY PERFORMANCE AND CARDIOVASCULAR FITNESS IN YOUNG HEALTHY ADULTS**

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*UNIVERSITY OF BASEL*

INTRODUCTION: Aerobic exercise and cardiovascular fitness have been shown to be beneficial to working memory. Empirical data mainly covers developmental changes in children and older adults leaving a research gap on the association in young adulthood. As memory performance reaches its peak in young adulthood, the lack of evidence in this age group may be attributed to the expectation of ceiling effects.
METHODS: The present study addresses this research gap by assessing the association between working memory performance at increasing difficulty and cardiovascular fitness and in young adults. The presented cross-sectional study examined the association between visual working memory performance and cardiovascular fitness and in N = 98 (57% female) healthy adults aged 18 to 35 years (M = 23.8, SD = 3.6). Cardiovascular fitness was assessed by estimation of maximal oxygen consumption (VO2max) from the Åstrand submaximal bicycle ergometer test (Nordgren et al., 2014). Working memory performance was assessed using the modified Sternberg task with increasing difficulty, using set-sizes 3 and 6 (Ludyga et al., 2018).
RESULTS: Estimated relative CRF (VO2max) was put into relation with accuracy and mean reaction time and the inverse efficiency score (RT/ACC) at low and high memory load using linear regression. The results showed no significant association between relative VO2max and working memory performance in young adults.
CONCLUSION: In conclusion, young adulthood may be a period, during which working memory performance may not be benefited by increased cardiovascular fitness.
References:
Ludyga, S., Gerber, M., Kamijo, K., Brand, S., & Pühse, U. (2018). The effects of a school-based exercise program on neurophysiological indices of working memory operations in adolescents. Journal of Science and Medicine in Sport, 21(8), 833-838. https://doi.org/https://doi.org/10.1016/j.jsams.2018.01.001
Nordgren, B., Fridén, C., Jansson, E., Österlund, T., Grooten, W. J., Opava, C. H., & Rickenlund, A. (2014). Criterion validation of two submaximal aerobic fitness tests, the self-monitoring Fox-walk test and the Åstrand cycle test in people with rheumatoid arthritis. BMC Musculoskeletal Disorders, 15, 305. https://doi.org/10.1186/1471-2474-15-305

**THE POTENTIAL IMPACT OF EXERCISE UPON SYMPTOM BURDEN IN ADOLESCENTS AND YOUNG ADULTS UNDERGOING CANCER TREATMENT.**

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INTRODUCTION: Adolescents and young adults (AYAs), in comparison to younger and older cohorts, are reported to experience the greatest symptom burden resulting from cancer treatment-related toxicities (TRTs). Growing evidence supports integrated exercise to mitigate several TRTs in other cohorts, however in AYAs specifically this is yet to be explored. This study sought to evaluate the impact of an exercise intervention on TRTs in AYAs undergoing cancer treatment.
METHODS: A prospective, randomised controlled trial allocated participants to a 10-week exercise intervention (EG) or control group (CG) undergoing usual care within an outpatient hospital setting. Participants undertook weekly blood tests and telephone interviewing to capture haematological and patient-reported TRTs throughout the intervention. All TRTs were graded per the Common Terminology Criteria for Adverse Events (CTCAE V5.0). Toxicities were then categorised for analysis into the maximal worst grade experienced as per standard clinical trial toxicities reporting. Further, novel exploratory longitudinal analysis was conducted to capture the trajectory of toxicities experienced over time between groups.
RESULTS: Forty-three (43) participants (63% male, mean age 21.1 years) were enrolled. The maximal worst grade toxicity experienced for haematological and patient-report TRTs (Grade 0, Grade 1-2 and ≥Grade 3) demonstrated no significant differences between groups ($p>0.05$). However, exploratory longitudinal analysis of the four most common toxicities (fatigue, pain, nausea and mood disturbances) revealed a decrease in the frequency of severe fatigue, nausea and mood in the EG, compared with the CG. Additionally, there was an increased incidence of severe pain toxicity in the EG compared with the CG. All exploratory analyses were not statistically significant ($p>0.05$).
CONCLUSION: While no group differences were apparent when utilising standard toxicity reporting, it appears that the longitudinal analysis of toxicities provided the greatest insight into the toxicity profile of AYAs undergoing cancer treatment. This novel approach revealed potentially clinically relevant differences between the two groups over time which would have been otherwise been missed using traditional analysis methods. As such, the exercise intervention appeared to provide benefit in terms of reducing the severity of fatigue, nausea

and mood disturbances in this cohort. While these trends must be interpreted with caution due to their lack of statistical significance, they provide insight into the possible reduction of symptom burden and should be investigated in a larger homogenous sample.

### EFFECTS OF ISOMETRIC RESISTANCE TRAINING AND SUBSEQUENT MAINTENANCE DOSE ON AMBULATORY BLOOD PRESSURE AND MORNING BLOOD PRESSURE SURGE IN YOUNG NORMOTENSIVES

BAROSS, A.W., JAY, G., STOODLEY, L.

*UNIVERSITY OF NORTHAMPTON*

INTRODUCTION: Hypertension, a modifiable risk factor for cardiovascular disease (CVD) is associated with approximately one third of deaths globally each year. Diurnal blood pressure (BP) variability and more specifically morning blood pressure surge (MBPS) are associated with increased risk of stroke, end-organ damage and are considered to be destabilising factors for atherosclerotic plaques. Isometric resistance training (IRT) has been shown to reduce ambulatory BP and MBPS following 8-10 weeks of training. However, there is no data at present which has established the dose of training needed to maintain these reported reductions following the initial IRT period. Therefore, the purpose of this study was to determine the effects of IRT on ambulatory BP and the MBPS in young normotensives following (i) 8 weeks of IRT and (ii) 8 weeks of a once a week maintenance dose.
METHODS: Twenty-five normotensive individuals (15 men, age=21±4 years; 10 women, age=22±3 years) were randomly assigned to a training-maintenance (TRA-MT, n=13) or control (CON, n=12) group. Ambulatory BP and MBPS were measured prior to, after an 8-week (3 days/week) training period and following an 8-week maintenance period (1 day/week) of bilateral leg IRT using an isokinetic dynamometer (4 x 2-minute contractions at 20% MVC with 2-minute rest periods). A two-way repeated measures MANOVA was used to assess the within and between groups changes in ambulatory BP and MBPS. MBPS was calculated as: mean systolic BP 2 hours after waking, minus the lowest sleeping 1-hour mean systolic BP.
RESULTS: There were significant reductions in 24-h ambulatory systolic BP following IRT (pre-to-post training, -7±5 mmHg, p=0.001) and these reductions remained after the maintenance period (pre-to-post maintenance, -6±4 mmHg, p=0.000). There were significant reductions in daytime BP (pre-to-post training, -5±5 mmHg, p=0.034) which remained following maintenance (pre-to-post maintenance, -5±5 mmHg, p=0.02), but there was no change in night-time systolic BP (pre-to-post training, -2±5 mmHg, p=0.685) or post maintenance period (pre-to-post maintenance, 1±6 mmHg, p=0.94). Additionally, there were significant reductions in the MBPS (pre-to-post training, -9±10 mmHg, p=0.005) which were maintained post maintenance period (pre-to-post maintenance, -8±11 mmHg, p=0.014). Additionally, significant correlation was identified between the magnitude of the change in MBPS and the magnitude of changes in mean SBP 2-h after waking (r = 0.78, P=0.002).
CONCLUSION: These results provide further evidence that IRT causes significant reductions in MBPS in addition to the previously reported reductions in ambulatory BP. Additionally, these reductions seem to be maintained with a reduced exercise dose. These findings may also have important clinical implications, the significant reductions in the MBPS offer the potential for meaningful CVD and stroke risk reduction, provided these effects can be demonstrated in those who are at risk.

## 16:30 - 17:45

## Invited symposia

### IS-PN10 The microbiome-diet-host interactions: Implications for health and exercise performance

### THE INFLUENCE OF DIET AND ORAL MICROBIOME ON NITRIC OXIDE HOMEOSTASIS AND CARDIOVASCULAR HEALTH

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Imbalances in the oral microbial community, and poor dental health, have been associated with impaired cardiovascular health and the role of the oral microbiota as a potential modulator of human health is a growing area of multidisciplinary research. One mechanism that may link the oral microbiota to good health is the nitrate-nitrite-nitric oxide (NO) reduction pathway. This, for its first step, crucially relies on the reduction of nitrate, which is ingested through diet, to bioactive nitrite by anaerobic bacteria residing in the mouth. Among many other physiological roles, NO regulates vascular endothelial function, and therefore blood pressure. Epidemiological studies show that a high dietary nitrate intake (such as in the vegetable-rich 'Mediterranean' or '≥5 a day' diets) may reduce the risk for adverse cardiovascular events, and several studies have shown that dietary nitrate supplementation significantly reduces blood pressure in both young and older adults. Differences between individuals in the ability to reduce nitrate to nitrite and in the effects on blood pressure indicate that the benefits derived from a high nitrate diet may be contingent on individuals having the right oral microbiota. The ability to produce NO in the body through the classical pathway involving nitric oxide synthase (NOS) enzymes is impaired in older age, leading to a gradual increase in blood pressure and associated comorbidities. The nitrate-nitrite-NO pathway has significant potential to compensate for dysfunctional NOS in older age and recent research has concentrated on how the symbiotic relationship between the human host and the oral microbiota might change with ageing and how the oral microbiota might be optimised to maintain cardiovascular health during ageing. This presentation will discuss recent advances in elucidating the role of the oral microbiome in the maintenance of NO homeostasis, and highlight the therapeutic potential of oral prebiotic and probiotic interventions for improving cardiovascular health in older age.

### FERMENTABLE DIETARY FIBRE AND ASSOCIATED EFFECTS ON THE GUT MICROBIOME, HEALTH, AND PERFORMANCE

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*UNIVERSITY OF EXETER*

Specific types of dietary fibre escape digestion and reach the colon, where they are fermented by beneficial bacteria to produce short chain fatty acids. These organic acids have potent anti-inflammatory effects and maintain gut barrier integrity. In recent years SCFA have been identified as the mechanistic link between gut microbiome and its systemic effects on the nervous (gut-brain axis), cardiovascular, and

immune system. There is emerging data pointing at the association between gut microbiome and exercise, with potential effects on muscle metabolism and performance.
This presentation will focus on one of the most studied and characterised fermentable fibre (inulin) and discuss the effects of inulin supplementation in health and performance outcomes. It will provide practical implications and recommendations for conducting such studies in real-world settings, including methodological implications and controlling for confounders. Our target audience includes those interested in healthy aging, non-communicable diseases, and performance, including researchers and practitioners (sports nutritionists, exercise physiologists)
The first part will discuss the mechanistic link between gut microbiome and cardiovascular and immune functions. This will include the ability of inulin supplementation of increasing the abundance of specific beneficial bacteria and metabolites, and how these affect vascular and immune markers both in the general population and athletes. This part will also discuss novel studies that combine inulin and exercise interventions or exercise alone, and how these differ in terms of gut microbiome changes and clinical outcomes.
The second part will focus on performance outcomes, and how inulin supplementation might improve this from mice to human studies. This part will present up-to-date evidence on the mechanistic role of specific gut microbiome metabolites (acetate and butyrate) on muscle metabolism and endurance capacity.

**THE EFFECTS OF DIETARY PATTERNS ON ORAL AND GUT MICROBIOMES AND IMPLICATIONS FOR EXERCISE PERFORMANCE IN ELITE ENDURANCE ATHLETES**

BURKE, L.

*AUSTRALIAN CATHOLIC UNIVERSITY*

The macronutrient content of the diet has a major influence on the composition of the microbiome in the mouth and throughout the gastrointestinal tract. The impacts of dietary patterns on the oral and gut microbiomes have been recently investigated in cohorts of elite endurance athletes who follow extremely specialised diets such as high carbohydrate (CHO) or periodised high-CHO diet, and the ketogenic low-CHO high-fat (LCHF) diet. The macronutrient composition of the diet may influence host physiology via metabolic outputs of bacteria (e.g. production of short chain fatty acids) and via alterations to the quantity of bacteria or composition of the microbial community (e.g. changes in abundances of nitrate-reductase bacteria). In a series of studies we examined the diet-microbiota interactions potentially affecting the physiology and/or metabolism of healthy, highly trained human subjects. The first comprehensive investigation of the effects of high-CHO and LCHF diets on the gut microbiome of elite endurance athletes revealed that LCHF diet significantly increased the relative abundances of key bacterial taxa (Bacteroides and Dorea spp.) that correlated with impaired exercise economy and fat oxidation. We subsequently showed that three weeks of LCHF diet in elite race walkers resulted in alterations in abundances of oral bacterial taxa (Haemophilus, Prevotella and Neisseria) that considered to be key nitrate-reducers in the enterosalivary nitrate-nitrite-nitric oxide (NO) pathway within the oral cavity. This lecture will highlight the most recent research findings suggesting that dietary patterns appear to exert a significant impact on the gut and oral microbiotas of endurance athletes. It is important that commonly used dietary approaches that are applied to enhance athletic performance are carefully monitored and managed to ensure that the microbiota is appropriately nurtured to maximise the available benefits from nutrition.

## Invited symposia

### IS-EX02 ACSM-ECSS exchange: Blood glucose regulation during exercise

**THE EFFECT OF TRAINING ON INSULIN SECRETION**

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Physical training improves insulin sensitivity in skeletal muscle. This effect is present regardless of the modality of training, being endurance exercise, strength training or high-intensity interval training. Likewise, the effect is present in healthy individuals, young as well as old, and it is present in patients with insulin resistance, e.g. obese patients and/or patients with type 2 diabetes.
However, glucose homeostasis is balanced by not only insulin action but also by insulin secretion from the pancreatic ß-cells. Perhaps as a consequence of the training-induced improvement in skeletal muscle insulin sensitivity, the □-cell secretory capacity diminishes. This has been described as the hyperbolic relationship between insulin secretion and sensitivity.
Diminished insulin response to a given stimulus (e.g. glucose, arginine) is prudent in a situation with enhanced increased insulin action. If the adaptive insulin response is not present, the risk of hypoglycemia increases.
The hyperbolic relationship between insulin secretion and sensitivity is important in healthy individuals, but it may not be advantageous in patients with type 2 diabetes. These patients suffer from a relative insulin deficiency, i.e. the insulin secretory capacity does not match the prevailing insulin sensitivity and hyperglycemia succeeds. In this situation, a decrease in insulin secretion, elicited by a training-induced increase in insulin sensitivity, will not be beneficial for glucose homeostasis.
Some studies indicate that patients with type 2 diabetes display an opposite β-cell response after aerobic physical training, i.e. the insulin secretory capacity increases in contrast to the decrease seen in healthy individuals. The enigma hidden here is the mechanism behind the opposite β-cell responses to the same stimuli.
β-cell secretory function is typically measured by a hyperglycemic clamp or an intravenous glucose tolerance test. This is done in the resting state with 1-2 days since the last training bout. Yet, the pancreatic □-cells are somehow able to sense the training status of the body and respond accordingly. Thus, a "memory" in the β-cells or elsewhere has been introduced by the exercise training. The nature of this "memory" is yet unresolved.
In the presentation, new data on β-cell adaptation to training in patients with type 2 diabetes will be presented. This will include responses to endurance training with and without simultaneous pharmacological antidiabetic treatment. Furthermore, an experimentally based hypothesis on the introduction of β-cell "memory" will be presented.

### THE PRECIOUS 5 GRAMS OF BLOOD GLUCOSE DURING EXERCISE: ROLES OF THE GLUCOSE SHUNT AND LACTATE SHUTTLE

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Physical exercise typically demands major increases in energy demand, particularly is exercise intensity is high and prolonged. As exercise intensity exceeds 65% of maximal oxygen uptake carbohydrate energy sources predominate. However, relative to the meager 5 g (one teaspoon) of blood glucose (1 g L x 5 L blood  20 kcal), carbohydrate oxidation rates of 20 kcal/min can be sustained in a fit person for an hour, if not longer. And while glucose rate of appearance (i.e., production, Ra) from splanchnic sources in a post absorptive person can rise 2-3 fold over rest during exercise, working muscle and adipose tissue glucose use must be restricted otherwise hypoglycemia would result in less than a minute during hard exercise because blood glucose disposal rate (Rd) could easily exceed glucose production (Ra) from hepatic glycogenolysis and gluconeogenesis and rapidly. While during rest most body glycolysis is from blood glucose, during exercise, use is glucose as body CHO fuel is restricted, shunted to working muscles even as working muscle glucose uptake is limited. Hence, glycogen in working muscle becomes the major CHO energy source in working muscle. As well, glycogen in working muscle and other depots (non-contracting muscles and adipose) produces lactate, the major gluconeogenic precursor in liver and kidneys. As well, lactate releases from glycogen depots can directly fuel heart, working red muscle and brain. In this presentation the integration of physiological, neuroendocrine, circulatory and biochemical mechanisms necessary for euglycemia to be maintained during sustained hard exercise are discussed. Among these are the integrated regulation of insulin, the sympathetic nervous system, other glucoregulatory hormones and competitiveness among energy substrates.

## Oral presentations

### OP-PN12 Energy availability

### SEMI-PROFESSIONAL RUGBY UNION PLAYERS MAY BE AT RISK OF LOW-ENERGY AVAILABILITY

ROBERTS, C., BEAVEN, C., POSTHUMUS, L., GILL, N., SIMS, S.

*UNIVERSITY OF NORTHAMPTON*

INTRODUCTION: Rugby players should aim to consume enough food to meet energy, macronutrient and micronutrient requirements. Failure to do so can negatively impact performance, recovery, health, well-being, cognitive function and may increase injury risk. Provincial academy players in New Zealand typically present congested schedules; alongside developmental rugby athletes will train and play at the local club level and balance study and work commitments. As such, monitoring and management of dietary intake is crucial.
METHODS: Nine semi-professional developmental rugby union players (age = 20.6 ± 1.7 years; height = 186.3 ± 9.0cm; body mass = 102.4 ± 18.2kg; fat free mass = 82.9 ± 12.1kg) recorded dietary intake over a 4-week pre-season using the remote food photography method. Body composition was assessed via three-dimensional optical scanning.
RESULTS: A total of 76 days were sufficiently logged. A large variability in daily total nutrient intake was observed (Energy = 2550 ± 914 kcal, protein = 135 ± 50 grams, carbohydrate = 270 ± 122 grams, fat = 97 ± 42 grams). Energy intake relative to fat free mass (FFM) was 31 ± 11 kcal.kg FFM. Relative to total body mass, protein intake was 1.3 ± 0.4 grams and carbohydrate intake 2.6 ± 1.3 grams. Requirements for protein and carbohydrates were not met on 49.4 and 96.6% of eating occasions, respectively.
CONCLUSION: Energy intake relative to FFM did not meet the proposed threshold of 40kcal.kg FFM to ensure optimal energy availability for physiological functions in male athletes [1]; previous research has demonstrated that high-level rugby players may expend 61 kcal.kg FFM daily [2]. Failure to meet the optimal threshold may result in physiological and metabolic dysfunction [3], impairment to adaptive responses to exercise and performance [1,3], increased risk of injury or illness [1,3] and a failure to meet macronutrient and micronutrient requirements [3]. Indeed, relative protein intake was at the low end of recommendations for athletes, potentially compromising FFM during periods of energy deprivation, which may be further exacerbated by inadequate energy intake [1]. Similarly, carbohydrate intake did not meet best-practice sports nutrition recommendations for rugby players.
Developing rugby players should take care to consume a high-quality diet that meets energy and macronutrient requirements to tolerate the demanding nature of the sport, promote adaptation and optimal health and decrease injury risk.
[1] Wasserfurth et al., 2020. Reasons for and consequences of low energy availability in female and male athletes: social environment, adaptations, and prevention. Sports med, 6(1), pp.1-14.
[2] Smith et al., 2018. Energy expenditure of rugby players during a 14-day in-season period, measured using doubly labelled water. Eur jour app phys, 118(3), pp.647-656.
[3] Logue et al., 2018. Low energy availability in athletes: a review of prevalence, dietary patterns, physiological health, and sports performance. Sports Med, 48(1), pp.73-96.

### COMPARISON OF PHYSIOLOGICAL AND CLINICAL MARKERS FOR CHRONIC SPRINT-INTERVAL TRAINING EXERCISE PERFORMED EITHER IN THE FASTED OR FED STATES AMONG HEALTHY ADULTS

TAN, A.

*CHANGI GENERAL HOSPITAL*

INTRODUCTION: Sprint-interval training (SIT) and intermittent fasting are effective independent methods in achieving clinical health outcomes. However, the impact of both modalities when performed concurrently is unclear. The aim of this study was to compare the effects of 6 weeks of SIT performed in the fasted versus fed state on physiological and clinical health markers in healthy adults.
METHODS: Thirty recreationally-active participants were equally randomised into either the fasted (FAS; 4 males, 11 females) or the fed (FED; 6 males, 9 females) group. For all exercise sessions, FAS participants had to fast ≥10 h prior to exercising while FED participants had to consume food within 3 h to exercise. All participants underwent three sessions of SIT per week for 6 weeks. Each session consists of repeated bouts of 30-s Wingate Anaerobic cycle exercise (WAnT). Pre- and post-training peak oxygen uptake (VO2peak), isokinetic leg strength, insulin sensitivity, blood pressure and serum lipid levels were assessed.

RESULTS: There were no differences in baseline physiological and clinical measures between both groups (all $p > 0.05$). VO2peak improved by 6.0 ± 8.8% in the FAS group and 5.3 ± 10.6% in the FED group (both $p < 0.05$), however the difference in improvement between groups was not statistically significant ($p > 0.05$). A similar pattern of results was seen for knee flexion maximum voluntary contraction at 300◦/s. SIT training in either fasted or fed state had no impact on insulin sensitivity (both $p > 0.05$). There was significant reduction in diastolic blood pressure (8.2 ± 4.2%) and mean arterial pressure (7.0 ± 3.2%) in the FAS group (both $p < 0.05$) but not FED group (both $p > 0.05$).
CONCLUSION: A lack of significant change in the VO2peak gains between FAS and FED groups after six weeks of SIT could be due to mismatch in fuel source for SIT, whereby the body's preferred energy source during SIT type of exercise is creatine phosphate and anaerobic glycolysis of muscle glycogen, rather than FFA oxidation as seen in fasting. Improvement seen in knee flexion MVC at 300◦/s was likely secondary to neural adaptation to WAnT training. The two different mechanisms elicited by fasting (increased production of nitric oxide (NO) through reduced oxidative stress to endothelial cells and upregulation of pathways (e.g. tyrosine phosphorylation and AMPK/PI3K/Akt/eNOS) via metabolic switching with increased uptake of FFA by the body) and SIT exercise (increases availability and production of NO by increasing endothelial nitric oxide synthase activity and reducing endothelin-1 levels to improve endothelial function and reduce arterial wall stiffness and peripheral vascular resistance) could have combined to amplify the positive effects on BP.
In conclusion, VO2peak and leg strength improved with SIT regardless of whether participants trained in the fasted or fed state. Chronic SIT in the fasted state may potentially reduce blood pressure to a greater extent than the same chronic SIT in the fed state.

### ADDITION OF FRUCTOSE TO A CARBOHYDRATE-RICH BREAKFAST IMPROVES CYCLING ENDURANCE CAPACITY IN TRAINED CYCLISTS

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*UNIVERSITY OF BIRMINGHAM*

INTRODUCTION: The importance of high carbohydrate (CHO) availability for optimal performance in endurance sports is well established and thus strategies have been developed to optimise CHO availability before, during and after exercise sessions. It has been demonstrated that fructose-glucose based CHO mixtures are superior in achieving high CHO availability if ingested during exercise and in recovery. During the latter, ingestion of fructose-glucose-based carbohydrates led to superior liver and similar muscle glycogen synthesis as compared to glucose-based CHO. After an overnight fast, liver glycogen stores are reduced, and based on this we hypothesised that addition of fructose to a glucose-based breakfast would lead to improved subsequent endurance exercise capacity.
METHODS: 8 trained male cyclists took part in this double-blind cross-over randomised study (VO2max: 62.2 ± 5.4 ml.kg-1.min-1). participants completed 2 experimental trials consisting of two exercise bouts. In the afternoon of Day 1, they completed a cycling interval training session aimed to normalise glycogen stores after which a standardised high carbohydrate diet was provided for 4 hours. After an overnight fast on Day 2, participants received 2 g.kg-1 of carbohydrates in the form of glucose and rice (GLU+RICE) or fructose and rice (FRU+RICE), both in a CHO ratio of 1:2 (fructose:glucose based CHO). Two hours later they commenced a cycling exercise session at the intensity of the first ventilatory threshold until task failure, during which blood glucose and lactate as well as substrate oxidation rates were assessed every 15 minutes.
RESULTS: Exercise capacity was higher in FRU+RICE (137.03 ± 22.72 min) as compared to GLU+RICE (130.06 ± 19.87 min; $p = 0.046$). Blood glucose and blood lactate remained stable throughout the trials and did not differ between conditions ($p>0.05$). Oxidation rates of CHO decreased, and fat increased over time with no differences between conditions ($p>0.05$).
CONCLUSION: Present data demonstrates that addition of fructose to a glucose-based CHO source at breakfast improves endurance exercise capacity, possibly as a result of higher CHO availability due to improved carbohydrate storage in the form of liver glycogen. It could therefore be recommended that athletes ingest a breakfast containing both fructose- and glucose-based CHO. Further studies are required to determine the optimal dose and ratio and to better understand the mechanisms.

## Invited symposia

### IS-AP07 How good are we in quantifying Training/Competition Load, Fatigue and Performance? – New insights

### UP-COMING BLOOD-BASED BIOMARKERS FOR MONITORING LOAD, FATIGUE, AND RECOVERY

HALLER, N.
*JOHANNES-GUTENBERG-UNIVERSITY MAINZ*

Blood biomarkers are routinely used in elite sports settings. They can play an important role in individualizing the workload of athletes by providing an objective measure of internal load, health, or recovery processes to reduce injury risk and maximize performance. Currently, many established biomarkers such as creatine kinase, while convenient and quick to measure, have drawbacks and are of limited use to coaches in managing athlete workload, especially when measured in the absence of further variables. Researchers have therefore increased their efforts to identify novel robust surrogate biomarkers to help in monitoring training load, fatigue, and recovery.
This lecture will provide an overview of emerging load-sensitive biomarkers and multi-marker approaches that should be considered in future research. A variety of such innovative markers (e.g., heat shock proteins, cell-free DNA, blood cell ratios) have shown meaningful and pronounced increases after standardized exercise settings or even correlations with performance traits. However, most of these markers have not been extensively studied, and the cost, time, and effort associated with measuring these variables on a regular basis remain high, making them unsuitable for monitoring purposes to date. Due to evolving technology, these innovative markers will likely become relevant to sports practitioners very soon. Finally, the section on practical applications will focus on statistical considerations and ideas for standardized study designs to help identify and establish new biomarkers.

### MODERN METHODOLOGIES AND CONCEPTS FOR TRAINING AND COMPETITION LOAD MONITORING: POSSIBILITIES AND CHALLENGES

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The quantification of training and competition load is of high relevance in modern load monitoring and management concepts. The provided data should serve to control the training, prevent injuries and overload and lead to the proper training stimulus and consequently the targeted adaptations to maximize performance. Various methodologies and concepts for quantification of the external and internal load are already applied in sport practice and science. Further, the trend towards miniaturization of measurement hardware and its integration into sports gear starts to allow an even more microscopic insight into physiology and biomechanics of human motion from a more global (E.g. heart rate, oxygen uptake, blood lactate) to local perspective (E.g. loading of single muscles). The introduction of novel sensor data as NIRS, power meters, sensor patches (E.g. glucose, lactate) but also modern training software applications open up a new world in the field of performance diagnostics and training load management. However, the greater possibilities and more microscopic view on the human body in motion leads also to novel challenges.
The presentation will provide insight into to date applied sensor technologies, methodologies and concepts for quantification of training and competition load in science and sport practice in elite endurance- and team sports. Challenges, pitfalls, possibilities and perspectives will be demonstrated on selected examples like concepts about the energy expenditure of training (E.g. energy expenditure during various endurance training concepts – isocaloric training), competition and training analysis based on wearable technology (e.g. heart rate, vs. high-end GNSS vs. NIRS), concepts about the quality of motion (E.g. acting forces, technique feedback, equipment behaviour) and the discrepancy of various concepts when aiming on quantification of the distribution of the training intensity and training volume. Further, concepts and ideas how to determine the total training load when it comes to mixed training content like endurance plus strength/speed training will be presented and discussed.

### RELATIONSHIP BETWEEN PHYSIOLOGICAL CHARACTERISTICS AND PERFORMANCE/FATIGUE IN INTERMITTENT AND CONTINUOUS SPORTS

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The overall aims of performance diagnostics are prescribing individualized training intensities, monitoring athlete's development, and predicting performance/fatigue in competition. For this purpose, the identification of physiological performance determinants as well as performance assessment under valid conditions seems to be essential. However, the various sports differ greatly in their load structure and are characterised by either a more continuous (e.g., running/cycling) or an intermittent load (e.g., soccer). It can therefore be assumed that the different types of sports also differ in their physiological requirements, and thus the physiological determinants. The lecture will give an overview of the relationship between physiological determinants/training load measures and performance/fatigue in continuous and intermittent sports. The data presented are from controlled trials and translational approaches.
Continuous exercise: In the last decades, research has helped to identify key metabolic, neuromuscular, and mechanical determinants of distance running performance or cycling time-trail performance. Indeed, several studies have revealed that maximum oxygen consumption, lactate thresholds and maximal speed/peak power output during incremental tests predict different lengths of running or cycling time trial performances. However, it remains unclear whether or how the relationship between laboratory test parameters changes over the course of short-, middle-, and long-distance performances, especially regarding the physiological profile of an athlete. The comparison of a runner's velocity-profile or a cyclist's power-profile with physiological and neuromuscular performance indicators could enable a better explanation of a measured performance, which considers the complex interplay of different physiological systems and allows specific training description. Accordingly, the assessment of the relationship between established laboratory test parameters and performance outcomes over different durations is of great practical relevance. This part of the talk will focus on the relationship between velocity-profiles of runners or power-profiles of cyclists and their physiological characteristics.
Intermittent exercise: One sport that has been studied quite extensively in the context of intermittent sports is football). The physical demands in football are characterized by a high total running distance, which is interspersed with short and repeated bouts of high-intensity running. Many studies deal with the question of quantifying the load and the associated metabolic and neuromuscular requirements. Due to the unpredictability of the game, there are large inter-individual differences in demands that make it difficult to systematically study stress and fatigue on an individual basis. This part of the talk will focus on the quantification of load/fatigue and their relationship with physiological determinants including laboratory and field data.

## Oral presentations

### OP-MH10 Health promotion and behaviour

### WHAT PREVENTS PEOPLE WITH SEVERE MENTAL ILLNESS FROM SITTING LESS AND MOVING MORE? PERCEIVED BARRIERS TO IMPLEMENT "SIT LESS, MOVE MORE" INTERVENTIONS IN OUTPATIENT MENTAL HEALTH CARE SETTINGS

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Introduction
Patients living with severe mental illness (SMI) live on average 10 to 20 years less than the general population partly due to pathologies linked with sedentary behaviour and physical inactivity. The health-benefits of reducing and breaking up sedentary behaviour in patients living with SMI are acknowledged, yet few interventions have focused on tackling sitting less and moving more in this population. Thus, knowing the patients' barriers to sit less and move more remains basically to promote effective interventions to reduce sedentary behaviour in people living with SMI.

Methods
Patients living with SMI and health care professionals (HCP) were recruited during November 2017 from the mental health care center "Osonament", located in the city of Vic (Barcelona). Qualitative data were gathered from five focus groups in an outpatient mental health care setting. Three groups were conducted with patients with SMI and two with HCPs. Participants in each group were purposely allocated on the basis of age, gender, and duration of illness to ensure some homogeneity. Inductive thematic analysis was used for data analysis.
Results
The main overarching theme was that patients and HCPs understand and experience the illness from different points of view. These different points of view impaired their mutual ability and communication to address patients' sedentary behaviour within outpatients´ mental health settings. First, HCP reify and view the pathology from a purely biological point of view, looking for the exact location of the pathology to treat it. Second, patients living with SMI live their illness as a global whole that affects their daily life in all its dimensions.
Discussion
Our findings suggested that in order to improve current practice for HCPs to promote sitting less and moving more in patients with SMI it is necessary the following issues. First, to understand that patients´ sedentary behaviour was not only a biological-related behavioural risk factor, but a lifestyle (i.e. sociocultural construction) with social implications and repercussions that also needed to be addressed. Second, socialization (e.g. with groups rather than individuality) may be a key strategy for dealing with sedentary behaviour. Thus, while for HCP it is important to sit less and move more, for patients living with SMI it is more important with whom they do and share this "sitting less and moving more" time. While for HCP is important to reduce sedentary behaviour to improve health, for patients with SMI are more important the social implications that might have reducing sedentary behaviour by being involved in active-based-social tasks. Targeting these aspects could hold promise for effective interventions in this population.
This work was cofounded by Osonament (Osona Psychopedagogical Medical Center) and the Industrial Doctorate Program funded by the Government of Catalonia [grant number 2015 DI 024].

**GOALS AND BARRIERS TOWARDS PHYSICAL EXERCISE IN PEOPLE WITH SEVERE MENTAL ILLNESS. THE PSYCHIACTIVE PROJECT 2.0.**

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INTRODUCTION: Physical inactivity is a major public health issue in people with severe mental illness (SMI). Exercise can improve clinical outcomes in SMI but poor adherence to exercise is often reported in this population [1]. Understanding and controlling the factors that affect physical exercise programs could improve the prevention and treatment of these patients. The aim was to study the goals and barriers towards physical exercise in people with SMI.
METHODS: A cross-sectional study was carried out in 61 adults (♀ = 13, 20-60 years) with SMI. Participants completed "The barriers self-report questionnaire for the practice of physical exercise" (ABPEF) and the "Goal Content for Exercise Questionnaire" (GCEQ). The ABPEF comprises 17 items related to four different subscales (body image/ physical and social anxiety; fatigue/ laziness; obligations/ lack of time; environment/ facilities), each item is measured according to a Likert scale from 0 ("Unlikely reason") to 10 ("Likely reason"). The GCEQ comprises 20 items measured on a seven-point Likert scale, from 1 ("Nothing important") to 7 ("Very important"). Each item is related to five different subscales (social affiliation; image; health management; social recognition; skill development) where the first, third and fifth factors are intrinsic, and the second and fourth factors represent extrinsic exercise goal content. The mean and the standard desviation for each factor were calculated.
RESULTS: Health management was the highest self-reported physical exercise goal for active (5.72±0.32) and inactive (5.63±0.22) men, as well as active (6.38±0.63) and inactive (6.05±0.43) women. Regarding the barriers to exercise, active men reported fatigue/ laziness (3.52±0.48) as the main barrier to exercise, as did inactive men (4.55±0.42). On the other hand, active women reported obligations/ lack of time (3.88±0.98) as the main barrier to exercise. Finally, the inactive woman reported fatigue/ laziness (5.02±0.50) as the main barrier to physical exercise.
CONCLUSION: Current findings suggest that physical exercise programs for people with SMI should be designed to improve intrinsic goals. Providing the necessary professional supervision would help overcome your barriers, improve exercise adherence, and enhance the effects of physical exercise on your health and physical recovery.
References:
1. Vancampfort, D., Rosenbaum, S., Schuch, F. B., Ward, P. B., Probst, M., & Stubbs, B. (2016). Prevalence and predictors of treatment dropout from physical activity interventions in schizophrenia: a meta-analysis. General hospital psychiatry, 39, 15-23.

**CHANGES IN TOTAL, MODERATE-INTENSITY AND VIGOROUS-INTENSITY PHYSICAL ACTIVITY ARE ASSOCIATED WITH ALL-CAUSE MORTALITY AMONG 87,302 ADULTS: THE LIFELINES COHORT**

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INTRODUCTION: Regular physical activity (PA) reduces the risk of all-cause mortality (1) with greater risk reductions at higher exercise intensities (2). However, an important limitation of most studies is that they examined the association between PA and mortality at a single time-point, whereas PA volumes change over time. We examined the effects of changes in PA volumes on all-cause mortality, and explored the role of exercise intensity on the association.
METHODS: Data was used from the Lifelines Cohort (N=87,302). Self-reported PA volumes at baseline and follow-up were presented as Metabolic Equivalent of Task (MET) minutes per week. Changes in PA were calculated by subtracting MET-min/week of the first from the second assessment (median interval 3.8 years), and study participants were categorized into 5 groups; large reduction (<-2000 MET-min/week), moderate reduction (-2000 to -500 MET-min/week), no change (-500 to 500 MET-min/week), moderate improvement (500 to 2000 MET-min/week) and large improvement (>2000 MET-min/week). Activities with a MET between 3-6 were defined as moderate-intensity PA and ≥6 as vigorous-intensity PA. All-cause mortality was retrieved from the Dutch national death registry. Cox regression was used to calculate hazard ratios (HR) with 95% confidence intervals (CI).
RESULTS: Participants were 45±12 years old and 40% was male. After a median follow-up of 7 years [IQR 6-8], 848 (1%) individuals died. After adjustment for confounders and baseline PA, individuals with a moderate to large improvement of total PA had a lower risk of death (HR 0.70 [95% CI 0.55-0.89] and HR 0.65 [95% CI 0.52-0.81], respectively) compared to individuals with no change in PA. Intensity specific analyses showed that moderate and large improvements in vigorous-intensity, but not moderate-intensity, PA were associated with a

reduced risk (HR 0.65 [95% CI 0.51-0.83] and HR 0.75 [95% CI 0.60-0.95], respectively). A large reduction in total PA resulted in a higher risk of death, but this was not statistically significant (HR 1.17 [95% CI 0.93-1.46]). Moderate and large reductions in moderate-intensity, but not vigorous-intensity, PA resulted in a significantly increased risk of death (HR 1.37 [95% CI 1.14-1.65] and HR 1.34 [95% CI 1.05-1.72], respectively) compared to no change in PA.
CONCLUSION: Increasing total PA, especially increasing vigorous-intensity PA and maintaining moderate-intensity PA, is an important and effective strategy to reduce the risk of premature death in the general population.
References
1. Bakker EA, et al. Dose-response association between moderate to vigorous physical activity and incident morbidity and mortality for individuals with a different cardiovascular health status: A cohort study among 142,493 adults from the Netherlands. PLoS Med. 2021.
2. Wang Y, et al. Association of Physical Activity Intensity With Mortality: A National Cohort Study of 403681 US Adults. JAMA Intern Med. 2021.

**ASSOCIATIONS BETWEEN PHYSICAL ACTIVITY, LUNG FUNCTION AND E-CIGARETTE USAGE IN YOUNG ADULTS.**

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INTRODUCTION: Regular physical activity (PA) is a key component of a healthy lifestyle and the prevention of future chronic conditions. The risk of developing lung conditions when smoking tobacco from an early age is increased. However, the association between smoking of electronic cigarettes and lung function and the role of regular physical activity is not clear. We aimed to determine the associations between self-reported physical activity, lung function and electronic cigarette usage in young adults.
METHODS: An availability sample of 100 young adults (21.7 ±2.9 years) who signed informed consent were included in the study. Demographic characteristics age, gender, weight, height and ethnicity were self-reported by the participants. All participants then performed a peak expiratory flow rate assessment (Easy One spirometer). The international physical activity questionnaire (IPAQ) was completed by each participant to calculate physical activity in MET.min/week. A self -developed smoking survey was completed online to record the smoking habit and electronic cigarette usage. A partial correlation analyses was performed on the data, with adjustments made for confounders, smoking behavior, BMI and gender. The level of statistical significance was set at p≤0.05.
RESULTS: The average physical activity levels of males (n=50) were significantly higher (8188.00±7005 MET.min/week) than those of females (6060.40 ± 4620 MET.min/week; p<005) (n=50). Males maintained their physical activity levels regardless of smoking habits, whereas females who smoked reported lower physical activity levels. Males had an overall higher peak expiratory flow rate (9.22 ± 189 L/min) compared to females (6.32± 1.79 L/min; p <0.001). A non-significant correlation was found between self-reported physical activity and peak expiratory flow rate (r = 0.191; p = .057), even when adjusted for smoking behavior, BMI and age (r = .121; p=.235).
CONCLUSION: Our study found that the associations investigated between physical activity, lung function and the smoking habit were not statistically significant, but trends were observed that persons with higher physical activity levels tend to produce higher flow rates, while adjustment for the smoking habit removed the trend. Longer periods of engagement with smoking might be needed before detrimental effects are observed in lung function.

## Oral presentations

### OP-SH02 COVID-19: Psychological well being and motivation

**POSITIVE AND NEGATIVE LEISURE ACTIVITIES AND THEIR RELATIONSHIP WITH ANXIETY AND DEPRESSION, DURING THE COVID 19 PANDEMIC**

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Positive and negative leisure activities and their relationship with anxiety and depression, during the Covid 19 Pandemic
Introduction
Participation in positive and negative leisure activities were related to levels of anxiety and depression in individuals from Mexico who were in social isolation during the Covid 19 pandemic.
Methods
Quantitative, correlational and longitudinal research, two measurements were applied that were carried out online during Phase 2 and Phase 3 of the COVID-19 pandemic; that is, during the peak of the epidemic; where the population was called to stay at home, restricting activities that the health authorities declared non-essential, two self-administered questionnaires were applied, the first called Leisure activities, from Cuenca (2000) validated at the Leisure Studies Institute. the University of Deusto, and the second Goldberg and Hillier questionnaire. (1979) in search of symptoms and/or signs of anxiety and depression, applied to 764 subjects of both sexes in Mexico
Results
Anxiety and depression was found during phase 2 in the total population represented by 67.26%, being higher in women than in men, with a significant difference, age, as well was significant, it turned out to be significant in tounger men and women suffered from more anxiety and depression than older men and women.
The negative leisure activities that presented higher levels of anxiety and depression were: Dedicating too much time to work at home and to housework. Surf the internet for a long period of time (check social networks). Watch TV for a long periods of time (more than 2 hours). Behave passively or as a spectator in family leisure activities. Feeling that you are wasting your time when you dont go to work.
The positive leisure practices that presented lower levels of anxiety and depression were: Listening to the radio. Doing physical activity. Taking care of plants. reading books. Helping the family. Listening to music. Helping with housecore. playing games. Buy online. Take care of animals. Watch movies. Take an online course. Eat as a family. Play with the family. Organize the days activities.
Discussion
Negative leisure activities are related to not knowing what to do and boredom with an increase in leisure time in social isolation. A longer periods of time that increased anxiety and depression for not knowing what to do with it. On the other hand, positive leisure practices are

activities that cause satisfaction and have an autotelic meaning , that is, they have an end in themselves, are more structured.. They are also found in which positive leisure activities refer to those that are a means for personal training and recovery and health prevention. As a main conclusion, the data indicated that the greater the positive leisure, the less depression, the effect of positive leisure is much lower on anxiety and only occurs with autotelic leisure. It can also be observed that the greater the negative leisure, the greater the

**A SEVEN-DAY REMOTE INTERVENTION TO MANAGE FOOD CRAVINGS AND EMOTIONS DURING THE COVID-19 PANDEMIC**

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Due to the physical and aesthetic demands of sport, elite athletes must pay meticulous attention to functional eating, with emphasis on adequate and nutritionally appropriate food. However, it is increasingly recognised that food may also be consumed in response to emotions, known as emotional eating. In the context of elite sport, emotional eating may compromise functional eating goals, as the use of food to regulate emotions is associated with a failure to maintain weight management goals. On March 11th 2020, the World Health Organisation declared COVID-19 a pandemic. Exposure to stress during the pandemic, and the subsequent potential for unpleasant emotions had the potential to influence poor eating habits during the pandemic. Notably, increased calorie consumption derived largely through consumption of foods high in fats and sugars, thus leading to weight gain. Targeting eating behaviour through provision of remote interventions is, therefore, a critical strategy to ameliorate the impact of COVID-19 and is the focus of this research. This study examined the effectiveness of two brief remote interventions targeting the general population that aimed to help individuals deal with food cravings and associated emotional experiences. Participants (n = 165) completed a seven-day intervention that involved two groups, a daily food craving diary or a daily food craving diary and mindful eating practice. Repeated measures MANOVA indicated significant differences in the experience of emotions by Measurement (T1 through T7). Follow-up analysis indicated significantly lower experience of unpleasant emotions across time. Group (food craving diary vs. food craving diary and mindful eating practice) effect was not significant. Repeated measures MANOVA also revealed significant decrease in experience of food cravings by Measurement but not by Group. Participants reported significantly less eating and enhanced wellbeing at T7 vs. T1. Qualitative feedback from participants indicated that they perceived completion of the food craving diary to be an easy task, and mindful eating practice to be a strategy that some intended to continue using. Our findings offer support for a growing body of research which indicates that many individuals experienced an increase in unpleasant emotions during the COVID-19 pandemic. Significantly less eating and better wellbeing were reported after both intervention conditions. The completion of a 7-day food diary was effective in reducing food cravings (i.e., frequency of craving experienced, giving into craving, and difficulty resisting), as well as the intensities of unpleasant emotions experienced at the time of the highest food cravings. Following mindful eating guidelines alongside a food diary for the same time period was no more effective than completion of the diary alone. The results from this study support the use of remote interventions to encourage healthy eating behaviours. Implications for elite athlete populations are discussed.

**OVERWEIGHT, OBESITY AND HEALTHY HABITS IN CHILDREN IN THE CITY OF MADRID DURING THE COVID-19 PANDEMIC: THE LONGITUDINAL ASOMAD STUDY.**

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INTRODUCTION: Overweight and obesity seem to be increasingly widespread in children over the last few years. Furthermore, COVID-19 has seriously affected the quality of life of the scholar population due to the restrictions imposed since its inception, the city of Madrid has been one of the most restrictive spots in Europe. Few studies have evaluated lifestyle changes throughout the pandemic. Thus, the aim of this study was to analyze the evolution of healthy lifestyle levels during the course of the pandemic in Madrid school-aged children.
METHODS: This is a part of a longitudinal study from 2020 to 2023 that is currently taking place in Madrid city which was carried out with a representative sample of children aged 8 to 14 living in the City of Madrid. Body composition was measured by BIA (TANITA DC-240MA, Japan). Diet quality, physical activity (PA), sleep measurements, and emotional well-being were measured by validated questionnaires (KIDMED Index, PAU-7S, BEARS9/SHSA8 and KIDSCREEN-10, respectively). Data were collected twice, 1 year apart, winter 2020/21 and winter 2021/22.
RESULTS: PA levels improved as the restrictions of confinement have been eased ($p<0.01$) mainly due to increased light PA. Similarly, mean adherence to Mediterranean diet improved in 2022 compared to 2021 ($p<0.01$). However, excess weight according to the International Obesity Task Force (IOTF) affected 32% (22.4% overweight and 9.6% obese) of children in 2021 and 35.3% (19.1% overweight and 16.2% obese) in 2022. Screen time during the week and sleep time on weekends increased without significance, meanwhile screen time on weekends and sleep time during the week did not improve significantly. Well-being did not differ statistically between 2021 and 2022, even 49 % of children indicated to be sad in 2021 and 52% in 2022. Loneliness improved from 36% in 2021 to 28% in 2022.
CONCLUSION: Between the two analysed periods, overall physical activity, adherence to Mediterranean diet and feeling lonely improved. Percentage of children with excess body weight, weekly screen time and sleep time during weekends increased. A careful follow-up is needed in this population to promote a recovery from the effects of the pandemia and improve their quality of life.
Funding: Agreement between UPM and Area Delegada de Deportes, Ayuntamiento de Madrid.

**A VIRTUAL EXERCISE PROGRAM THROUGHOUT PREGNANCY DURING THE COVID-19 PANDEMIC MODIFIES MATERNAL SMOKING HABITS AND BIRTH WEIGHT. RANDOMIZED CLINICAL TRIAL**

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INTRODUCTION: The intrauterine environment is key to the health of the newborn and infant in the short and long term. Birth weight is an important indicator of fetal health and is related to maternal variables that may influence the fetal environment due to epigenetics. Considering the current situation of COVID-19 and the lack of physical activity, in parallel with higher levels of stress affecting smoking patterns and the physical and emotional health of the pregnant population, establishing non-invasive approaches to maintain the health of future generations is crucial.

METHODS: A randomized clinical trial (NCT04563065) was conducted. One-hundred and ninety-two pregnant individuals without obstetric contraindications were assigned to the intervention (IG) or the control group (CG). A supervised virtual program of moderate exercise was developed throughout pregnancy based on the Barakat Model and following the recommendations of international clinical guidelines. Study adherence was sealed at 80%. Data on maternal and neonatal outcomes were collected from hospital records
RESULTS: Overall, there were no differences in the mean of birth weight between IG and CG (3197.85 ± 423.95 g vs. 3187.75 ± 462.37 g; p= 0.896; respectively). However, significant differences were found between the study groups when strategized by birth weight ($\chi 2$ (7) = 6.610; p = 0.037) with low birth weight and macrosomia found more often in the CG (4% vs 14% and 3% vs 9%, respectively) and higher admissions to the neonatal intensive care unit ($\chi 2$ (4) = 5.075; p = 0.024) in the CG (20/28.6%) compared to the IG (9/13.0). Smoking during pregnancy was also found more often in the CG (12/17.1%) compared to the IG (3/4.4%) (p = 0.016).
CONCLUSION: A virtual program of supervised exercise throughout pregnancy during the ongoing pandemic could help to maintain adequate birth weights, modify maternal smoking habits, and lower admissions to the neonatal intensive care unit.

**THE INFLUENCE OF ABSENT CROWDS ON NATIONAL RUGBY LEAGUE MATCH PLAYER STATISTICS AND RUNNING METRICS**

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INTRODUCTION: The novel strain of coronavirus disease, COVID-19, was first identified in 2019, and due to its highly contagious nature, many elite sporting competitions were suspended and/or postponed. Sporting events that could continue, whether immediately or delayed, implemented strict bio-safety precautions to minimise the risk of spreading infection. Consequently, in many cases, crowds were prohibited from attending games. Research suggests that the presence or absence of a crowd may exert a social facilitation effect on players and officials in elite sport, which in turn might affect performance. Along with social facilitation theory, a related phenomenon known as the home advantage, suggests that the home team typically wins more games and scores more points than the away team. Research suggests that supportive crowds are social representatives of their players and encourage the home team to play well. However, minimal research has investigated the interaction between crowd (present or absent) and match location (home or away) on sport performance.
METHODS: This study used a retrospective observational design to investigate the influence of the crowd and match location in the National Rugby League (NRL) by comparing player statistics (attacking or defending) and Global Positioning System (GPS) metrics between season 2020 Round 1 (crowds) and Round 2 (no crowd). Data were obtained for 203 professional NRL players. A linear mixed model with a random intercept (Player ID) was used to assess the relationship between crowd removal and match location on performance indicators and GPS metrics. Effect sizes (ES) were also calculated to determine the magnitude of change.
RESULTS: The effect of a crowd and match location were trivial to small (ES range: -0.213 to 0.224). Attacking statistics suggest that NRL players engaged in more decoys (p=0.022, ES=0.162), increased post-contact metres (p=0.020, ES=0.206), and decreased support runs (p=0.005, ES=-0.184) in the absence of a crowd. When defending, the number of missed tackles increased (p=0.018, ES=0.213) in the absence of a crowd. GPS running metrics suggest that players had higher maximal velocities (p=0.027, ES=0.155), however, lower relative acceleration loads (p=<0.001, ES=-0.224), in the absence of a crowd. When playing away from home, athletes spent more time in the high-speed running thresholds (p=0.020, ES=0.072).
CONCLUSION: The findings suggest that the absence of a crowd had minimal effect on players' performance indicators. Further, findings also showed that the HA was largely unaffected by the removal of the crowd in the sample of professional rugby league games examined in the present study. Any changes were more likely to result from the score margin and other contextual factors. Potentially, the removal of the crowd may have reduced the advantage toward the home-team. However, it appears that elite rugby league athletes can maintain optimal physical performance without a crowd.

## Oral presentations

### OP-PN25 Cardiovascular II

**CEREBRAL BLOOD FLOW RESPONSE TO GRADED EXERCISE IN MIDDLE-AGED MEN AND WOMEN: THE TOLEDO STUDY FOR HEALTHY AGING IN MIDDLE AGE**

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INTRODUCTION: Cerebral blood flow (CBF) regulation is vital for proper delivery of O2 and energy supply to the brain (1). Although brain's blood demand is relatively constant, exercise represents a challenge for the cerebral vasculature (2). During exercise, skeletal muscle blood flow response is usually greater in women; however, it is unclear whether this sex-specific difference occurs in CBF as well (3,4). Therefore, the main goal of this investigation was to assess sex-specific differences in CBF responses to maximal graded exercise during middle age.
METHODS: Twenty-six participants (15 females and 11 males, 54.8±1.5 years old) completed a progressive incremental exercise test (GXT) on an electromagnetically braked cycle-ergometer (800X, Ergoline, Germany). All subjects completed 5-min resting and 5-min warm-up (women: 15 W; men: 30 W) stages. Thereafter, power output increased 3 and 4 W every 12 s for women and men, respectively, until volitional fatigue or inability to maintain proper cadence (≥60 rpm), while receiving intense verbal encouragement. Afterwards, a verification test was performed. Ventilation and pulmonary gas exchange were assessed using a breath-by-breath system (Oxycon Pro, Jaeger, Germany) and heart rate was continuously measured (GEH-ECG-1200, General Electric Company, Spain). Middle cerebral artery mean blood flow velocity (MCAv) was continuously measured via quality transcranial doppler during the GXT (Multi-Dop T, DWL Compumedics, Germany). When possible, both left and right MCA were recorded and data were averaged together.
RESULTS: Men achieved greater peak power (Wmax) (2.81±0.63 vs 1.74±0.35 W/kg, p<0.001) and VO2max (33.9±7.5 vs 24.5±3.7 ml/kg/min, p<0.001) during GXT in comparison with women. There was no difference in resting MCAv between men and women (52.69±11.24 cm/s vs 59.39±14.28 cm/s, p=0.210). MCAv kinetics was similar between men and women during the different stages of GXT.

The most pronounced rise in MCAv was recorded from resting to warm-up (+3.48 cm/s in men; +2.55 cm/s in women). During low to moderate intensity exercise (25-75% Wmax) MCAv increased slightly (1.64 cm/s in men; 1.83 cm/s in women), and then (from 75 to 100% Wmax) MCAv declined slightly in men (-2.89 cm/s) and reasonably in women (-7.74 cm/s) (all p>0.05).
CONCLUSION: Despite the sex-differences in VO2max and Wmax, these differences were not present for the middle to middle cerebral artery mean blood flow velocity. Ultimately, this work will need to be continued to identify mechanisms of cerebrovascular responses and sex-specific differences that may occur.
REFERENCES
1. Ashley, JD, et al. Physiol Rep, 2020. 8(20), e14622
2. Hartmann, SE, et al. BMC Pulm Med, 2014. 14(1):99
3. Peltonen,GL et al. Physiol Rep, 2015. 3(7), e12451
4. Ward, JL, et al. Am J Physiol – Heart Circ Physiol, 2018. 315(3):H492-H501

## RESTING RIGHT VENTRICULAR SYSTOLIC FUNCTION PARAMETERS ARE NOT ASSOCIATED WITH PEAK EXERCISE CARDIORESPIRATORY FUNCTION IN HEALTHY ADOLESCENT ELITE MALE ATHLETES

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INTRODUCTION: The relationship between right ventricular (RV) systolic function and cardiorespiratory fitness is complex, especially during exercise, when cardiac output and oxygen uptake (VO2) change in relation to one another. Previous small studies have alluded to a possible correlation between resting RV function and peak VO2 in young athletes. The aim of this study was to investigate this relationship using a large cohort of healthy elite adolescent football players.
METHODS: Adolescent male players from an elite football club were included, undergoing a minimum of 12 h per week training and game time. All players underwent a comprehensive cardiac evaluation, including cardiopulmonary exercise test (25 W or 50 W step increments) and baseline resting echocardiography. Relative VO2 was calculated at peak VO2, gas exchange threshold (VO2@GET) and at respiratory compensation point (VO2@RCP). The following RV systolic function parameters were calculated at rest: free wall longitudinal strain (RV-FW Sl), strain rate (RV-FW SRl), fractional area change (RV-FAC), peak tricuspid annular systolic velocity (RV-S') and tricuspid annular plane systolic excursion (TAPSE). Associations were explored using the Pearson's correlation coefficient (r) and linear regression R-squared. RV-FW Sl and SRl are negative by convention, with higher negative values denoting better function.
RESULTS: A total of 81 participants were included, mean age 14.5 ±1 y (range 12.6-16.6 y). All athletes had been screened for cardiac disease and cleared for sport participation. None had noted abnormalities, and all had cardiac normal RV function. Mean peakVO2 was 46 ±6.3 mL•min-1•kg-1,, mean VO2@GET 2 8±4.8 mL•min-1•kg-1 and mean VO2@RCP 40.6 ±5.8 mL•min-1•kg-1 . Mean RV-FW Sl was -27.7±3.6%, mean RV-FW SRl -1.5 ±0.3 s-1.
RV-FW Sl showed weak or moderate correlations with oxygen uptake measurements: with peakVO2, r= -0.35, R2 = 0.13, (p=0.003); with VO2@GET, r=-0.36, R2=0.13 (p=0.002); with VO2@RCP: r=-0.11, R2=0.01 (p=0.4). RV-FW SRl showed weak or moderate correlation with oxygen uptake measurements: with peak VO2, r= -0.33, R2=0.11 (p=0.006); with VO2@GET, r= -0.27, R2=0.08 (p=0.02); with VO2@RCP, r= -0.07, R2=0.006 (p=0.6). Weak associations were also observed between other RV function parameters and oxygen uptake measurements (r range from 0.001-0.31, p value range from 0.006-0.95, of which TAPSE showed the strongest correlation).
DISCUSSION & CONCLUSION: In healthy adolescent elite footballers, RV myocardial function at rest shows weak or moderate correlation to oxygen uptake at different physiological thresholds during a max exercise test. RV longitudinal function at rest explained at most 13% of observed variation in peak VO2 and GET and had no association with VO2@RCP This supports the hypothesis that cardiorespiratory fitness is not well predicted by resting cardiac function in healthy individuals, but rather by RV myocardial function responses during exercise.

## METHODS: RESULTS: CONCLUSION: COMPARISON OF LEFT VENTRICULAR MYOCARDIAL FUNCTION BEFORE AND AFTER SPORTS SEASON IN PROFESSIONAL MALE ADOLESCENT FOOTBALL PLAYERS

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INTRODUCTION: Professional athletes undergo intense and rigorous training regimens during sporting seasons, and whether there are any post-season changes in cardiac function, beneficial or detrimental to performance e.g., cardiac fatigue, is not well known. The aim of this preliminary study was to compare left ventricular (LV) myocardial function before and after a competitive season in a group of adolescent elite football players, using state-of-the-art echocardiographic exercise testing.
METHODS: Adolescent male players from an elite football club were recruited. They had a minimum of 12 h per week training, game time and selection, actively participating in international competitions. All players underwent comprehensive cardiac evaluations, including exercise echocardiography, with images being acquired (Artida/Aplio i900 machine, Canon Medical Systems, Japan) at rest, 0, 50, 100, 150 W, 2 minutes, and 6 minutes recovery, pre- and post-season. LV myocardial function was analysed using speckle tracking echocardiography (STE) and expressed as LV longitudinal strain (Sl) and strain rate (SRl), LV circumferential strain (Sc) and strain rate (SRc). A two-way repeated measures ANOVA was used, with pre-/post- season timing and exercise test steps as repeated measures.
RESULTS: A total of 25 participants were included, mean age 14.1±0.7 y at pre-season visit (range 12.7-16.1 y). All were cleared for participation, none had cardiac conditions, and all had normal baseline cardiac function.
Exercise step test had a significant effect on LV Sl ($F(6, 66)=10.7$, $p=<0.001$, $\eta2=0.5$), SRl ($F(3,36)=100$, $p<0.001$, $\eta2=0.9$), basal Sc ($F(6,54)=15.2$, $p<0.001$, $\eta2=0.6$) and basal SRc ($F(6,60)=87.8$, $p<0.001$, $\eta2=0.9$), with a gradual increase up to 150 W, and return to baseline in recovery for all parameters.
There were no statistically significant effects of pre-/post- season timing on LV Sl ($F(1,11)=2.3$, $p=0.2$, $\eta2=0.2$), SRl ($F(1,11)=0.003$, $p=0.9$, $\eta2=0$), basal Sc ($F(1,9)=5$, $p=0.8$, $\eta2=0.01$) or basal SRc ($F(1,10)=0.2$, $p=0.6$, $\eta2=0.02$). In addition, there were no statistically significant effects of pre-/post- season and exercise test step on LV Sl ($F(6,66)=0.7$, $p=0.6$, $\eta2=0.06$), SRl ($F(6,66)=1.3$, $p=0.3$, $\eta2=0.1$), basal Sc ($F(6,54)=0.8$, $p=0.6$, $\eta2=0.1$) or basal SRc ($F(2,23)=1.5$, $p=0.2$, $\eta2=0.1$). Analyses were repeated for baseline to stage 100 W (missing data mostly at 150 W) with similar results, of no significant effect of pre-/post-timing on any of the LV function parameters.

CONCLUSION: Resting LV cardiac function, as well as myocardial strain dynamic changes during exercise stages and recovery remain unchanged between pre- and post-season in adolescent footballers. These findings show that intense training periods such as that of professional sports season are not associated with "cardiac fatigue," or other major changes in LV function. More research is needed into the differing effects of teams sports compared to ultra-endurance training, as well as differing impacts on the right ventricle.

### HEART RATE VARIABILITY: OBTAINING THE STRESS SCORE FROM SDNN VALUES

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INTRODUCTION: Heart Rate Variability (HRV) is a feasible tool for quantifying training loads and physiological stress (1). Its feasibility appears in Apps and devices which comprise HRV parameters as recovery index. Usually, these Apps use linear parameters like the Standard Deviation of Normal Sinus Beats (SDNN). The Stress Score (SS) is a new measure of sympathetic stress (2) calculated from the Poincaré plot, which is not performed by most of the existing Apps, so they cannot incorporate this stress index. However, we know that there is a close relationship between SD2 and SDNN (2), so it would be possible to obtain SD2 estimating it from SDNN (ESD2) and using it to estimate SS (ESS). Thus, the aim of the present study was to prove that is possible to obtain de SS from the SDNN.
METHODS: 16 active males (25.17±5.84 years; 178.37±8.77 cm; 70.2±12.73 kg) performed 2 exercise treadmill running tests on separate days; one incremental until exhaustion, and other at constant load (70% of maximal aerobic velocity). All subjects underwent 5' HRV analysis: a) seated pre-test, b) during both exercise tests, and c) seated post-test at 3 intervals (0-5', 5-10' and 10-15'). From those analysis, SDNN and SD2 were selected. For the validation, the regression line between SDNN and SD2 was obtained, and it was used to calculate ESD2 from SDNN values. Then, ESS was calculated from ESD2 values, and it was compared with the SS obtained from the real SD2. Given that the SS is calculated as 1/SD2*1000, the ESS was set as 1/ESD2*1000. The reliability of the use of the ESS (versus the SS) was evaluated using a Bland-Altman analysis. Bias, limits of agreement (LoA), standard deviation of difference (SDD), intra-class correlation (ICC) and Person's coefficient were calculated.
RESULTS: Bias and upper-lower LoA were 1.23 (16.16, -13.71). The SDD was 7.62. Bland-Altman plot showed a good correlation without systematic error when comparing SS with ESS measurements. SD2 and SDNN showed a positive linear relationship (r2=0.981) in all conditions (n=147). Both SS and ESS were highly correlated (Pearson´s coefficient > 0.9) (significant agreement ICC > 0.9) and low variation (CV < 10%) during all conditions (pre-test, during test, and post-test). SS and ESS described a positive linear relationship (r2=0.97) in all conditions measured (n=147).
CONCLUSION: ESS provides values very close to SS, so obtaining it from SDNN (which is present in most of the current Apps and devices for training loads control) is a valid alternative.
REFERENCES:
1. Malik M, Camm AJ, Bigger JT, Breithardt G, Cerutti S, Cohen RJ, et al. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. European Heart Journal. 1996;17:354-81.
2. Orellana JN, de La Cruz Torres B, Cachadiña ES, de Hoyo M, Domínguez Cobo S. Two new indexes for the assessment of autonomic balance in elite soccer players. International Journal of Sports Physiology and Performance. 2015;10(4):452–7.

### HRV DYNAMICS: FROM INDIVIDUAL PROFILES TO INTERPERSONAL COORDINATION IN ATHLETES

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INTRODUCTION: Interpersonal coordination is the term used to describe how several individuals synchronize their activity. Recent studies have explored the level of coordination based on correlations between physiological signal outputs [1], although this has not been documented to date in athletes.
Based on a conceptual network that governs brain-heart interactions, recent works have shown the potential of heart rate variability (HRV) to monitor psychophysiological modulations when tasking [2,3]. This approach could yield promising results in the study of interpersonal coordination.
The objective of the present study was twofold: first, by using a clustering approach, we established psychophysiological profiles of athletes confronted to a prolonged cognitive task designed to induce mental fatigue. Then, to show how these psychophysiological profiles can influence interpersonal coordination, causal interactions between athletes HRV dynamics were explored through Granger causality computations.
METHODS: To establish clusters, HRV metrics (RMSSD, LF, HF entropy) were obtained in 52 sport students (20.7 ± 2.9 years, 27 males) while performing 20-min of Continuous Vigilance Task (CVT) as a source of mental fatigue. Unsupervised clustering analysis (k-means) was used to determine individual psychophysiological profiles.
To determine interpersonal coordination while performing cooperative tasks on a computer, similar HRV metrics were collected in 12 dyads of athletes (20.9 ± 1.3 years, 17 males) before and after CVT. Granger causality computed on each HRV metric (RMSSD, LF, HF entropy) provided the quantitative coordination.
RESULTS: The clustering analysis revealed three clusters wherein all subjects showed similar levels of fatigue and task performance but exhibited distinct profiles of cardiac autonomic control (RMSSD, LF, HF entropy).
Granger causality showed effective autonomic interactions between subjects within dyads. Most importantly, individual behaviors within a dyad depended on the cluster the athlete was belonging. Athletes with high autonomous power had a lower propensity to synchronize with a partner and conversely.
CONCLUSION: This study shows that distinct cardiac autonomic control responses lead to similar levels of mental fatigue and task performance. Moreover, interpersonal coordination within dyads of athletes is strongly influenced by their autonomic behavior. Grangers causality may be a useful tool for managing groups of athletes, especially when dealing with mental fatigue.
REFERENCES:
[1] E. Blons et al, « Physiological Resonance in Empathic Stress: Insights from Nonlinear Dynamics of Heart Rate Variability », 2021.
[2] H. Young et D. Benton, « We should be using nonlinear indices when relating heart-rate dynamics to cognition and mood », 2015.
[3] V. Deschodt-Arsac et al, « Entropy in Heart Rate Dynamics Reflects How HRV-Biofeedback Training Improves Neurovisceral Complexity during Stress-Cognition Interactions », 2020.

## OP-BM24 Biomechanics/Sports Tech

### WHY ARE PLAYERS WITH A PREVIOUS ACL INJURY AT ELEVATED RISK OF SUSTAINING A NEW SECONDARY ACL INJURY?

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INTRODUCTION: About 25% of the ball/team sports athletes who return to play after an anterior cruciate ligament (ACL) injury end up with a new, secondary ACL injury. To make return to these sports safer we need more knowledge of injury causation. Also, ACL injuries typically occur during single-leg landings or cutting maneuvers, which is why such movements should be in the center of research attention. The purpose of this study was to investigate whether knee biomechanics during sidestep cutting maneuvers differ between athletes with and without a history of ACL injury.
METHODS: 751 female elite handball and football players, 72 of which with a history of ACL injury, performed sport-specific cutting tasks while 3D kinematics and kinetics were measured. We compared seven knee related variables between both the previously injured leg and the uninjured leg of players with an ACL injury history with legs of injury free players.
RESULTS: For the previously injured leg, we found that players with an ACL injury history had significantly lower peak knee valgus angles (MD, 1.3°; 95% CI [0.0, 2.6]) and lower valgus angles at initial contact (MD, 1.2°; 95% CI [0.1, 2.3]) as compared to injury free players. Also, they showed significantly lower peak knee flexion moments (MD, 0.31 Nm/kg; 95% CI [0.16, 0.45]), knee abduction moments (MD, 0.27 Nm/kg; 95% CI [0.13, 0.41]) and knee internal rotation moments (MD, 0.06 Nm/kg; 95% CI [0.00, 0.11]). For the non-injured leg and for knee flexion angles, no differences were found.
CONCLUSION: 3.7 years after an ACL injury, female elite athletes still, unintentionally or intentionally, unload their previously injured leg. These loading alterations might be part of the explanation for why players with previous ACL injury are at elevated risk of sustaining a new secondary ACL injury.

### ASSOCIATIONS BETWEEN VELOCITY AT DIFFERENT RELATIVE INTENSITIES IN THE SQUAT EXERCISE, PHYSICAL PERFORMANCE, AND TENSIOMYOGRAPHY.

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INTRODUCTION: The force-velocity (F-V) relationship in the squat (SQ) exercise has recently increased its popularity since it provides a unique means of viewing the whole individual performance spectrum in a single action (1,2). This study aimed to compare the relationships between velocity at the different percentages of one-repetition maximum (%1RM) in SQ and physical performance and muscle contractile properties.
METHODS: One hundred and seven strength-trained men (≥2 years of experience in the SQ) participated in the study. Tests were performed in the following order: 1) tensiomyography (TMG) measurements of the vastus lateralis (VLA) and medialis (VME) muscles at rest; 2) countermovement jump (CMJ); 3) maximal voluntary isometric contraction (MIF) in SQ; and 4) progressive loading test in SQ. The relationships between variables were determined using Pearson's coefficients (r) and 95% CI. Velocity values described for each %1RM correspond to mean propulsive velocity.
RESULTS: Significant correlations ($p<0.001$) were found between velocity at different %1RM, being the highest associations between velocities at near %1RM. No correlations were found between velocity at low %1RM (0-30%) and velocity at high %1RM (80-100%) (all $p>0.05$), while velocities at medium %1RM (40-70%) were associated to those observed at low (r=0.28-0.84) and high %1RM (r=0.38-0.98) (all $p<0.05$). Significant correlations were found between velocity at low and medium %1RM and CMJ (r=0.23-0.48, $p<0.01$). Regarding maximal strength, significant correlations were found between velocity at low %1RM and 1RM (r=0.23-0.45), MIF (r=0.22-0.34), and RFDmax (r=0.27-0.35) (all $p<0.05$). In addition, significant relationships were observed between velocity at any %1RM and velocity reached against 20 and 60 kg (r=0.31-0.92; all $p<0.05$), showing a decreased correlation as %1RM increased. No associations were observed between velocity at any %1RM and tensiomyography data of the VLA and VME muscles (all $p>0.05$).
CONCLUSION: Our findings suggest that velocity at which a specific %1RM is lifted is related to velocity with loads at near %1RM, but as it gets further from this %1RM, the correlation disappears. In this sense, the performance achieved against a specific load (i.e low load) does not seem to be explained by the same factors that would explain performance with another different load (i.e high load). In addition, the physical performance variables analyzed were more related to velocity at low %1RM (0-30%).
REFERENCES:
1) Alcazar et al., IJSPP, 2021
2) Andersen et al., JAP, 2005

### DEVELOPMENT AND EVALUATION OF A HORIZONTAL SQUAT JUMP TEST TO MEASURE THE PEAK PUSH-OFF VELOCITY IN ACYCLIC LOWER LIMB EXTENSION

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INTRODUCTION: The restricted range of velocity measures during vertical force-velocity profiling has been questioned [1, 2]. Lower limb extension velocities assessment beyond 60%V0 have been examined using customized force plates on a wall [3] or a modified leg press [4]. Therefore, this study aimed to assess the reliability and validity of the horizontal squat jump push-off (HoPu) with a linear velocity transducer (LVT) to make it accessible for the practitioner.
METHODS: 28 healthy male (n=18) and female (n=10) sports students volunteered in a test-retest design. Participants were placed supine on a roller device, maintaining an individual preferred knee angle with their feet against a perpendicular wall before maximal lower limb extension. Peak push-off velocities were measured on a typical indoor sports floor using a double pulley with an LVT (100Hz). Further, a motorized resistance device (MRD, 333Hz) was attached parallel to the board to obtain peak velocity and peak force values. Additional

assessments of vertical squat jump (SJ) and maximal isometric force output (MVIC) matching the HoPu push-off position were performed. Repeated measures ANOVA was used to account for relative within-session (ICC2,5), relative between-session (ICC2,1), and absolute (SEM, CoV) test-retest reliability. Peak velocity measurements of both devices were compared (100 Hz vs 333Hz) for external validity.
RESULTS: Both the MRD and the LVT showed an excellent within-session (ICC2,5: 0.95-0.98 [0.92-0.99]; SEM-MRD: 0.08, SEM-LVT: 0,02, CoV: 2%) and a good-to-excellent between-session (ICC2,1: 0.79-0.86 [0.61-0.93]; SEM-MRD: 0.08, SEM-LVT: 0,03, CoV: 3%) reliability. Between-device comparison for mean peak velocity from both devices demonstrated no significant difference with a mean bias of 0.005 m*s-1. HoPu resulted in significantly higher take-off velocities compared to SJ (+34%), very close to V0. Force values were maximized during MVIC and lowest during the HoPu.
CONCLUSION: Both devices were able to measure peak push-off velocities accurately. The results point to sufficient reliability and construct validity of the HoPu for assessing the maximal acyclic lower limb velocity extension capacities with both an MRD and an LVT combined with a pulley hoist. The HoPu demonstrates a possibility to quantify the ability of the neuromuscular system to develop force at extremely high lower limb contraction velocities. This information can extend the possibilities of force-velocity profiling, notably of force production capabilities at high velocities.
1. Ćosić et al. (2018). doi.org/10.22190/FUPES1703467C
2. Cuk et al. (2016). doi.org/10.1080/14763141.2016.1159724
3. Samozino et al. (2018). doi.org/10.1016/j.jbiomech.2008.07.028
4. Rivière JR et al. (2021). doi.org/10.31236/osf.io/ncbd2

### KNEE AND HIP JOINT ANGLES DURING SQUAT EXERCISE IN NATURAL AND ARTIFICIAL GRAVITY

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INTRODUCTION: Long duration space flight-induced muscle atrophy is a major concern during prolongued space missions. Replacing the loss of the natural gravity (NG) vector with centrifugal forces generated by a short arm human centrifuge (SAHC) has been proposed as a viable muscle atrophy mitigation strategy. SAHCs allow squatting by means of an adjustable sliding sledge. This study investigated the biomechanical differences between squatting under normal (NG) and artificial (AG) gravity conditions.
METHODS: The study was conducted at the ESA Ground Base Facility »PlanHab« (Rateče-Planica, Slovenia). A total of 10 subjects performed 3 sets of 6 timed squats in the upright position (NG), and in the supine position on a bespoke sledge system on the SAHC (AG) with 1 minute rest between sets. The total time of centrifugation was 10 minutes per subject with the AG set at 1.5G at heart level. An Xsens Awinda motion capture system was used to record subjects movements at a rate of 60Hz, and the joint angles of the knees and hips extracted and analysed.
RESULTS: During NG, the joint trajectories of both knees and hips were consistent during all of the squatting sets. However, for the first squat under AG, the knee and hip joint angles presented oscillations of up to 2° during the flexion. Further, at the deepest squat position, the joint angle oscillations were 14° at the knee and 13° at the hip just prior to initiating extension. These oscillations were not present during the extension movement, nor at any other stage of the movement from the third squat on. The average knee joint (15° to 101°) and hip joint angles (19° to 84 for left hip, and to 88° for right hip) for the remaining squats indicate a shortening of the overall movement pattern. While in the NG condition, the joint angles for the knee ranged between 3° to 119° and from 6° to 123° for the hip.
CONCLUSION: The joint oscillations present on the first AG squat may be attributed to a transient adaptation to the distortion of subjects center of mass displacement induced by a novel gravity vector and possibly the movement interference caused by the sledge. The main differences were present during the lowering phase of the squatting movement. The difference between the left and right hip trajectories may be a consequence of the load difference due to Coriolis forces and spin direction. Development of an exercise strategy on the SAHC requires further analysis of muscle activation during the exercise.
This study was supported, in part, by the European Space Agency and the Slovene Research Agency.

### DOES MOVEMENT SMOOTHNESS DURING WALKING DIFFER BETWEEN POLYNEUROPATHY PATIENTS AND AGE-MATCHED HEALTHY CONTROLS?

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INTRODUCTION: Walking is a complex sensorimotor behaviour, which is usually characterized by spatio-temporal and rhythmic parameters, while the quality of movement execution, e.g. smoothness, has rarely been considered [1]. Smooth movements might reflect a well-coordinated neuromuscular activity and are particularly economical regarding energy expenditure [2]. In order to separate movement smoothness from effects of movement amplitude and velocity covered by conventional gait parameters, some authors suggest corrections for amplitude and velocity effects, leading to e.g. smoothness spectral arc length (SPARC), or log-dimensionless jerk (LDLJ) [3,4]. Our study's purpose is to evaluate smoothness aspects of gait in patients with sensorimotor dysfunctions, i.e. polyneuropathy (PNP).
METHODS: We recorded whole-body movements of 20 PNP patients and a matched healthy control group (CG, n=20) during fast walking (≤10 steps) via a marker-less, vision-based motion capture system. We calculated movement smoothness of 11 segments (left/right ankle, knee, hip, shoulder, elbow, center of mass (COM)) using SPARC and LDLJ. Mean values of step cycles were statistically analysed (non-parametric testing). Subsequently, conducted a principal component analysis (PCA) including all segments for both groups.
RESULTS: Compared to CG, PNP patients' movements are less smooth in terms of LDLJ as they showed a significantly higher LDLJ in all segments ($p<.023$). Concerning SPARC, the PNP group was less smooth at COM ($p<.001$), right knee ($p=.005$), and right hip ($p=.001$). LDLJ values across segments correlated highly, which corresponds to the first principal component (PC) covering ≤89% of the entire variance of data. SPARC variance across segments, both in CG and PNP, converged to three major PCs with the first covering about 40%. In CG, rotated PC 1 accounted for lower limbs, COM, left elbow, but without the left knee and ankles. PC 2 accounted for upper limbs and left knee. In PNP, PC 1 accounted for all upper joints and COM. PC 2 accounted for lower limbs and COM without ankles. PC 3 in CG and PNP covered both ankles.
CONCLUSION: Since PNP patients' proprioceptive feedback is impaired, it seems plausible that their movement execution is less smooth compared to CG. The parameters SPARC and LDLJ appear to address different dimensions of smoothness. LDLJ characterizes overall smoothness differences between PNP and CG while SPARC seems to uncover different movement patterns in terms of segmental coupling. More specifically, PCA of SPARC in PNP reveals a smoothness pattern along the body axis (upper limbs, proximal lower limbs, and ankles),

while for CG, PCA delivers a diagonal pattern. Thus, analysing smoothness patterns reveals movement abnormalities in PNP, which are not covered by spatio-temporal and rhythmic parameters.
[1] Beck et al. (2018). JNER, 15(1), 49.
[2] Wong et al. (2021). eLife, 10, 1–18.
[3] Garcia et al. (2021). PLOS ONE, 16(4), e0250100.
[4] Balasubramanian et al. (2015). JNER, 12(1), 112.

# Oral presentations

## OP-BM23 Central and / or spinal drive II

### PROBING THE LINK BETWEEN CORTICAL INHIBITORY AND EXCITATORY PROCESSES AND MUSCLE FASCICLE DYNAMICS

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INTRODUCTION: Goal-directed voluntary human movements require refined levels of neural drive generated by the interplay between the activity of cortical excitatory and inhibitory neurons. This neural drive is descending from the motor cortex via the corticospinal pathway to the motoneurons ultimately activating the muscle(s) resulting in muscle fiber shortening. Previous studies either concentrated on neural or on mechanical aspects but information about the relationship of neural activation and muscle fiber behavior is scarce. This study investigated cortical excitatory and inhibitory processes in relation to muscle fascicle dynamics during isometric explosive contractions.
METHODS: Fourteen adults performed submaximal and maximal explosive dorsiflexions. Single and paired pulse transcranial magnetic stimulation of the tibialis anterior (TA) was applied during rest, the activation and deactivation phase of submaximal explosive contractions to test for short- (SICI) and long-interval intracortical inhibition (LICI) and intracortical facilitation (ICF). Furthermore, to relate the measures of cortical activity with muscle fascicle behaviour, B-mode ultrasound images were taken during submaximal as well as maximal explosive contractions to measure muscle fascicle dynamics of the superficial (TASF) and deep (TADP) TA compartments.
RESULTS: The results show significantly greater maximal shortening velocities ($p = 0.003$) and greater maximal fascicle shortening ($p = 0.003$) in TASF than TADP during submaximal dorsiflexions. Significantly lower SICI levels during activation compared to deactivation ($p = 0.019$) and at rest ($p<0.0001$) were observed. ICF was significantly greater during activation ($p = 0.03$) than during rest while LICI did hardly modulate. Maximal TASF but not TADP shortening velocity was associated with SICI levels at activation ($p = 0.06$) and correlated with the rate of torque development ($p = 0.02$).
CONCLUSION: The present results suggest a strong coupling between SICI and TA muscle fascicle behavior. the present study shows movement-phase dependent modulations in cortical excitatory (ICF) and inhibitory processes (SICI, LICI) during explosive isometric dorsiflexions. Noteworthy, GABA-A mediated inhibition (SICI) shows the strongest modulations. Furthermore, we show that a reduction in the level of GABA-A mediated cortical inhibition is associated with the fascicle dynamics of the superficial compartment of the TA.

### EFFECT OF COMBINED ELECTRICAL STIMULATION AND MUSCLE LENGTHENING ON TORQUE DEVELOPMENT

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INTRODUCTION: Neuromuscular electrical stimulation (NMES) can elicit muscle contractions through peripheral and central pathways. Peripheral pathways consist of motor axons' depolarization, whereas central pathways involve depolarization of sensory axons. The use of wide-pulse duration delivered at low stimulation intensities results in contractions mainly originating from a central pathway and gives rise to the phenomenon of extra torque (ET), which is characterized by an additional torque of what would be developed through peripheral pathways (1). The reflex activation of spinal motoneurons likely proceeds to a more physiological motor units' recruitment following Henneman's size principle and may hence be promising in rehabilitation since it can induce less fatiguing contractions (2). However, the occurrence of ET is not present for all subjects (3). Combining a technique that enhances the activation of these afferent pathways, such as muscle lengthening (LEN) (4), could facilitate ET generation. The study aimed to evaluate the effect of the combination of these two modalities (NMES + LEN) on torque development and to examine the associated neuromuscular changes.
METHODS: Fourteen subjects participated in a unique experimental session consisting of 20-s stimulation trains delivered over the tibial nerve at 20 or 100 Hz (1-ms pulse duration, intensity set to initially evoke ~10% of maximal voluntary contraction). During these stimulation trains, the ankle joint was either moved (180°/s) from a stretched position (80°) to the reference position (90°) (shortening, SHO), either from a shortened position (100°) to the reference one (lengthening, LEN) or maintained constant at 90° (isometric, ISO). For all stimulation trains, the torque-time integral (TTI) was calculated (TTILEN, TTISHO, TTIISO) and was expressed as a percentage of the TTI of ISO condition. Spinal excitability, assessed by the maximal H-reflex (Hmax) normalized with respect to the maximal M-wave (Mmax), was evaluated at rest, before and after each stimulation train.
RESULTS: Results showed that TTILEN was significantly higher than TTISHO during low-frequency NMES ($P<0.05$), while there were no significant differences during high-frequency NMES. Spinal excitability remained unchanged after the stimulation trains for both frequencies.
CONCLUSION: These results indicate that low-frequency NMES combined with LEN increases the developed torque, while there is no effect of superimposed LEN with high-frequency NMES. A possible explanation is that the combination of LEN with high-frequency NMES induced a saturation of the afferent pathways limiting further torque increase. The unchanged spinal excitability suggests that inhibitory and facilitatory phenomena at the spinal level were similarly modulated by both low and high frequencies.
REFERENCES:
(1) Collins, Exerc. Sport Sci. Rev., 2007
(2) Lagerquist et al., J Appl Physiol, 2009
(3) Wegrzyk et al., Clin. Neurophysiology, 2014
(4) Burke et al., J Physiol, 1978

### MODULATION OF TORQUE INDUCED BY WIDE-PULSE, HIGH-FREQUENCY NEUROMUSCULAR ELECTRICAL STIMULATION: IMPLICATION OF PERSISTENT INWARD CURRENTS?

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INTRODUCTION: Wide-pulse high-frequency neuromuscular electrical stimulation (WPHF NMES) favors a reflexive recruitment of motor units at the spinal cord level by the depolarization of large diameter sensory afferents at low stimulation intensity. WPHF NMES has been observed to evoke a progressive increase in torque during the stimulation ('extra torque' (ET)), which occurs in ~60% of individuals (Wegrzyk et al., 2015). However, the mechanisms responsible for ET production remain largely unknown. The main hypothesis is the potential contribution of persistent inward currents (PICs), which are depolarizing currents that can amplify motoneuronal synaptic inputs (Heckman & Enoka, 2012). Similarities between the development of PICs and ET in response to WPHF NMES support the hypothesis of a link between the two mechanisms.
Thus, any intervention aiming at modulating ET production in response to WPHF NMES should also modulate PIC strength. The aim of this study is to test the hypothesis that a remote contraction (i.e. contraction of an unrelated muscle) would increase ET during WPHF NMES of the plantar flexors because of enhanced PIC strength.
METHODS: Twenty five healthy volunteers (26 ± 6 years, 7 women and 18 men) took part to the protocol. Participants were asked to perform an isometric triangular contraction with their plantar flexors (0-20-0% of maximal voluntary contraction (MVC) torque). The intensity of stimulation necessary to evoke 10% of MVC torque using WPHF NMES (1 ms, 100 Hz) was determined with 1-s stimulation trains and trains of 20 s of WPHF NMES were delivered at this intensity. High-density electromyography (HD EMG) of the gastrocnemius medialis (GM) and the soleus (SOL) muscles was recorded. The experiment was performed in two conditions: Control and Remote condition, where the participants sustained an isometric elbow flexion at 20% of MVC torque.
ET was calculated as the variation (%) between the last s and the first s torque during WPHF NMES. Participants with a positive ET value were considered as 'responders'. Estimates of PICs were calculated using HD EMG recordings with the DeltaF technique (Gorassini et al., 2002).
RESULTS: ET was lower in Control compared to Remote (median ±SD: +15 ±113 and +55 ±180%, p=0.003). The percentage of responders increased from 60 (Control) to 80% (Remote) of the tested sample. DeltaF was not different between Control and Remote for SOL (mean ±SD: 1.40 ±1.39 and 0.74 ±1.90 Hz, p=0.278) and GM (1.12 ±1.34 and 0.96 ±2.47 Hz, p=0.721).
CONCLUSION: Our results show that WPHF NMES ET can be enhanced by a remote contraction and that the occurrence of responders can be increased, which supports the central origin of ET in WPHF NMES. Although these findings may open new therapeutic strategies, our results do not support a direct link between PIC estimates and ET in response to WPHF NMES.
Heckman, C. J., & Enoka, R. M. Compr Physiol, 2, 2629, 2012
Gorassini, M. et al. J Neurophysiol, 87, 1850, 2002
Wegrzyk, J. et al. Clin Neurophysiol, 126(7), 2015

### NON-INVASIVE MUSCLE BIOPSY: ESTIMATES OF MUSCLE FIBER SIZE FROM A NEUROMUSCULAR INTERFACE

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INTRODUCTION: The gold-standard technique to assess fiber size and composition is muscle biopsy. However, although safe and reliable, it is characterized by some degree of invasiveness, and more importantly it provides morphological information dissociated from the neural control of the sampled muscle fibers (1). Due to its purported linear relation with muscle fiber diameter, motor unit conduction velocity (MUCV) may be adopted as an alternative physiological parameter to assess muscle fiber properties non-invasively in humans. This relation has been assessed in animal models (2), in humans through intramuscular EMG and electrically-stimulated contractions (3-4), or it has been mathematically-derived from separate datasets, as in Stålberg's seminal work (5). Here we systematically explored the relation between MUCV of large and representative populations of motor units (MU) and muscle fiber diameter derived from muscle biopsies.
METHODS: Twenty-nine healthy volunteers (age: 21.9±3.2yr; body mass: 82.1±13.9kg) completed linearly increasing isometric elbow flexions at forces up to 70% of maximum, whilst high-density surface EMG signals were recorded from biceps brachii and in turn decomposed into MU discharge timings. The mean (MUCVmean), minimum (MUCVmin), and maximum (MUCVmax) MUCV value of 701 MU was estimated in the ascending phase of the ramp contractions. The diameters of 5619 muscle fibers (MFDmes) were derived from muscle biopsies. We fitted Stålberg's original equation (5) with our experimentally-derived MFDmes data and estimated muscle fiber diameters (MFDest). In particular, we iteratively changed the two normalization parameters of the original equation and computed the Euclidean distance between the two distributions, which were fitted with gaussian distributions
RESULTS: Correlation analyses revealed positive linear associations between the minimum, maximum and mean MFDmes and minimum ($r=0.75$, $P < 0.001$), maximum ($r=0.80$, $P < 0.001$) and mean ($r=0.81$, $P < 0.001$) MFDest at the individual subject-level. Additionally, when we pooled data from all participants with a different training status, the proposed novel methodology was able to predict with high accuracies the distribution histograms of the MFDmes (90.8 ± 19.6 µm) from the MFDest (90.8 ± 19.7 µm) estimated from MUCV values.
CONCLUSION: We revealed the possibility to predict with high accuracy the minimum, maximum and mean muscle fiber diameter from an EMG-derived parameter, i.e. MUCV, at the individual subject level in healthy individuals. Thus, MUCV may be considered a novel non-invasive marker of muscle fiber size that could be adopted as an alternative to the more invasive biopsy sampling, therefore opening new avenues for research in aging, training and neuromuscular diseases.
REFERENCES
1 Del Vecchio et al., Acta Physiol Scand, 2018
2 Hakansson, Acta Physiol Scand, 1956
3 Blijham et al., J Appl Physiol, 1985
4 Methenitis et al., Med Sci Sports Exerc, 2016
5 Stålberg, Acta Physiol Scand, 1966

**LOWER EXTREMITY MUSCLE ACTIVITY DURING WALKING AT DIFFERENT SPEEDS: THE QUADRICEPS CHANGE MOST**

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INTRODUCTION: Impairment of walking performance is linked to the loss of mobility of the elderly, and caused by the deterioration of muscle strength in the lower extremity [1]. To know the muscles responsible for walking performance, we need to clarify the loads imposed on the muscles engaged. In the present study, muscle loading was evaluated for the thigh and lower leg during walking under a wide variety of speed.
METHODS: Twenty healthy adults (10 women and 10 men, 24 ± 3 yr) voluntarily participated. Each subject walked on a treadmill (level surface) at the speed from 0.6 to 2.0 m/s (increased by 0.1 m/s). During walking, the subject reported her/his most preferrable walking speed. Surface electromyogram (EMG) was recorded from the vastus lateralis (VL) and medialis (VM), rectus femoris (RF), biceps femoris (BF, long head), semitendinosus (ST), tibialis anterior (TA), gastrocnemius medialis (GM) and lateralis (GL), soleus (Sol) of the right side. Each EMG amplitude was normalized to the value at the preferred speed. Pressure sensors on the right shoe insole detected the heel contact and toe off in the stance phase, and the walking cycle was divided into early and late stance, and swing phases. Repeated measures (speeds) and factorial (muscles) ANOVA was applied to detect the main effect and interaction with $p<0.05$ being significant, and Bonferroni corrected multiple comparisons were performed where applicable.
RESULTS: The preferred walking speed was 1.16 ± 0.16 m/s and 1.22 ± 0.18 m/s for women and men, respectively with no significant difference. There was a significant main effect of speeds as well as muscles, and their interaction was also significant in all (early stance, late stance, and swing) phases of walking. When EMG data were pooled for women and men, their amplitudes showed exponential increases. Its magnitude was largest / smallest for VM (404%@2.0m/s) / GM (169%) in the early stance phase, VM (572%) & RF (612%) / MG (190%) in the late stance phase, and VM (350%) / Sol (216%) in the swing phase, respectively. At speeds lower than preferred, the above tendency was reversed and VM, VL and RF showed smaller activities.
CONCLUSION: Results suggest that the increase in walking speed is achieved by systematic but inhomogeneous increases in muscle activity in the lower extremity. At higher speeds, the quadriceps (VM in particular) are activated remarkably and vice versa at lower speeds, indicating that these muscles sensitively change their activation in response to the motor command to control walking speed. It is therefore likely that in daily normal walking at preferred or slower speed, the quadriceps are not adequately activated, which can be associated with the specific atrophy of these muscles in the elderly [2]. In contrast, the quadriceps come into play during brisk walking, and this type of exercise would favor prevention of sarcopenia and health promotion in the elderly.
[1] Gallaghaer D. et al. Acta Physiol Scand (1997).
[2] Kasai T. et al. Geriatr Gerontol Int (2015).

**NEURAL AND CONTRACTILE DETERMINANTS OF BALLISTIC (BURST-LIKE) CONTRACTIONS OF KNEE EXTENSORS**

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INTRODUCTION: Human locomotion has been described as generated by an impulsive (burst-like) excitation of muscle groups (1). The activation profiles are Gaussian-shaped curves (2) without any holding phase. The timing and shape of force production during ballistic contractions is crucial. To elucidate the neuromuscular determinants of rate of force development (RFD) some studies adopted ballistic contractions with various durations from ≈1 to 3 s (3, 4). Neural and contractile determinants of purely explosive contractions (≈ 200 ms) without holding phase are unknown although it is relevant in human locomotion and also for sporting tasks and daily activities.
The aim of this work is to investigate the neural and contractile determinants of time-locked force (50, 100, 150 ms) and in RFDpeak in burst-like isometric knee extensions through High Density surface Electromyography (HDsEMG) and electrically evoked contractions to elicit the maximum RFD.
METHODS: 24 (5 females) healthy adults performed 10 purely explosive isometric knee extension interspersed with 3 s rest. Voluntary sequential force (50 ms epochs), RFDpeak and maximal voluntary force (MVF) were assessed. HDsEMG was recorded from vastus lateralis and medialis muscles with two grids of 64 electrodes. We evaluated the contractile and EMG responses in voluntary and electrically evoked stimulation with twitch and octets (8 stimuli delivered at 300 Hz). Pearsons correlation and linear stepwise regression analysis were used to assess the significant determinants of force in the various time blocks of voluntary contractions (F50, F100, F150) and for RFDpeak.
RESULTS: For F50 the adjusted R2 was 0.361 ($p=0.001$) explained by RMS. For F100 was 0.646 ($p<0.001$) explained by RFD octet and for F150 was 0.711 ($p<0.001$) explained by MVF and 0.061 ($p=0.016$) by RFD octet. For RFDpeak the adjusted R2 was 0.518 ($p<0.001$) explained by the MVF and another 0.074 ($p = 0.036$) explained by RMS.
CONCLUSION: Accordingly with previous evidence (3,4), the present findings suggest that the burst-like isometric force production exhibited different neural and contractile determinants depending on the considered force-time intervals. The first 50 ms of a purely explosive contraction are explained by neural determinants, at 100 ms by contractile determinants and at 150 ms the combination of both. Moreover, the RFDpeak is explained for the most part by contractile determinants and to a small share by neural determinants.
References:
1) Sartori et al., Front Comput Neurosci, 2013
2) Gizzi et al., J Neurophysiol, 2011
3) Folland et al., Scand J Med Sci Sports, 2014
4) Andersen & Aagard, Eur J Appl Physiol, 2006

# Oral presentations

## OP-MH23 Physical activity and education

### COACHING JUDO FOR OLDER ADULTS: RESULTS FROM SEVEN NATIONAL FOCUS GROUPS

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Introduction

To counteract the negative secular trend of global sedentary behaviours the promotion of novel interventions of physical activity in advancing age are needed [1]. A crucial aspect of coaching is to ensure health and safety of participants, especially those experiencing age-related functional declines [2]. The purpose of this study was to provide eminence-based knowledge on judo coaching for older adults.

Methods

Between May and October 2021, seven focus groups were organized in Croatia, Italy, Malta, Romania, Slovenia, Spain, Turkey encompassing a four-step process: 1) definition of research questions, procedures, data processing; 2) purposeful experts' sampling of the scientific/judo communities; 3) participants recruitment through invitation letter and informed consent; 4) data gathering, analysis, summary, collation. Seventy-eight (F=29.5%) academic and technical experts in geriatrics, psychology, physiology, nutrition, medicine, kinesiology, and combat sports volunteered for the study.

Results

The 262 collected items were organized in five themes: 1) judo benefits (N=83, 31.7%); 2) training information (N=58, 22.1%); 3) risk prevention/management (N=50, 19.1%); 4) older practitioner groups definition criteria (N=33, 12.6%); 5) tools/tests/measurements (N=38, 14.5%). The items deemed most important were related to physical (N=16, 3%; e.g., fitness, constitution, limitations), tests (N=16, 3%; e.g., technical, balance, stress), and social (N=9, 2%; e.g., family, environment, relations) aspects. For health issues, other relevant aspects (N=12, 4.6%) were: diabetes, bone, and blood pressure. Other significant information involved training (N=6, 2.3%; e.g., safety, adjustments, intensity), status (N=11, 4.2%; e.g., psychophysical and social), and sports (N=5, 1.9%; e.g., lifetime sport participation).

Discussion

The present cross-national qualitative study synthesized the experts' perspectives about the most relevant content of an educational programme for judo coaches of older practitioners. These findings will be used to create a sound educational content for judo coaches to ensure optimal supportive programmes for individuals approaching judo with advancing age [3].

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References:

1.World Health Organisation. (2018). Global action plan on physical activity 2018–2030: more active people for a healthier world. Available at https://www.who.int/ncds/prevention/physical-activity/global-action-plan-2018-2030/en/

2.Ciaccioni, S., Condello, G., Guidotti, F., & Capranica, L. (2017). Effects of Judo Training on Bones: A Systematic Literature Review. J Strength Cond Res, 33(10), 2882-2896.

3.Ciaccioni, S., Capranica, L., Forte, R., Chaabene, H., Pesce, C., & Condello, G. (2019). Effects of a judo training on functional fitness, anthropometric, and psychological variables in old novice practitioners. J Aging Phys Act, 27(6), 831-842.

### AN INVESTIGATION INTO THE GAIN IN KNOWLEDGE OF, ATTITUDES TOWARDS AND CONFIDENCE TO DELIVER A GAMES-BASED PHYSICAL LITERACY CONCEPT IN PRACTITIONERS ACROSS THE UK

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INTRODUCTION: It is well recognised that practitioner education could impact on a learners Physical Literacy (PL) and subsequent Physical Activity (PA) throughout life [1]. Boing is a workshop-based programme that aims to help practitioners develop children's PL through active play. However, the impact on practitioners is unknown. Therefore, the aims of this study was to explore current knowledge of, attitude towards, and confidence to deliver PL and investigate changes following the programme.

METHODS: 926 practitioners (coach educators, teachers, coaches, volunteers and other facilitators) from 45 organisations were recruited. Two sequential validated questionnaires exploring perceived knowledge, attitude towards and confidence to deliver the Boing programme were completed prior to and immediately post a 90-minute interactive online workshop. Variables were scored on a Likert scale (1-very poor, 5-very good). Potential changes elicited were assessed using Wilcoxon signed-rank tests for non-parametric data. Rank-biserial correlation [r] was utilised to calculate the effect size based on existing criteria [2]. Chi-square tests explored differences between organisations. The alpha level was set at 0.05 a priori.

RESULTS: 738 participants completed both questionnaires (community focused n=337, sport/sporting governance n=130, education providers n=125, wider facilitators of physical activity n=146). Perceived knowledge and confidence before the workshop were poor across all organisations (2.2±1.1; 2.4±1.2) however attitude was apathetic (3.0±1.2). Significant differences in attitude between organisational groups before training was evident (p=0.01) whereby sporting organisations frequently reported more positive attitudes towards PL. The majority of practitioners (82%) were not aware of any programmes to develop PL. Participants on average agreed strongly that they needed a greater understanding of exercises and games that can improve physical activity (87%); how to implement PL into sessions (77%); and how to design fun games (88%). Increases pre/post were statistically significant ($p<0.001$) with large positive effect sizes: knowledge ($r= 0.99$ [95% CI = 0.98 – 0.99]), confidence ($r= 0.98$ [95% CI = 0.98 – 0.99]) and attitude ($r= 0.96$ [95% CI = 0.95 – 0.97]). The majority of participants (90%) reported intention to implement the programme.

CONCLUSION: Given that current knowledge, confidence, and awareness of PL among practitioners is poor; intervention is needed. Current attitude differed between organisations however this was not reflected in knowledge and confidence. Practitioners clearly identified a need for education. It is evident the workshop developed knowledge, confidence and attitude which was reflected in intention to implement. Follow-up is needed to explore if the positive changes in practitioners' confidence and intention translates into impacting on learners PL and subsequent PA.

[1] Durden-Myers et al. (2018)
[2] Goss-Sampson (2019)

## EFFECTS OF A SCHOOL-BASED PHYSICAL EDUCATION INTERVENTION ON INCREASING PHYSICAL ACTIVITY LEVELS IN CHILDREN FROM MARGINALIZED COMMUNITIES IN SOUTH AFRICA

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INTRODUCTION: While non-communicable diseases (NCDs) tend to appear in adulthood, most risk factors develop at a young age and are preventable through healthy, active lifestyles (1). Results from South Africa (SA) show that many children, particularly from marginalized communities, do not achieve the minimal requirements of physical activity (PA) (2). Moreover, physical education (PE) is no longer a stand-alone school subject in SA. Thus, primary schools present unique opportunities for interventions to increase PA among schoolchildren and decrease their risk for NCDs (3).
METHODS: Within "the KaziBantu model (Healthy Schools for Healthy Communities)" we developed KaziKidz, an educational toolkit to bring PE to public primary schools. KaziKidz was implemented between February and October 2019 as a clustered randomized controlled trial in 8 primary schools from low resourced settings in the Eastern Cape of SA. Children between 8 and 13 years of age wore the ActiGraph automated accelerometry device (wGT3X-BT) around the waist for 7 consecutive days to assess the effect of the intervention on PA levels. Repeated measures analyses of variance (rANOVAs) were performed to examine changes in the outcome variables from baseline to post-intervention.
RESULTS: Baseline results showed that 35.6% of children did not meet the WHO recommended daily 60 minutes of moderate to vigorous PA (MVPA). During the school day, a significant decrease in sedentary behaviour was observed both for the control ($F(1, 435)=44.32$, $p<0.001$, $\eta2 = 0.09$) and intervention ($F(1, 425)=18.57$, $p<0.001$, $\eta2 = 0.04$) groups. Interestingly, while a moderate significant increase was observed for the control group in light PA ($F(1, 435)=30.65$, $p<0.001$, $\eta2 = 0.07$) but not for the intervention group ($F(1, 425)=0.43$, $p=0.513$, $\eta2 = 0.01$), the intervention group showed a significant increase of large effect size on MVPA ($F(1, 425)=72.24$, $p<0.001$, $\eta2 = 0.15$) that was only moderate for the control group ($F(1, 435)=53.11$, $p<0.001$, $\eta2 = 0.11$). However, between-group analyses showed no statistically significant differences between the control and intervention groups post-intervention both for sedentary ($p=0.67$) and MVPA ($p=0.07$).
CONCLUSION: While PA levels increased throughout the study population, the KaziKidz intervention appears to promote daily minutes in MVPA during the school hours compared to light PA observed in the control schools. With increase in MVPA being associated with health benefits, it is important to identify opportunities throughout the day to promote MVPA in children, especially in disadvantaged settings where PA opportunities outside of school are scarce.
REFERENCES:
1. Joshi et al., Int. J. Cardiol., 2014
2. van Biljon, et al., S. Afr. Med. J., 2018
3. Pfledderer et al., Obes Rev, 2021

## MOTIVATIONAL MODELING OF SPORTS, EXERCISE, PHYSICAL ACTIVITY BEHAVIOURS AND SEDENTARY LIFESTYLES IN UNIVERSITY STUDENTS

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Introduction
Motivational modeling of sports, exercise, physical activity behaviours, and sedentary lifestyles of young people are explained by varous theories, models and approaches. Amongst those, the Self-Determination Theory (SDT) and the Theory of Planned Behavior (TPB) are the most commonly used theories in the international literature. Our aim was to identify patterns of sports, regenerative/recreational exercise, and leisure-time physical activity in university sports students, and what motivational factors influenced their activities.
Material and method
Following ethical approval, 100 university students (60 female) were recruited. Thirteen identified as elite athletes and/or competitive athletes and 87 as recreational athletes and/or bodybuilders. Respondents ranged in age from 19 to 24 years (mean age = 21.4 years). Among them, 71 people played individual sports and 29 team sports, training 1-8 times per week for between 30 and 150 minutes per day. Motivational orientation was measured utilising seven-point validated Likert scales using 2 items from each of autonomy, competence and relationships from the SDT, and attitude, perceived behaviour control, and subjective norms of the TPB. IBM SPSS v.25 software package was employed to determine descriptive statistics.
Results
During the study period, the elite/competitive athletes trained 2-8 times a week and spent a mean of 105 minutes per day in training or competition. The recreational athletes/bodybuilder group, spent an average of 55 minutes per day on physical activity, with 30% doing it alone and 70% with peers, family or friends. Leisure-time physical activity was undertaken on average 3-4 days a week (mean 33 minutes per day). With respect to motivation, competence (mean = 5.27) was most important for regenerative/recreational exercise, with autonomy support (5.05) and relationship factors (4.75) being second and third respectively. Reviewing the information obtained from the Theory of Planned Behavior (contributions to the behavioural effect) perceived behavioral control (mean = 6.06) scored first, with attitude being second (5.52). Third rated was subjective norm resulting from the environmental influence (4.89). Young university athletes, reported that they received most support from their family (mean = 5.82), with support from friends (5.80) and coach (3.71) being the next most important respectively.
Conclusions
Young sports students in our sample were engaged in sports, exercise and physical activity in accordance with international recommendations, but we suggest that there is still a need to reduce the amount of time spent in sedentary activities. From a motivational perspective, it is important for their regenerative/recreational exercise to maintain competence, promote a positive attitude, and continue to receive autonomy support from family, friends, and coaches.
Keywords: motivational theories, physical activity, sedentary lifestyle, university student athletes

### THE IMPACT OF A YOGA TRAINING PROGRAM ON MUSCLE CONTRACTILE PROPERTIES IN ELITE SOCCER PLAYERS

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INTRODUCTION: Yoga challenges the body in many ways, and being a very different methodology to normal training, it can be an important complementary technique for more extensive training or even replace traditional methods, with a highly positive impact on football practice and training [1]. Considering the results showing the potential of Yoga to reduce perceived propensity to reduce injuries and general fatigue, its integration into football training can be considered [2]. Our hypothesis is that Football players undergoing additional Yoga training, improve the lower limbs muscles contractile properties[3,4].
METHODS: Twenty-one professional football players from the 1st Portuguese Football League, senior levels under-23 and B, voluntarily participated, divided into two groups: Intervention (IG), Control (CG), all of them being assessed by tensiomyography before training and after 12 weeks. IG practiced Yoga at the end of the training, during 12 weeks, 2 weekly Yoga sessions, 60 minutes/each, guided by a certified teacher with 40 years of experience. Yoga techniques were selected and ordered according to the objectives of the study: pránáyáma (breathing techniques), ásana (psychophysical techniques), yoganidrá (relaxation), samyama (concentration, meditation and so on).
RESULTS: Comparing the two groups after 12 weeks Yoga: IG and CG, verified statistically significant differences for the variables: left biceps femoris muscle (LBF): Time Contraction, Tc (ms), $t(14) = 2.690$, $p = .018$, (-13.06 vs 0.29); Time Delay, Td (ms), $t(14) = -2.593$, $p = .008$, (-1.16 vs 1.54); Displacement, Dm (mm), $t(14) = 3.879$, $p = .018$, (-2.17 vs 2.99); Contraction Velocity, BFE_Vc (mm/s), $t(14) = -3.851$, $p = .012$, (72.18 vs 12.91) with the evolution being significantly greater in GI. In the remaining muscles contractile properties there were no significant differences between the groups.
CONCLUSION: Results showed when comparing the two groups: the GI after Yoga shows a significantly higher evolution, contributing to the growing understanding of the impact Yoga can have on muscle contractile properties, allowing for hypothesis testing in future work.
References:
1. Polsgrove, M J., Eggleston, B. M., Lockyer, R. J., 2016. Impact of 10-weeks of Yoga practice on flexibility and balance of college athletes. International Journal of Yoga.
2. Arbo, G. D., Brems, C., Tasker, T. E., 2020. Mitigating the Antecedents of Sports-related Injury through Yoga. International Journal of Yoga.
3. Ravi, S., 2016. The Application and Effectiveness of Yoga in Prevention and Rehabilitation of Sport Injuries in Athletes Participating in Competitive (RSL). Lase Journal of Sport Science. DOI: 10.1515/ljss-2016-0012
4. Rey, E., Corredoira, F. J., Costa, P. B., Pérez-Ferreirós, A., Fernández-Villarino, M. A., 2020. Acute effects of training load on contractile properties during a competitive microcycle in elite soccer players. Biology of Sport. DOI: https://doi.org/10.5114/biolsport.2020.93041

## Oral presentations

### OP-SH17 Cognition

### EFFECTS OF JUDO TRAINING ON WORKING MEMORY CAPACITY IN CHILDREN WITH ADHD

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INTRODUCTION: Background: Children with ADHD show deficits in working memory capacity that affect academic performance and the ability to learn. Skill acquisition in judo places demands on visuospatial working memory and has the potential to promote related functions. We investigated the effects of 12 weeks of judo training on behavioral and neurophysiological indices of working memory capacity in children with ADHD. Method: 57 children with ADHD (aged 8-12 years) were randomized to a judo training group, who completed 120 min of judo per week over 12 weeks, and a wait-list control group. Before and after the intervention period, patients completed a Change Detection task demanding visuospatial working memory. Using electroencephalography, the contralateral delay activity elicited by the task was assessed as proxy for working memory capacity. Additionally, patients completed a motor test battery to measure balance and manual dexterity.
Results: In comparison to the control group, patients in the judo training group showed a higher K-score (indexing the number of items hold in working memory) following the intervention, when pretest scores were accounted for. Similarly the posttest contralateral delay activity was higher in the judo training group than the control group, after accounting for its amplitude prior to the intervention. In contrast, no differences between groups were observed in balance and manual dexterity.
Conclusion: A short judo training program promotes the ability to maintain visuospatial information in working memory in children with ADHD. An increase in the effectiveness of working memory processes seem to underlie these improvements in behavioral performance.

### METHODS: RESULTS: CONCLUSION: COMPARATIVE STUDY OF MOTOR PROFICIENCY AND COGNITIVE ABILITY IN ADOLESCENTS WITH AND WITHOUT LEARNING DISABILITY.

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Introduction.Development and maturation of body movements play a critical role in cognition of adolescents. Motor competence serves as a foundation for cognitive functioning in childhood and adolescence. This study aimed to explore motor proficiency and cognitive ability in adolescents with and without learning disability (LD). Methods. Participants were 17 adolescents with (LD) (13 males, age:13.21±2.01 years), and 28 adolescents without LD (9 males, age: 13.59± 1.42 years)
Motor abilities were assessed with the four subtests from Bruininks- Oseretsky Test of Motor Proficiency (BOT-2) including bilateral coordination, balance, strength, agility and running scores. The Vienna Test System's six subtests (Adaptive Matrice test, Cognitron, Determination test (DT), Figural Memory (FM) test, Stroop test and Reaction time (RT) test) were used to assess general intelligence, concentration, attention, stress tolerance and reaction time, respectively.
Results and Discussion.

Analysis of BOT-2 scores revealed significantly higher performance of adolescents without LD in balance and body coordination (p =.037 and p = .003, respectively). Regarding cognitive abilities, adolescents without LD had significantly higher results in General intelligence test (p = .047), in overall Cognitron test scores (p = 0.00 to .002), in short and long term memory test outcomes (p = .00) and Stroop test (p = .00). However, significant difference between the two groups were not found in stress tolerance and reaction speed test outcomes. Analyses of correlations between motor proficiency and cognitive ability scores revealed that 14 of a total of 32 correlations reached statistical significance for adolescents without LD. The strongest positive correlations were between DT scores presenting stress tolerance and ability correctly react under complex stimulus conditions and BOT-2 total scores (r = .441 to .501, p < .05). The moderate significant negative correlations were between reaction time and errors in reaction to stimuli and total BOT-2 scores, indicating that adolescents with higher motor proficiency scores needed less time and made fewer errors in RT test (r = -.495 to - .468, p <.05).
For adolescents with LD only 4 of a total of 32 correlations reached statistical significance including variables that indicates errors or incorrectly performed tasks, for example, in concentration performance negative significant correlation was between mean time spent on incorrect responses and BOT2, indicating that those students who in short time made more errors in the Cognitron test had better motor proficiency scores (r = -.527, p <.05). Regarding reaction to complex stimuli those students with LD who omitted more tasks had better BOT2 scores (r = - .580, p <.05).
Conclusions.
The data demonstrated that motor proficiency was positively correlated with several aspects of cognitive functions in adolescents without LD, while such relationships were not found in adolescents with LD.

**PROMOTING EXECUTIVE FUNCTIONS BY LINDY HOP DANCE TRAINING IN ADULTS**

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INTRODUCTION: Early development and lifelong promotion of executive functions (EF) have been identified as important goals of children's education and better aging. In young and older people, dance-based interventions have shown to be effective training programs to accomplish these objectives (e.g. 1, 2) as dancing poses demands on physical, cognitive and social functions by multisensory stimulation in an enriched environment. In this vein, we examined the efficiency of a 10-week Lindy Hop dance training on multi- and single-component measures of EF in healthy adults, which is an underrepresented cohort when additive cognitive benefits are concerned.
METHODS: In the experimental study with physically active adults aged 22-56 yrs (half females), 3 dance groups (n=39) practiced, on average, 3.5 h/wk Lindy Hop (half in teaching classes, half in free training) while matched controls (n=20) did not undergo any dance training. Beginners with little or no prior knowledge were instructed on the basic techniques and moves of Lindy Hop, intermediates that had already attended at least one basic class learned new moves and refined their basics while advanced dancers aimed to further improve and perfect their technique by new inputs and feedback. Pre- and post-performance on EF were assessed by 3 well-known assessment tools.
RESULTS: Planned contrasts (one-way ANOVA) on change scores from pre- to post-test revealed significant improvements of the 3 dance groups in contrast to the control group in the performance of the Design Fluency Task with 9.4%p more attempted designs (p=.004; d=2.62) and 8.2%p more correct designs (p=.041; d=1.62). Medium to large training effects were also found in the Trail Making Task but without conclusive evidence (total time part B-A: p=.232; d=0.83 and number of errors part B: p=.175; d=0.88). The intervention did not systematically affect the Stop-Signal Task performance (p=.990; d=0.01). Planned comparisons between beginners, intermediate and advanced dancers indicate similar intervention effects across dance levels in all three EF tasks (p>.330; d<0.41).
CONCLUSION: Our results extend the findings in children and elderly as they provide valuable indications that dance training like Lindy Hop dancing is a promising recreational activity for the improvement of EF even in healthy adults. This is particularly remarkable since the studied cohort consisted of already previously physically active subjects with a high level of education and a pre-test performance on the DFT of about 1 SD above the norm. In contrast to the aggregated measure of EF, performances on specific tests of cognitive flexibility and inhibitory control were not significantly advanced by the dance intervention, suggesting that generally fit adults already exhibit efficient processing on core EF or need longer intervention periods to improve single EF components.
REFERENCES
1 Zinelabidine et al., Percept Mot Ski, 2022.
2 Kosmat & Vranic, J Aging Phys Act, 2017.

**EFFECTS OF DAYTIME NAPPING ON PHYSICAL AND COGNITIVE PERFORMANCES IN OLDER ADULTS**

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INTRODUCTION: Napping is common among older adults [1]. This systematic review aimed to: 1) determine how studies evaluated napping behavior in older adults (frequency, duration and timing); 2) explore how napping impacts perceptual measures (i.e., sleepiness, fatigue and alertness), cognitive and psychomotor performances, night-time sleep and physiological parameters in the elderly.
METHODS: This systematic review was conducted in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. Four bibliographic databases were searched from database inception to December 2021. Primary research published in peer-reviewed journals, conducted with older adults (i.e., ≥ 55 years of age) and investigating the effect of napping on cognitive and/or physical performance were included. The quantitative assessment tool 'QualSyst' was used to assess the risk of bias of each study.
RESULTS: The predefined search strategies yielded a preliminary pool of 738 possible papers, 41 of which remained after duplicates had been excluded and titles and abstracts had been screened. After a careful review of the 41 full texts, eleven articles were included, as well as four additional records identified through the screening of the references and related citations from other journals via Google Scholar lists of included articles. In total, fifteen studies met our inclusion criteria with a mean age ranging from 60.8 to 78.3 years and a cumulative sample size of n=326. Daytime napping had an overall positive impact on subjective measures (i.e., sleepiness and fatigue), cognitive and psychomotor performances (i.e., reaction time and accuracy) and learning abilities (i.e., declarative and motor learning). Further, studies investigating acute and chronic effects of daytime napping on nighttime sleep showed (i) consistency between nap and control conditions regarding sleep duration, efficiency and latency, and proportion of sleep stages, and (ii) increase of 24 h sleep duration with nap compared to control condition. Based on the findings of the present review, there is minimal evidence to indicate that napping is detrimental for older adults' nighttime sleep.

CONCLUSION: The findings of the present systematic review are meaningful for understanding the impact of daytime napping on the life of older adults. Because short sleep is associated with cognitive impairment in older adults across ages, and given the huge beneficial effect of napping on perceptual measures, physical and cognitive performances, and declarative and procedural learning, a diurnal daytime nap opportunity could be proposed as a solution to improve older adults' health and daily performance. Nonetheless, considering the long-term impact of long sleep on cognitive performance, researchers, geriatric specialists and doctors should be careful about which nap duration to propose to older adults in order to not exceed the recommended duration of sleep.
References
[1] Xiao & Hale, 2018 Sleep 41 (7):zsy076.

### ASSOCIATIONS BETWEEN MUSCULAR STRENGTH AND MENTAL HEALTH IN COGNITIVELY NORMAL OLDER ADULTS. A CROSS-SECTIONAL STUDY FROM THE AGUEDA TRIAL

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INTRODUCTION: Over 38% of European individuals are affected by mental disorders, which in turn, contribute to other physical health problems and high morbidity. Muscular strength has been associated with lower mortality risk in older people. Nevertheless, its role in mental health is not clear yet at this age range. Therefore, the aim of the present cross-sectional study was to examine the associations between muscular strength and mental health (i.e., psychological distress and well-being) in a sample of older adults.
METHODS: In the present cross-sectional study, we used a sample of 82 cognitively normal older adults aged 65-80 years (59% female) who were participating in the AGUEDA randomized controlled trial (https://profith.ugr.es/agueda). Absolute muscular strength (i.e., the maximum amount of force exerted in kg, regardless of muscle or body size) was evaluated using the handgrip strength test (TKK 5101 Grip dynamometer). Additionally, relative muscular strength (the amount of strength/body size) was expressed per kg of body weight. The test was performed twice for each hand and, the average of the highest score of each hand was used. Satisfaction with life was assessed by the Satisfaction With The Life Questionnaire (SWLQ), self-esteem by the Rosenberg Self-Esteem scale (RSE), anxiety by the Hospital Anxiety and Depression Scale (HADS), depression by the Geriatric Depression Scale (GDS), loneliness by the University of California, Los Angeles Loneliness (UCLA-L) scale, and stress by the Perceived Stress Scale (PSS). First, linear regression models, adjusted for sex, age, and years of education (model 1) were performed to explore the relationship of absolute and relative muscular strength (predictor variables) with mental health outcomes (dependent variables). Secondly, we entered cardiorespiratory fitness into the model to examine whether cardiorespiratory fitness attenuated the association of muscular strength with mental health outcomes (model 2).
RESULTS: Relative muscular strength was positively associated with self-esteem in model 1 (β= 0.414, p= 0.004) and model 2 (β= 0.384, p= 0.018). However, absolute muscular strength was not associated with self-esteem in models 1 (β=0.383, p=0.06) and 2 (β=0.310, p=0.152). Furthermore, muscular strength was not associated with any other psychological distress or well-being indicator (all p > 0.08).
CONCLUSION: We observed a positive association between relative muscle strength and self-esteem that was independent of cardiorespiratory fitness and other confounding factors. However, muscular strength may not influence any other mental health indicator in cognitively normal older adults. Large scale experimental studies are needed to decipher the temporality of the associations.

### ASSOCIATIONS BETWEEN PHYSICAL ACTIVITY AND GRAY MATTER VOLUME IN COGNITIVELY NORMALOLDER ADULTS. A CROSS-SECTIONAL STUDY FROM THE AGUEDA TRIAL.

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INTRODUCTION: The practice of physical activity is associated with a better physical and mental health, especially physical activity of moderate-to-vigorous intensity seems to increase gray matter volume, or at least, slow down gray matter atrophy during aging. This might imply numerous benefits in terms of working memory, attention, executive function, and other brain function, as well as the prevention of the neurodegenerative disease, which is common in older adults. The aim of the present study was to examine the association between moderate-to-vigorous physical activity and gray matter volume in cognitively normal older adults.
METHODS: A total of 79 cognitively normal older adults (45 females; average age =71.2 ± 3.73 years) were included in this cross-sectional study from the Agueda trial. Daily moderate-to-vigorous physical activity was measured with a movement sensor (GT3x+, Actigraph, Pensacola, US) worn on the no dominant wrist by the participants for 9 days and 12 hours. The first day and the remaining hours of the last day were excluded from the analyses. Participants wearing the device for at least 16 hours during four days (including at least one weekend day), out of the remaining eight complete days, were included in this analysis. T1-weighted images were acquired with a 3.0 T Siemens Magnetom Prisma Fit scanner. Gray matter volume was determined by voxel based morphometric analysis. The accelerometers raw data were processed using the GGIR package in R. General linear models were used to assess the association of moderate-to-vigorous physical activity with gray matter volume. All models were adjusted for sex, age, and years of education. The statistical threshold was calculated with AlphaSim and further Hayasaka adjustment was performed to account for the non-isotropic smoothness of structural images.
RESULTS: The results showed that higher daily moderate-to-vigorous physical activity was positively associated with a greater gray matter volume (p<0.001;) in in the right side of cerebellum posterior lobe (right cerebellum Creus II) (K=238; t= 4.76). No negative associations were found in any region of the brain.
CONCLUSION: A higher practice of daily moderate-to-vigorous physical activity could have benefits on brain structure, specifically on the cerebellar gray matter volume, but not on any other brain region. A greater gray matter volume supposes a healthier brain condition and one way to prevent cognitive decline in cognitively normal older adults. Future studies should investigate whether increasing the gray matter volume in the right cerebellum implies any benefit in the cognitive status in older adults.

## 17:45 - 18:45

### Conventional Print Poster

### CP-MH13 Children health and fitness

**ASSOCIATION OF SCHOOL NEIGHBORHOOD-BUILT ENVIRONMENT WITH SCHOOL-AGED CHILDREN'S PHYSICAL ACTIVITY: A LARGE-SCALE CROSS-SECTIONAL STUDY OF FIFTH- TO TWELFTH-GRADE CHILDREN IN JAPAN**

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INTRODUCTION: Physical activity in school-aged children is not only associated with various health indicators but also contributes to an active lifestyle and the prevention of chronic diseases in adulthood. In recent years, increasing numbers of studies have examined the built environment of neighborhoods as a potential factor related to physical activity. A neighborhood environment is essential for children because they have a limited range of activities and cannot make independent behavioral choices. However, previous studies have been biased in favor of a few countries, and evidence for children in Japan is limited. Thus, this study aimed to clarify the association of school neighborhood-built environments with school-aged children's physical activity.
METHODS: A total of 21,491 fifth- through twelfth-grade students from 76 schools covering all regions of Japan were included in the study. The International Physical Activity Questionnaire for Japanese Early Adolescents was used to investigate daily moderate-to-vigorous physical activity (MVPA). Using the geographic information system, the number of parks, sports facilities, public transportations, intersections, households, registered cars, and mixed land use within 500, 1000, 1500, and 2000 m in each school-centered network buffer were calculated. Multilevel linear regression analysis was used to examine the relationship between MVPA and built environment elements.
RESULTS: For elementary school boys, the number of parks and public transportations within 1500 m were significantly positively associated with MVPA. For elementary school girls, the number of parks within 500 to 1500 m was significantly positively associated with MVPA, while the number of sports facilities and the number of registered cars within 500 m were significantly negatively associated with MVPA. For junior high school boys, the number of parks within 500 m, the number of intersections within 500 to 2000 m, and the number of households within 500 and 2000 m were significantly positively associated with MVPA, while the number of public transportations within 500 and 1500 m, and the number of registered cars within 500 to 2000 m were significantly negatively associated with MVPA. For junior high school girls, the number of intersections within 500 to 2000 m was positively associated with MVPA, and the number of registered cars within 500 to 2000 m was significantly negatively associated with MVPA. Among high school boys, the number of households within 1000 m showed a significant negative relationship.
CONCLUSION: For elementary school students, having more usable exercise places in the school neighborhood was consistently associated with having more MVPA. For junior high school students, having good road connectivity and less reliance on the car in the school neighborhood were consistently associated with having more MVPA. For high school students, the association between the built environment of the school neighborhood and physical activity was not pronounced.

**SECULAR CHANGE IN SELECTED MOTOR PERFORMANCE PARAMETERS AND BMI IN SWISS PRIMARY SCHOOL CHILDREN FROM 2014-2021: THE SPORTCHECK+ STUDY**

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INTRODUCTION: Motor performance is known to be a meaningful marker for healthy child development [1] and the development of appropriate motor skills enhances the likelihood of lifelong physical activity [2]. Based on the mentioned associations, it has recently been suggested to apply regular and standardized monitoring of motor performance in childhood to identify individuals with diminished motor performance [3]. However, studies with population-based samples and standardized monitoring of motor performance in childhood including regular measuring points over several years are scarce.
METHODS: The aim of this study was to describe secular changes in motor performance (20-m sprint, balancing backwards, jumping sidewards, 20-m Shuttle Run Test (SRT)) and anthropometric data (BMI) in Swiss first graders from 2014 to 2021. The sample included eight birth cohorts with a total of 10'953 children. Multilevel mixed-effects models were used to estimate secular trends for boys vs. girls, lean vs. overweight as well as fit vs. unfit children.
RESULTS: In our sample, balance performance decreased (-1.1 steps per year, 95% CI [-1.16;-0.93]; 2.8%), whereas we found improvements for jumping (0.6 jumps per year, [0.47;0.68]; 1.3%) and BMI (-0.12 kg/m2 per year [-0.14;-0.10]; 0.7%). 20-m SRT performance increased by 0.6% per year in unfit children (0.1 [0.07;0.20]). Secular trend revealed enhanced jump performance development for boys when compared to girls, but also more pronounced decrease in 20-m SRT in fit girls compared to fit boys.
CONCLUSION: Secular changes differed in various motor performance parameters showing plateaus (20-m sprint and 20-m SRT), improvements (jumping sidewards, BMI) and deteriorations (balancing backwards). Identified increase in 20-m SRT performance over years in unfit children is encouraging as poor physical fitness levels during childhood are associated with negative health trajectories. However, it remains unclear whether the improvements in unfit children are already relevant from a public health perspective.
References:
1. Ortega, F. B., Ruiz, J. R., Castillo, M. J., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: A powerful marker of health. International Journal of Obesity, 32(1), 1–11.
2. Hulteen, R. M., Morgan, P. J., Barnett, L. M., Stodden, D. F., & Lubans, D. R. (2018). Development of Foundational Movement Skills: A Conceptual Model for Physical Activity Across the Lifespan. Sports Medicine, 48(7), 1533–1540.
3. Utesch, T., Zinner, J., & Büsch, D. (2018). Stabilität der physischen Fitness im Kindesalter: Konstruktvalidität der Referenzkategorien für den Deutschen Motorik-Test 6–18 im Projekt „Berlin hat Talent" über fünf Jahre. German Journal of Exercise and Sport Research, 48(3), 404–414.

### A DELAYED EVENING MEAL ENHANCES SLEEP QUALITY IN YOUNG RUGBY PLAYERS

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INTRODUCTION: The aim of this study was to examine the effect of delayed evening mealtime on sleep quality in young athletes.
METHODS: Twelve young rugby players (age 15.8 ± 0.7 years) participated in a cross-over within-participant design. Adolescents spent 5 consecutive days in each of two conditions, separated by a two-week washout period: routine dinner (RD, 3.5 hours before bedtime) and late dinner (LD, 1.5 hours before bedtime). Dietary intakes and amount of physical activity were constant throughout the study. Sleep was assessed using polysomnography on the first and the last nights of each condition. Data were analyzed using Student paired t-test or Wilcoxon tests.
RESULTS: Sleep efficiency (SE) was of 4.8% higher in LD compared to RD ($p = 0.001$, $d = 1.24$). An increase in total sleep time by 24 min ($p = 0.001$, $d = 1.24$) was obtained during LD. Improvement in SE was mainly due to a lower wake after sleep onset (-25 min, $p = 0.014$, $d = -3.20$), a decrease in the number of micro-arousals (-25%, $p = 0.049$, $d = -0.64$) and awakenings of more than 90s (-30%, $p < 0.01$, $d = -0.97$) in LD compared to RD. There were no significant differences in sleep architecture except for a shorter slow-wave sleep (SWS; N3) latency (-6.9 min, $p = 0.02$, $d = -0.778$) obtained during LD compared to RD.
CONCLUSION: Evening dinner 1.5 hours before bedtime leads to better quality and less fragmented sleep compared to evening dinner 3.5 hours before bedtime in young athletes.

### FACTORS RELATED TO THE PERCEPTION OF BARRIERS TO PHYSICAL ACTIVITY PRACTICE IN ADOLESCENTS

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*UFPR*

INTRODUCTION: Different social contexts foster different types of behavior [1]. Receiving social support from parents and friends for physical activity has been shown to increase physical activity levels in adolescents [2]. Conversely, barriers to physical activity have been explored by several researchers, with the aim of discovering what prevents adolescents from engaging in physical activity [3]. The aim of this study was to verify whether adolescents who have active parents and receive social support to practice physical activity (from parents and friends) perceive lower barriers to physical activity practice.
METHODS: A cross-sectional study including a representative sample of 1984 adolescents (55.9% girls), aged 15-17 years, from a southern city of Brazil. The ASAFA scale (Scale of Social Support for Physical Activity) was used to determine the social support from parents and friends, and the questionnaire "Barriers for the practice of physical activity in adolescents" to investigate the barriers related to the physical activity engagement. The adolescents' physical activity level was assessed by the QAFA (Physical Activity Questionnaire for Adolescents) and the parents' physical activity level was evaluated by the IPAQ (International Physical Activity Questionnaire). For the statistical analyses, a conceptual model of structured equations, weighted least squares means and variance adjustment were applied (Software R versão 3.6.1).
RESULTS: Parental social support increased the number of barriers perceived by adolescents (10.9%), while social support from friends reduced the number of perceived barriers (10.0%). Boys perceived lower barriers in comparison with girls (119.7%). Physically active parents provided more social support to their adolescents (149.5%). The analyzes were significant for $p<0.05$. Having physically active parents was not significant in explaining adolescents perception of barriers. The results showed good quality of fit (CFI=0.939; TLI=0.903; RMSEA=0.077; SRMR=0.081).
CONCLUSION: Active parents provide more social support to their children and social support from parents has been shown to increase the number of barriers perceived by adolescents. However, receiving social support from friends for the practice of physical activity seems to reduce the number of barriers perceived by adolescents.

## Conventional Print Poster

### CP-MH01 COVID-19: Effects on sports and physical functions

### THE IMPACT OF COVID-19 ON THE ORGANISATION OF INTERNATIONAL SPORT EVENTS

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INTRODUCTION: Safety has been a long-standing issue in the sport business trends, but since 2020, this area has taken on a new meaning, with health safety becoming the main issue. The health situation, which is still predominant today, has affected international sport events that attract large crowds and consumers who attend them in person.
METHODS: Investigate the impact of the health crisis of the last two years on international sport events, we used a qualitative research method, drawing on primary and secondary sources.
We analysed international sport events from a risk management perspective. By secondary sources we identified global economic impacts and risks associated with the organisation of international sport events.
We investigated sports event management solutions and risk management strategies over the past two years. As a primary source, we interviewed experts from the organisers of international sport events in Hungary. Our research question: what are the impacts of COVID-19 on the organisation of international sport events? This question is broken down into sub-questions: what are the risk management solutions? What trends can be identified in the impact of COVID-19 on international sport events?
RESULTS: Recent sport events highlighted the need for new risk management.
In our study, we distinguish four temporal phases in the way sporting events are organised, which can be linked by applying Leopkey and Parents (2021) seven risk mitigation strategies of (1) reduction, (2) avoidance, (3) redistribution, (4) dispersal, (5) prevention, (6) legal measures and (7) relationship management (Leopkey and Parent 2021).
Based on the experiences of the expert interviews in 2020 and 2021, three versions of implementation scenarios can be identified: 1) bubble system, 2) sport events with the participation of domestic fans and 3) sport events with the participation of international fans.

Technological developments, the focus on fan experiences, the need for a change of business model, the rise of over-the-top content are some of the sport business trends that have emerged or been reinforced by the impact of COVID-19 on the organisation of international sport events.
CONCLUSION: Strategies for organising international sport events before 2020 need to be rethought. The main aspect of organising a sport event is the safety of life, reducing and then stopping the spread of the epidemic, and thus protecting the human side: the health of athletes, participants and fans.
Despite the new health, safety and hygiene measures fully "safe" sport events cannot be guaranteed. Instead of "Covid-safe" sport events, we can talk about "Covid-reduced" sport events. Sport must adapt to changing environmental factors. In terms of sport business trends, 2022 is the year of adaptation and innovation.
Leopkey, B., & Parent, M. M. (2021). Risk Management Strategies by Stakeholders in Canadian Major Sporting Events. Event Management, 13 (3), 153–170.

**PHYSICAL ACTIVITY AND ITS INDIVIDUAL AND INTERPERSONAL CORRELATES AMONG YOUNG ADULTS DURING THE COVID-19 PANDEMIC**

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Introduction
COCID-19 pandemic brought out many challenges for physical and mental health of populations around the globe. Health-related behavior in general and physical activity in particular was also affected. Meanwhile, lack of physical activity is correlated with many health outcomes. The purpose of this study was to assess the physical activity of adults aged 18-36 years old during the pandemic and determine the relationship between physical activity, body mass index, sociodemographic characteristics, psychological distress, nutrition habits, and social capital indicators as the protective factors.
Methods
One thousand two hundred fourteen participants filled the questionnaire. The physical activity was identified by IPAQ questionnaire, nutrition habits were measured by MEDAS scale, psychological distress was measured by Kessler 6 scale. Cognitive social capital was identified in the context of family, neighborhood, peers, and colleagues as indicators of social trust, support, coherence. Structural social capital was defined as the number of people within the participant's social network and the frequency of participation in social gatherings. Body mass index was calculated from height and weight, sociodemographic characteristics were also identified.
Results
On average young adults are physically active at a moderate-to-vigorous level of 4.3 hours a week, 47 percent lack adequate physical activity. Regression analysis revealed that higher social trust, number of friends, having fun with friends, higher adherence to a healthy diet is related to higher and sedentary behavior to lower moderate-to-vigorous physical activity. Among sociodemographic characteristics, male gender and lower education predict higher physical activity. Neither body mass index nor psychological distress was related to physical activity.
Discussion
Almost half of the young adults were inadequately physically active in the period of the COVID-19 pandemic. Wider social networks, social trust, and social participation serve as the factors encouraging physical activity among young adults. Physical activity and healthy nutrition are interrelated. Sedentary behavior and female gender are risk factors. Building social capital at university and work settings by encouraging team sports and sports competition is an option to increase both physical activity and social capital. Access to physical activity-friendly environments should be provided.

**EFFICACY OF COVID-19 SAFETY PROTOCOL AT THE 2021 WRESTLING EUROPEAN OLYMPIC GAMES QUALIFIER ORGANIZED IN BUDAPEST**

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INTRODUCTION: The pandemic Covid-19 imposes several difficulties to organize multi-day international sports events. This is - in part - due to the close physical contact among the athletes, known to promote the spread of virus, even in individual sports, such as wrestling. Thus, at the Wrestling Qualifier it was utmost important to introduce screening for the disease and exclude infected participants (and then isolate them). We have developed a screening protocol and aimed to test the efficacy during this competition.
METHODS: The event was attended by 281 competitors from 37 countries. The criteria to enter Hungary were a negative polymerase chain reaction (PCR) test, epidemiological and symptomatic negativity within 72 hours. We have also performed Antigen rapid tests (ART, chromatographic immunoassay) and retesting if necessary. Upon departure a negative PCR test or a certificate issued after the end of the quarantine period was required.
RESULTS: In total, 1,500 PCR tests and 1,250 rapid tests were performed. At arrival, there were 21 PCR positive (1.4%) individual, and they were quarantined. At the departure 6 PCR tests were positive (0.47%). One of the ARTs performed at the accreditation was positive.
CONCLUSION: We have developed a successful protocol to screen for Covid-19 and isolation of participants as indicated by the very low positivity for Covid-19 at departure. Thus such protocol can be used for organize multi-day international sports events.

**POST-COVID PERFORMANCE IN FRENCH SWIMMING CHAMPIONSHIPS**

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*INSEP*

INTRODUCTION: Performance trends of French swimmers were assessed before and after the lockdown associated with the first anti-COVID-19 policies.
METHODS: Individual best performances were collected for all events at the French national championships from 2000 to 2020. Yearly proportions of swimmers who improved, stagnated, or regressed in performances were assessed compared to their previous year performances.
RESULTS: In 2020, the proportion of swimmers with performance regression has significantly increased (33% vs 17% in 2019). Women showed a higher proportion of performance regression (41%) than men (26%, $p < 0.0001$) in 2020. Only 39% of women and 53% of men

experienced progression in 2020 (vs 60.8 ± 3.7 % and 66.7 ± 5.2% respectively in the previous years). Between 2005 and 2020, only for the 2008-2009 championships, the coefficient of performmance regresion doesn't increase with age. Consequently, the 2010 championship highlight a coefficient of athletes with performance regression higher than previous year equivalent to the regression coefficient in 2020. Long-distance events showed higher regression (36.2 ± 0.5% for 400-800-1500m races) than short-distance ones (32.1 ± 3.2% for 50-100-200m events). Breaststroke events also showed higher regression (42.4%) than other styles (30.5 ± 2.1%). Younger swimmers more often improved their performance than older ones (61.9 ± 8.5% for swimmers under 18 vs 20.0 ± 10.8% for those over 25).
CONCLUSION: A high proportion of swimmers experienced performance regression during the 2020 French national championships. A higher impact was observed among female, long-distance and breastroke swimmers. Eight weeks of lockdown without training may have led to poorer swimming performances.

## IMPACT OF LOCKDOWN ON PHYSICAL ACTIVITY, BODY COMPOSITION, RESTING METABOLIC RATE AND MAXIMUM STRENGTH AND POWER IN PHYSICALLY ACTIVE FEMALES

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INTRODUCTION: The restrictive measures imposed to control the spread of the COVID-19 virus have led to unprecedented conditions of confinement and isolation [1]. The closure of social, gym and sports facilities led to changes in daily habits and physical activity [2]. Short-term abstinence from organized training and possible changes in daily physical activity patterns are likely to affect body mass and composition, resting metabolic rate (RMR), and muscle strength and power. Thus, the present study examined the effect of a 12-week lockdown due to the pandemic on body mass, body composition, RMR as well as upper and lower body strength and power.
METHODS: Ten physically active women (age: 30.1 ± 5.8 yrs) with at least one year of resistance training experience, were examined before and after 12-weels of lockdown in Cyprus. Body mass and height were measured, and physical activity was evaluated using the IPAQ questionnaire. RMR was measured using a metabolic system. Maximum strength and power in ten selected resistance upper and lower-body exercises were also recorded.
RESULTS: The 12-week lockdown resulted in a 12.1% decrease in physical activity (from 5871.7 ± 2449.9 met·min-1·wk-1 to 5163.2 ± 3276.7 met·min-1·wk-1, $p<0.05$), a 7% increase in RMR (from 1918.2 ± 158.5 kcal·day-1 to 2058.9 ± 346.7 kcal·day-1, $p<0.05$), a 2% decrease in body mass (from 60.6 ± 9.8 kg to 59.1 ± 9.3 kg, $p<0.05$), accompanied by a 5% decrease in body fat (from 18.3 ± 4.5 % to 17.4 ± 3.7 %, $p<0.05$). Maximum strength was similar in 9 out of the 10 exercises. However, maximum power decreased by 10.1%-21% ($p<0.05$) in 4 out of the 10 selected exercises (leg extension, leg curl, low row and deadlift) and increased by 5% and 7.3% ($p<0.05$) in the shoulder press and squat respectively.
CONCLUSION: During the quarterly lockdown, alternative training solutions were sought by previously active females, which seem to have functioned as an effective training stimulus for improving or maintaining muscle power in some exercises. The increased RMR and possible dietary modifications, which were not recorded, may explain the small but significant body fat loss. Organized strength-power training at home may serve to maintain and even improve strength and power under similar circumstances in the future.
1. Ding et al. (2020), 2. Constandt et al. (2020)

## EFFECT OF INJURY ABSENCE ON THE ACCELERATION-SPEED PROFILE AND THE DIFFERENCE BETWEEN COVID-19 AND TRAUMATIC OR OVERUSE INJURY.

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INTRODUCTION: The acceleration-speed profile (ASP) is a new method for evaluating players with Global Postioning System (GPS) devices [1]. Maximal theoretical acceleration (A0) and maximal theoretical speed (S0) are the main variables collected from the ASP. After an injury, strength levels as other physical capacities show a significance decrease [2]. Therefore, the aim of this study was to compare A0 and S0 values pre-injury and post-injury and to analyze the differences between suffer from COVID-19 or another musculoskeletal injury.
METHODS: All injuries of a professional football team (2nd spanish division) were collected from the beginning of the present season until March by GPS WIMU PROTM 15Hz. It was considered as injury any complaint that unable a player to take part of a session [3]. Injuries were grouped into two: traumatic and overuse (T-O) (n=7) and COVID-19 (n=16). The variables of A-S profile A0 and S0 [1] were considered for the analysis. Pre-injury and post-injury data of those variables were analysed in different time frames of 7, 14 and 21 days in which included training sessions and matches. It was considered pre-injury the days before the injury occured. Post-injury collection started from the return to full participation. Shaphiro Wilk´s test was used to test the normality distribution. T-test for paired sample was developed for each time-frame of the variables and for each injury category (e.g. A0 7 days-preinjury and A0 7 days-post injury). The confidence level was established at 95%. Significance was set at $p<0.05$.
RESULTS: The T-O group, in the 7 days previous to the injury showed higher values than the same time post-injury (0.99 m/s2;-0.21 to -2.21 m/s2; d= 1.31). A0 values dicrease is also significance in T-O category for the 14 days timeframe (0.64 m/s2;-0.79 to 2.06 m/s2; d= 1.54). However, the COVID-19 group showed significance lower values in pre-injury block for A0 in the 7 days previous when compared to post-injury (-0.72 m/s2;-1.44 to -0.01 m/s2;d= 0.92). For S0, both groups showed lower in pre-injury 7 days block when compared to the same time post-injury (T-O: 1.17 m/s;-0.1 to 2.44 m/s; d=1.37) (COVID-19: 0.58 m/s;-0.18 to 1.33 m/s; d=0.98). Furthermore, the decrease of S0 remained until 28 days timeframe in both groups (T-O: 0.86 m/s;-0.1 to 1.83 m/s;d=1.04) (COVID-19: 0.58 m/s;-0.11 to 1.3 m/s; d=1.07).
CONCLUSION: T-O injury showed a decrease in A0 and S0 in post-injury. However, COVID-19 reduced only S0. It might be due to T-O had rehabilitation period in which activity is minimal, but COVID-19, despite being confinated, they could train at home with fitness equipment. Being A0 a variable related to horizontal force, its decrease could be atenuated by the endurance training at home. Nevertheless, COVID-19 group could not train properly speed demands because of the available space and it might justify lower values in S0 in both gropus after injury.
1.Morin et al. (2021); 2.Maniar et al. (2016); 3.Fuller et al. (2006).

**EFFECT OF PROTEIN INTAKE ON BODY COMPONENTS AND PHYSICAL FUNCTION IN OLDER ADULTS IN A RURAL COMMUNITY OF SOUTH KOREA DURING THE COVID-19 PANDEMIC**

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INTRODUCTION: South Korean society is facing an unprecedentedly high and fast population aging in the rural community. The average age of farm owners exceeds 65 years old, and the sustainability of rural communities is also threatened. Thus, physical function or muscle strength is particularly important for this population. On the other hand, sarcopenia, as a new disease in older adults, which is defined by both loss of muscle mass and loss of muscle function or strength, is entering the public consciousness. Low physical activity, decreased protein synthesis, or increased protein degradation are all possible mechanisms of sarcopenia. Therefore, we aimed to investigate the effects of nutritional supplements (protein and vitamins) on sarcopenic components and physical function among the elderly living in rural communities in South Korea during the COVID-19 pandemic.
METHODS: This study was designed to analyze the effects of nutritional diets on skeletal muscle and physical function in older adults in rural communities. For eight weeks, participants aged more than or equal to 65 years old were randomly assigned to a protein intake group (n= 12) and a vitamin group (n= 12) and given 23 g/d of nutrition (protein: whey, soybean, BCAA; vitamins: B, C, D, E, and mixed minerals such as calcium, magnesium, and zinc). They returned twice as the COVID-19 situation worsened. It was delivered to each participant with the help of Sunchang Country officials and a courier, and at the same time, the instructions on how to take it and precautions were explained over the phone. All of the people who took part in the study had their height, weight, skeletal muscle mass, body mass index, and body fat percentage measured using bioelectrical impedance analysis (BIA). The physical function of the body was measured by instrument short physical performance battery (SPPB).
RESULTS: When compared to the baseline, there was a higher level (2.33 %) of SMM ($p<.01$) in the protein group ($p=.002$, 4.92 %). When compared to the baseline, the vitamin group had a significant increase in body fat percentage ($p=.001$, 15.35 %): it fell by 4.49 %. Grip strength and weight, SPPB, gait speed, chair stand test, and sensation of balance did not differ significantly between the two groups.
CONCLUSION: More protein intake helps improve body composition in older adults but has no effect on physical function. The findings revealed that protein consumption was effective in promoting older adults health in rural communities in South Korea during the COVID-19 pandemic. In the context where the health of the older adults in rural communities is deteriorating due to the decrease in physical activity due to COVID-19. Therefore, this study will provide an established basis for the future provision of personalized nutrition for older adults in rural communities.

**NEUROMUSCULAR FATIGUE AND RECOVERY IN PATIENTS AFTER SARS-COV2 INFECTION**

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INTRODUCTION: COVID-19 is a respiratory disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV2) [1]. Although some patients present severe form of the disease, most infected people are asymptomatic or experience mild symptoms, not requiring hospitalization [2]. Emerging evidences suggest a substantial proportion of patients refers persistent muscle weakness and exercise intolerance after 4–7 months from infection: "Post-Acute Sequelae of COVID-19" (PASC) [3]. The aim of this study was to evaluate the cause of muscle weakness and fatigability in PASC patients.
METHODS: 18 patients previously infected by SARS-CoV2 were recruited after 4-8 months from negative COVID-19 test and divided into two groups according to their quality of life (QL; [4]): PASC (n=9, QL<85, 54±9ys) and CTRL (n=9, QL>85, 46±10ys). Patients visited the laboratory on 3 non-consecutive days. After familiarization session and clinical measurements, neuromuscular functions were assessed. We measured: i) rate of torque development (RTD) from single isometric maximum speed contractions of knee extensor (KE); ii) maximal voluntary isometric contractions (MVIC) torque of KE and iii) torque from on high-frequency electrically-evoked potentiated doublet (Db100pot) delivered on femoral nerve. MVIC and Db100pot were performed before (PRE), immediately after (POST) and 10 minutes (POST10) after 80 maximal velocity contractions (1 contraction every 3s) with 20% of the MVIC load. Finally, specific isometric force (P0/CSA) and the no-load shortening rate (V0) of chemically skinned single muscle fibres isolated from muscle biopsies samples of vastus lateralis were determined with the slack test technique [5].
RESULTS: RTD was lower in PASC compared to CTRL (428±139 vs 769±12Nms-1; $p=0.001$). At PRE, MVIC and Db100pot torque were lower in PASC than CTRL (41±18 vs 68±36Nm and 123±36 vs 196±60Nm, respectively; all $p<0.009$). At POST, MVIC and Db100pot torque decreased similarly from PRE in both PASC (-28±13% vs -18±17%; all $p<0.04$) and CTRL (-26±13% vs -15±7%; all $p<0.009$). At POST10, MVIC remained lower from PRE in PASC than CTRL (-18±6% vs-6±5% from PRE; $p=0.001$), while Db100pot was not different between PASC and CTRL (-7±6% vs -9±8% from PRE, respectively; $p>0.05$). P0/CSA and V0 were not different between PASC and CTRL.
CONCLUSION: Muscle weakness reported by PASC patients is accompanied by reduced maximal force-generating capacity and ability to generate force within a short time interval of the KE which seem not attributable to altered actin-myosin cross-bridge. Interestingly, PASC patients also showed a slower recovery of torque after a dynamic fatiguing task which we can speculate being independent from excitation-contraction coupling impairments.
1. Wiersinga et al., JAMA. (2020).
2. Yanes-Lane et al., PloS one (2020).
3. Raveendran et al., Diabetes Metab Syndr. (2021).
4. Devlin et al., Health economics. (2018).
5. Bottinelli et al., The Journal of physiology (1996).

**LIFESTYLE HABITS IN OVERWEIGHT AND OBESE ADULT POPULATION: THE ROLE OF PHYSICAL ACTIVITY, SLEEP AND DIET**

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INTRODUCTION: Overweight and obesity compromise health, leading to significant long-term consequences, including the development of several chronic diseases such as diabetes, coronary heart disease, and osteoarthritis as well as increasing the risk of developing cancers [1].

Overweight, and obesity in particular, are rapidly growing public health problems affecting an increasing number of countries worldwide [2], so acting on lifestyle habits may be the best strategy [3]. The present study aims to assess the relationship between body mass index (BMI) and lifestyle habits, such as physical activity levels, chronotype, sleep and adherence to the Mediterranean diet (MD), in an overweight and obese adult population.
METHODS: We recruited 744 participants (516 females, 70%, 228 males, 30%; 49.4 +/-12.7 years) who spontaneously attended the International Centre for the Assessment of Nutritional Status (ICANS), University of Milan. Participants filled out the Godin Shephard Leisure-Time Physical Activity Questionnaire (GSL-TPAQ), the reduced version of the Morningness–Eveningness Questionnaire (rMEQ), the Pittsburgh Sleep Quality Index (PSQI) and the Mediterranean Diet Adherence Screener (MEDAS), to assess physical activity levels, chronotype, sleep and MD, respectively. Data were analyzed with SPSS version 27.
RESULTS: Based on the scores of the questionnaires administered, the participants were classified as active (n=487, 66%) and inactive (n=257, 34%), Morning-types (n=237, 32%), Neither-types (n=421, 57%) and Evening-types (n=86, 11%), good sleepers (n=406, 55%) and bad sleepers (n=338, 45%), adherent to MD (n=151, 20%) and not adherent to MD (n=593, 80%).
The correlation analysis on the entire sample showed that higher adherence to the MD (rs -0.13, p<.001), higher levels of physical activity (rs -0.12, p<.001), more hours spent in bed (rs -0.07, p<.05), and more slept hours (rs -0.11, p<.001) significantly reduce the BMI. Additionally, higher PSQI score, which is indicative of poor sleep quality, significantly increased BMI (rs 0.08, p<.01). No correlations were found between rMEQ score and BMI.
CONCLUSION: These findings show the importance of promoting strategies aimed at maintaining healthy active lifestyle in order to reduce the onset of overweight and obesity. Multidisciplinary interventions including physical activity, diet and sleep counseling could be effective in improving the overweight and/or obesity condition.
REFERENCES
1. Agha M. and Agha R., The rising prevalence of obesity: part A: impact on public health. Int J Surg Oncol (NY), 2017. 2(7):e17.
2. National Institute for Health and Clinical Excellence (NICE). Obesity: the prevention, identification, assessment and management of overweight and obesity in adults and children. 2006.
3. Wulaningsih W. et al., Investigating nutrition and lifestyle factors as determinants of abdominal obesity: an environmental-wide study. Int J Obes, 2017. 41:340-347.

## Conventional Print Poster

### CP-AP05 Strength II

#### EFFECT OF 8 WEEKS OF INDIVIDUALIZED CONTRAST TRAINING ON PHYSICAL PERFORMANCE OF BASKETBALL PLAYER

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INTRODUCTION: High intensity ballistic actions such as sprints, jumps and changes of direction are decisive in the sports performance in team sports, complex and dynamic such as basketball, so developing interventions that improve these physical qualities are of great interest to basketball coaches and physical trainers. Therefore, the aim of this study was to examine the effects of 4 and 8 weeks of contrast training based on individualized vertical force-velocity profile upon linear velocity, vertical and horizontal jumps, and change of direction in basketball players.
METHODS: Thirty senior basketball players participated in the study. The players were randomly divided into: control group (CON, n = 15; age, 22.7 ± 4.93 years; height, 1.84 ± 0.05 m; weight, 82.2 ± 6.00 kg), who performed their usual training schedule; intervention group (INT, n = 15; age, 22.9 ± 6.52 years; height, 1.88 ± 0.08 m; weight, 90.3 ± 23.0 kg), who underwent individualized intervention based on the protocol of Jiménez Reyes et al. (2019), in addition to continuing with basketball training. At baseline (T1), at week 4 (T2), and at week 8 (T3) of intervention, an evaluation was performed including different jumping tests, linear speed and changes of direction. Training effects were evaluated at 4 and 8 weeks of intervention by 2x3 repeated measures ANOVA.
RESULTS: The imbalance in the force-velocity profile was significantly improved after the intervention in the INT group ($p < 0.05$), which led to significant improvements after 4 weeks of intervention in vertical jumping actions ($p = 0.00$), both bilateral (7.29%, ES = 0.73) and unilateral (12.1%, ES = 0.67), but not in horizontal jumping. Such improvements were also observed for speed actions and changes of direction, showing greater changes in the angles of 45º (-8.43%, ES = 0.32, $p = 0.01$) and 180º (-6.58%, ES = 0.51, $p = 0.00$), although the latter were only observed at 8 weeks of intervention.
CONCLUSION: An optimized and individualized contrast training improved the physical performance after 8 weeks of intervention, being observed changes in vertical jumping and sprint since 4 weeks. Therefore, the authors would think that these variables obtained faster changes than the COD and that the improvements were specific with respect to the trained force vector, since the proposed intervention emphasized the vertical vector and the highest percentages of change were observed in this vector. Even so, we would recommend to strength and conditioning coaches to develop individualized training based on the strength demands of their athletes and to combine different intensities in order to optimize the force-velocity continuum.

#### EFFECTS OF VELOCITY LOSS THRESHOLDS DURING RESISTANCE TRAINING ON STRENGTH, MUSCLE HYPERTROPHY, AND SPRINT AND JUMP PERFORMANCE: A SYSTEMATIC REVIEW AND A META-ANALYSIS

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INTRODUCTION: Velocity based training has been reported as an effective resistance exercise method for manipulating intensity and volume during resistance exercise by several research groups (Hickmott et al. 2022). This study aimed to examine the effects of velocity loss (VL) thresholds during resistance training on muscle strength, muscle hypertrophy and sprint and jump performance using a meta-analysis.

METHODS: For this study, literature searches of the PubMed and SPORTDiscus databases were conducted from all time points until (December) 2021. Criteria for the study included (a) studies examining training effectiveness using velocity loss training methods, (b) outcome measures included a measure of strength, hypertrophy or sprint and jump performance, and (c) data necessary to calculate effect sizes (ESs) must be included or available. Combinations of the following keywords were used as search terms: velocity-based training, velocity based training, velocity loss, absolute velocity, load-velocity profile, load velocity profile, weight-training, weight training, resistance-training, resistance training, resistance-exercise, resistance exercise, strength-training, strength training, one-repetition maximum, one repetition maximum, strength, muscle strength, hypertrophy, muscle hypertrophy, muscle size, muscle thick-ness, muscle cross-sectional area. The average and variance of pre and post each measurement were extracted from the adopted studies. Cohen's d and their variance as ES of training response were calculated from average, variance and N for each of the 116 measurements in eight studies. VL was divided into three groups: low (VL0-10), medium (VL15-25), and high (VL30-50).
RESULTS: Result of meta-analysis of eight studies revealed in training responses (ESs) in VL thresholds as: muscle strength was 0.67 ($p<0.0001$), 0.69 ($p<0.0001$), and 0.72 ($p<0.0001$); muscle hypertrophy was 0.13 ($p=0.62$), 0.51 ($p=0.02$), and 0.42 ($p=0.04$); and sprint and jump performance was 0.48 ($p<0.0001$), 0.39 ($p=0.01$), and 0.15 ($p=0.18$), for VL0-10, VL15-25, and VL30-50, respectively.
CONCLUSION: Muscle strength was found to increase over a wide range of VL (VL0-50), muscle hypertrophy over a medium to high VL (VL15-50), and sprint and jump performance over a low to medium VL (VL0-25). Traditionally, low VL is known to improve muscle strength and high VL is known to improve muscle hypertrophy, but the present results suggest that a high VL may also improve muscle strength via muscle hypertrophy. Furthermore, the new finding of improving sprint and jump performance at the VL0-10 has an advantage of less exercise volume than medium to high VLs. Therefore, low VL is an effective tapering method.
Hickmott LM, Chilibeck PD, Shaw KA, Butcher SJ: The Effect of Load and Volume Autoregulation on Muscular Strength and Hypertrophy: A Systematic Review and Meta-Analysis. Sports Med Open 2022, 8(1):9.

**EFFECTS OF DIFFERENT VELOCITY LOSS THRESHOLDS IN FULL SQUAT WITH BLOOD FLOW RESTRICTION IMPLEMENTATION ON LEG STRENGTH AND JUMP PERFORMANCE**

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INTRODUCTION: Interest in resistance training with blood flow restriction (BFR-RT) has increased markedly due to higher evoked adaptations in muscle hypertrophy and strength gains (Lixandrao et al, 2018). On the other hand, velocity loss (VL) induced within the set during velocity-based resistance training (VBRT) programs is well known as a critical variable to determinate leg strength adaptations (Pareja-Blanco et al, 2020). However, the long-term effects of BFR-RT inducing different degrees of fatigue within the set have not been studied yet. Therefore, the aim of this study was to analyze the changes of two BFR-RT programs with different VL thresholds (20% vs 40%) in the full squat (SQ) exercise on leg strength gains and vertical jump performance.
METHODS: Twenty-five strength-trained men (n=25) carried out a longitudinal research design and were randomly assigned to two groups, BFR20 (n=12) and BFR40 (n=13). Subjects followed an eight-week (twice per week) VBRT program from 55 to 70% of 1RM using the SQ exercise. The VL was the independent variable (20% vs 40%). All subjects performed 3 sets per training session with 2 min rest between sets after a standardized warm-up without occlusion. Partial occlusion (50% arterial occlusion pressure) was maintained during the whole training session (excluding the warm-up). Subject carried out a battery of test (pre and post each protocol) in the following order to analyze the long-term effects: 1) countermovement jump (CMJ) and 2) incremental loading test in SQ. To compare the effects of each training intervention the following variables were analyzed: CMJ height; 1RM load; average mean propulsive velocity (MPV) attained against all absolute loads common at pre and post training (AV): average MPV attained against absolute loads that were moved faster or equal than 1 m/s at pre (AV ≥ 1) and average MPV attained against absolute loads that were moved slower than 1 m/s at pre (AV < 1).
RESULTS: A significant "protocol x time" interaction ($p = 0.013$) was reported for 1RM. Moreover, significant "time" effects were found for all variables ($p < 0.001$). Regarding intra-group differences, significant increases were reported by BFR20 and BFR40 ($p < 0.001$-$0.036$) in all variables too.
CONCLUSION: Despite both levels of fatigue induced improvements in all variables, a 20% VL threshold produced similar or even greater gains than 40% VL. For that, moderate level of induced fatigue within the set with BFR could be more beneficial than higher level to improve leg strength gains and vertical jump performance.
References:
Lixandrao et al, 2018. Sports Med.
Pareja-Blanco et al, 2020. Med Sci Sports Exerc.

**RELIABILITY OF LEG PRESS POWER-FORCE-VELOCITY PROFILING OUTCOMES USING THE ISOMED 2000 DYNAMOMETER**

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INTRODUCTION: Vertical jump power-force-velocity profiling (P-F-v) is considered a time-efficient method to estimate the theoretical lower limbs maximum force (F0), velocity (v0), power (Pmax), and the slope of the force-velocity relationship (SFV). However, the latest research found limited reliability and advised caution – at least when testing athletes not highly familiar with vertical jumps.(1,2) Switching to the coordinatively less challenging leg press movement might be a solution. Actually, a recent study found acceptable reliability for leg extension P-F-v profiling outcomes in elite athletes from a wide variety of sports using a protocol for a pneumatic Keiser leg press device.(1) Here, we examined the reliability of P-F-v profiling outcomes for the first time using a protocol for an isokinetic leg press, specifically the IsoMed 2000 leg press device.
METHODS: Forty-five elite athletes (22 female) from various sports and all familiar with isokinetic testing participated in 3 identical sessions (T1–T3), separated by 7 days. In each session, subjects completed an isokinetic leg press (IsoMed 2000; D&R Ferstl GmbH) P-F-v profile consisting of maximum concentric leg extensions at 0.1, 0.3, 0.7 and 1.2 m/s (ROM at tension: ~80–170º). At each velocity, 4 trials were performed. Mean force and mean velocity throughout the whole ROM were calculated. The trial with the highest mean force of each velocity condition was used to create the P-F-v profile (F0, v0, Pmax, SFV). Reliability statistics were done between consecutive pairs of sessions (T1–T2, T2–T3): Two-tailed paired samples t-tests were applied for detection of systematic errors. Intraclass correlation coefficients (ICC(3,1)) and coefficients of variation (CV) were used to estimate relative and absolute reliability, respectively.(3)

RESULTS: No systematic errors were found over sessions. Values of ICC(3,1) ranged from .90 to .98 for T1–T2 and from .88 to .99 for T2–T3. Corresponding CV-values ranged from 2.6 to 5.8% for T1–T2 and from 1.9 to 5.4% for T2–T3.
CONCLUSION: Overall good to excellent relative and acceptable absolute reliability was found for P-F-v profiling outcomes using the IsoMed 2000 isokinetic leg press. These results are in line with the findings of Lindberg et al. using a pneumatic Keiser leg press. The better reliability of the pneumatic leg press compared to vertical jump profiling outcomes was partly attributed to a shorter extrapolation distance to the axis interceptions.(1) However, the extrapolation distance to the x-axis was considerably longer in the present study. Consequently, we attribute our results mainly to the better standardization and the lower coordinative demands of the leg press movement compared to vertical jumps, which leads to more reproducible force and velocity input data for the individual P-F-v profiles.
References
1. Lindberg et al., PLOS ONE, 2021
2. Fessl et al., Int J Sports Physiol Perform, 2022
3. Hopkins, Sports Med, 2000
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**EFFECT OF BENCH PRESS EXECUTION VELOCITY, LOAD, AND LOAD DISTRIBUTION ON PERCEIVED EXERTION AND NUMBER OF REPETITIONS PERFORMED**

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INTRODUCTION: Barbell bench press exercise adaptations depend on how several of its parameters are tailored. Exercise intensity, which plays a pivotal role in resistance exercise adaptation, is generally prescribed as the load to be lifted for a specific number of repetitions. Traditionally, load is expressed as a percentage of one repetition maximum (i.e., the greatest resistance that can be lifted in a controlled manner with good posture) (1). However, execution velocity also affects exercise intensity (2). Moreover, no studies assessed the effect of load distribution (i.e., the distance between the disc stacks at the two sides of the barbell) on exercise intensity. The present study aimed to evaluate how different combinations of load, execution velocity, and load distribution on the barbell affect the number of repetitions to failure (REPfailure), and rating of perceived exertion (RPEfatigue) and number of repetitions (REPfatigue) at fatigue onset.
METHODS: Eleven males (age 23.3±1.8 years) performed bench press exercises to failure following the National Strength and Conditioning Association guidelines (3). Three loads (80% [1-RM80], 65% [1-RM65], and 50% [1-RM50] of one repetition maximum), execution velocities (90% [V90], 70% [V70], and 50% [V50] of maximal concentric velocity), and two distributions (narrow and wide) were randomly combined. Participants' perceived exertion was also recorded during the repetitions eccentric phases (4). Three separate three-way repeated-measure ANOVAs (α=0.05) were performed to assess the effect of load, velocity, and distribution on REPfailure, RPEfatigue, and REPfatigue normalized as a percentage of REPfailure.
RESULTS: REPfailure was affected by load ($p<0.001$), velocity ($p<0.001$), and distribution ($p=0.005$). The interactions between load and velocity ($p<0.001$) and load and distribution ($p=0.004$) showed a significant effect on REPfailure, whereas the interaction between velocity and distribution was not significant ($p=0.360$). More REPfailure were performed using lower loads (1-RM50=21.2±3.5; 1-RM65=12.1±1.8; 1-RM80=4.8±1.3), higher velocities (V90=14.2±8.0; V70=12.7±7.2; V50=11.0±5.9), and wider distribution (wide=13.2±7.5; narrow=12.2±6.8). RPEfatigue and REPfatigue were affected by load ($p<0.001$ and $p=0.007$, respectively) and velocity ($p<0.001$ and $p<0.001$, respectively), whereas they were not affected by distribution ($p=0.510$ and $p=0.571$, respectively) or the two-way interaction effects. Using higher loads yielded higher RPEfatigue but lower REPfatigue, while RPEfatigue and REPfatigue were higher when slower velocities were used.
CONCLUSION: The present study shows that, when prescribing resistance exercise intensity, not only exercise load but also execution velocity and load distribution should be considered.
1. American College of Sports Medicine, Med Sci Sports Exerc, 2009; 2. Sakamoto A, et al., J Strength Cond Res, 2006; 3. Earle RW, et al., NSCA's essentials of personal training, 2004; 4. Gearhart, RE, et al., J Strength Cond Res, 2001.

**REGIONAL HYPERTROPHY: THE ROLE OF EXERCISE RESISTANCE PROFILE IN TRAINED WOMEN**

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INTRODUCTION: Inhomogeneous muscle growth, also known as regional hypertrophy, is influenced by several factors including exercise selection, time under tension, time spent in each phase of an exercise and performing only concentric/eccentric exercises. The aim of the present study was to analyse the role of exercises resistance profile in regional hypertrophy
METHODS: 39 healthy women participated in this study. All participants completed a 9-week resistance training program consisting of either 4 sets of 12 repetitions of inclined bicep curls (INC group) or preacher curls (PREA group) three times per week performing each set to muscle failure. Pre- and post-intervention Muscle thickness was measured using B-mode ultrasound imaging with a linear-array transducer. Scan acquisition sites were determined by measuring the 50%, 60% and 70% of the distance between the posterior crest of acromion and the olecranon. The center of the bicep brachii muscle was calculated as a line between the coracoid process and the anterocubital crest
RESULTS: No region of the INC group grew when comparing pre- to post-intervention ($p = 0.95$, ES = 0.019; $p = 0.520$, ES = -0.242 and $p = 0.536$, ES = -0.193 in the 50%, 60% and 70% region respectively). However, the 70% region of the PREA-group grew significantly ($p = 0.017$, ES = -0.623). We found no growth differences between regions when analysing per group ($p = 0.274$, ES = 0.014), Region ($p = 0.571$, ES = 0.013) or when anaysed per group * region ( $p = 0.367$, ES = 0.024).
CONCLUSION: This study shows that regional hypertrophy is affected by the resistance profile of an exercise. This means that different regions of a muscle will grow in response to exercises that place the highest difficulty in specific points of the range of motion. In particular, our results show that the distal region of the arm grows in response to exercises that place the highest amount of strain in the part of the range of motion in which the arm muscles are more elongated.

**CAN RATE OF FORCE DEVELOPMENT BE USED AS AN EFFECTIVE SCREENING TOOL FOR INJURIES IN HANDBALL?**

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INTRODUCTION: Max Rate of Force Development (RFDmax) has been long looked at as a measure and predictor of athletic success in a variety of sports along with its role in the rehabilitation process. Its ability as an injury screening tool for lower limb injuries, however, has yet to be extensively examined. Olympic Handball has been recognized as having one of the highest injury rates of any Summer Olympic event. Dynamic in nature with sudden high velocity sprints, stops and, jumping moments, lower limb injuries of the ankle and knee are common occurrences. Recent injury reports stated that the average player was injured 2.8 times per season resulting in a month of missed training. Therefore, we examined an athlete's relative to bodyweight RFDmax from a countermovement jump (CMJ) and its ability to screen for lower limb injury in Handball athletes.
METHODS: In the preseason, within one month of their season beginning, 18 German youth Handball athletes (age range: 13-19 y.o., 9 female) volunteered to be a part of the study. After a warmup and trial jumps, participants completed 5 CMJs on a force plate to calculate their RFDmax. Players were then surveyed for the following 6 months collecting injury information.
RESULTS: The RFDmax cut-off value of the CMJ that was set at 125 N/s/kg is considered a suitable screening value for lower limb injures in this group of players. A Sensitivity value of 86% was recorded (6 athletes out of 7 with a score below cut-off value sustained an injury in the following 6 months), along with a Specificity of 67% (6 of the 9 athletes below the cut-off were injured).
CONCLUSION: RFDmax from a CMJ has strong evidence to assess those at risk for a lower limb injury in this group of athletes. Adding this test as a pre-season screening and subsequent corrective training for those below the 125 N/s/kg cut-off value could significantly impact the average amount of injuries per season per player and lower the total amount of training time lost. Further improvements of this screening could be explored by investigating if higher earlier RFD are more beneficial than later within a jump. In addition, specific cut-off values for sex, age group, and ability level should also be identified.

**ACUTE EFFECTS OF ECCENTRIC AND CONCENTRIC RESISTANCE EXERCISE ON THE NEUROMUSCULAR FUNCTION IN THE CONTRALATERAL ELBOW FLEXORS OF HEALTHY INDIVIDUALS**

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INTRODUCTION: Cross-education effect refers to the neuromuscular adaptations transferred from the ipsilateral (or trained) to contralateral (or untrained) limb after strength training. The cross-education effect of eccentric resistance training has shown to decrease the detrimental effects on the morphological and neuromuscular function of skeletal muscles during immobilization more than concentric resistance training (1). Thus, it seems that contralateral training could be an interesting treatment during immobilization or desuse. However, the mechanisms of the acute neuromuscular adaptations (both central and peripheral) after one bout of eccentric and concentric exercise in the contralateral limb are unknown.
METHODS: Healthy young individuals were randomly allocated to ECC (n=10) or CONC (n=10) exercise conditions. Participants performed one bout of ECC or a CONC exercise (5 sets of 10 repetitions at 80% of their eccentric and concentric 1-repetition maximum, respectively), and a control condition without exercise (CTRL). NASA-TLX questionnaire was measured following ECC and CONC. Neuromuscular function (transcranial magnetic stimulation (TMS) and brachial plexus electrical stimulation) of the contralateral non-trained biceps brachii (BB) was evaluated during voluntary contractions and in relaxed muscle before and immediately after exercise. Voluntary activation level during maximal voluntary contractions (MVC), from peripheral nerve electrical (VA_PNS) and transcranial magnetic stimulations (VA_TMS) were also calculated. The amplitude of the potentiated twitch (Pt) and its contractiles properties, the evoked [M-waves, motor evoked potentials (MEPs) , cortical silent period (CSP)] and voluntary EMG activities were also recorded from the elbow flexors muscles before and after each experimental condition.
RESULTS: NASA-TLX after ECC showed greater cognitive demand than CONC. ECC induced a greater decrease in MVC strength than CONC in the contralateral limb, while CONC induced greater decrease in EMG of BB (RMS/M-wave) than ECC. VA_PNS showed an increase after ECC while it tended to decrease after CONC. Pt M-wave remained unchanged after ECC while increased after CONC. 10:100 Hz doublet ratio remained unchanged after both conditions. VA_TMS was similar between ECC and CONC, while MEPs (MEP/M-wave) at 25% and 50% MVC showed a greater increase after ECC compared to CONC. CSP at 25% and 50% MVC increased more after CONC compared to ECC.
CONCLUSION: These results show that a single bout of eccentric and concentric resistance exercise with similar relative intensity, but different absolute load and cognitive demand can modulate different peripheral and central neuromuscular changes in the contralateral untrained limb. Despite of a greater contralateral acute decrease of MCV after ECC than CONC, the tentative conclusion is that high load eccentric contractions are more effective to increase acutely the contralateral corticospinal excitability in comparison to concentric contractions.

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### CP-PN11 Metabolism / Genomics

**EFFECTS OF ECCENTRIC AND CONCENTRIC CYCLING TRAINING ON PLASMA MARKERS OF CARDIOMETABOLIC RISK, OXIDATIVE STRESS AND INFLAMMATION OF COPD PATIENTS**

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INTRODUCTION: A common extra-pulmonary manifestation of chronic obstructive pulmonary disease (COPD) patients is the lower limb muscle dysfunction [1]. COPD patients typically show an increased systemic oxidative stress and inflammation, which can impact on skeletal muscle by increasing muscle proteolysis, worsening the muscle dysfunction [2]. The present study compared the effects of eccentric cycling (ECC) and conventional concentric cycling (CONC) training on plasma markers of cardiometabolic risk, oxidative stress and inflammation in patients with moderate COPD.

METHODS: Twenty patients with moderate COPD were randomly allocated to ECC (n=10) or CONC (n=10) group. They performed 12 weeks of ECC or CONC training. Before and after training peak oxygen consumption (V O2peak) and time-to-exhaustion (TTE) at 75% of maximal power output tests were assessed. Furthermore, plasma antioxidant (total antioxidant capacity; TAC, superoxide dismutase; SOD, catalase; CAT, glutathione peroxidase activity; GPx) and oxidative markers (thiobarbituric acid reactive substances; TBARS), insulin resistance (HOMA-IR), lipid profile (total cholesterol; TC, triglycerides; TAG, plasma high-density lipoprotein-cholesterol; HDL, low-density lipoprotein-cholesterol; LDL) and systemic inflammation (interleukin 6; IL-6, tumor necrosis factor α; TNF-α, interleukin 1 beta; IL-1β) markers were measured before and after training at rest, and before and following TTE.
RESULTS: VO2peak and TTE performance remained unchanged after ECC and CONC training. CONC induced a 137.9 ± 162.4% increase in TAC, while ECC decreased GPx 17.2± 20.8%) after training. CONC induced a -60.1 ± 205.3% lesser increase in TBARS following TTE (P=0.04). CONC induced a decrease in HOMA-IR (-30.8 ± 22.9%; P=0.0006) and a tendency to increase HDL (P=0.06).
CONCLUSION: These results suggest that CONC training induced an increase in antioxidant capacity at rest, and a lesser increase in oxidative stress markers following submaximal exercise. Furthermore, CONC reduced markers of cardiometabolic risk in moderate COPD patients. Thus, CONC seems to induced greater oxidative adaptations after training than ECC training.
References
1) Vant Hul, A., et al., Muscle Nerve, 2004.
2) Barreiro, E., et al., Thorax, 2008.

**MYOSIN HEAVY CHAIN DETERMINATION IN HUMAN SKELETAL MUSCLE: VARIABILITY ASSESSMENT OF WITHIN-DAY REPEATED MUSCLE BIOPSIES**

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INTRODUCTION: In human skeletal muscle (SM) fibers, the three prominent myosin heavy chain isoforms are MHCI, MHCIIA and MHCIIX, whose proportions determine its contractile properties, histochemical type and rate of ATP utilization. MHC isoform separation by sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) has been used extensively to study fiber type in humans, despite its inherent methodological challenges. Fiber type proportions present larger variability in humans than in smaller animals where, using histochemical techniques, variability has been found between repeated measurements from the same biopsy, as well as from one leg to the contralateral, and even the site and depth of the biopsied fibers from the same SM have an impact. However, no study has systematically investigated variability of fiber type composition using MHC-SDS-PAGE in the same SM, as well as in repeated biopsies from the same incision and compared it from one leg to the contralateral. Thus, the aim was to determine the variability of vastus lateralis intra- and inter-biopsy as well as between legs in human SM.
METHODS: SM biopsies from vastus lateralis were obtained (Bergstrom technique) from 65 volunteers, 52 males (age:22.7±2.9yo, weight:74±9kg, Fat%:18.3±5, VO2max:48.8±6.7 ml/kg/min) and 13 females (age:22.2±1.5yo, weight:59.2±11.6kg, Fat%:28.2±4.4; VO2max:39.9±3.5ml/kg/min). In 10 of the males, biopsies were taken from both legs at rest, and in two more occasions within 1h for a total of 6 biopsies per subject (3 from dominant, and 3 from non-dominant leg), from the same incision but varying needle inclination. MHC% was determined by SDS-PAGE. VO2max (IC) and body composition (DEXA) were assessed. Statistics: ANOVA, t-tests and CV (SD divided by mean, in %).
RESULTS: MHC% in the whole group was 42.1±14.8% for MHCI (range 16-71%), 45.1±11% (range 25-70%) for MHCIIA and 16.5±7.3% (range 5-40%) for MHCIIX. CV for duplicate measurements from the same biopsy (intra-biopsy) was 2.6 for MHCI, 2.0 for MHCIIA and 4.9% for MHCIIX. CV for the 3 biopsies from the same incision (inter-biopsy) was 14.9 for MHC-I, 16.2 for MHCIIA and 20.1% for MHCIIX. The proportion of MHCIIX was 3.3 (percentage units) lower in the dominant compared to the non-dominant leg (16.3% vs 13.3%; p=0.005) while MHC-I and IIX proportions were similar in both legs.
CONCLUSION: This study shows that MHC isoform proportions in repeated measurements from the same biopsy can be determined within the range of biological variability (6-8%) previously documented on fiber type assessment by histochemical techniques. Our data for biopsies from the same incision confirm those from histochemistry where variability inter-biopsy doubles intra-biopsy variability, achieving CVs up to 20%, confirming the importance of limb dominance randomization to avoid additional variation due to mechanical loading. Caution should be taken for interpretation of muscle fiber type data from repeated SM biopsies using histochemical and gel electrophoresis techniques.

**MYOFIBER HYPERTROPHY AND PROLIFERATIVE RESPONSES IN RAT SKELETAL MUSCLE INDUCED BY REPEATED COOLING STIMULATION**

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INTRODUCTION: Cooling to a cellular environment of approximately 5 degrees Celsius increases intracellular calcium ion concentrations and causes contraction in rat skeletal muscle. This cooling-induced response is characterized by reversibility and a shift toward higher temperatures due to caffeine loading. The purpose of this study was to test the hypothesis that repeated stimulation of cooling-induced muscle contraction and caffeine loading leads to a hypertrophic response in myofibers.
METHODS: Male adult Wistar rats, including those fed orally with caffeine, were subjected to repeated loads of percutaneous icing under anesthesia to reduce the muscle temperature below about 5 degrees Celsius. The tibialis anterior muscle, which consists mainly of fast twitch muscle fibers, and the soleus muscle, which consists mainly of slow twitch muscle fibers, were sampled after 28 days of two-day cycle intervention.
RESULTS: Myofiber cross-sectional area, a marker of muscle hypertrophy, was increased (1.15±0.04 times) by cooling stimulation in tibialis anterior muscle. In the soleus muscle, no change was observed in the cross-sectional area, but the number of myofibers was significantly increased (1.21±0.07 times) by cooling in rats fed orally with caffeine. The calcium ion concentration response to cooling stimuli was elicited at a significantly higher temperature range in the soleus muscle than in the tibialis anterior muscle, and this difference was enhanced under caffeine-loaded conditions.
CONCLUSION: Changes in intracellular calcium ion homeostasis during muscle contraction, such as resistance training and electrical stimulation, have been reported to be the main factor leading to skeletal muscle plasticity. The present study confirms the hypertrophic and

proliferative responses of myofibers to chronically repeated cooling-induced increases in intracellular calcium ion concentrations. The increase in fiber number observed in soleus muscle may be related to myofiber splitting and satellite cell-induced proliferative responses observed in parallel with muscle hypertrophy. The findings of this study are noteworthy as a novel model that contributes to the maintenance of morphological and functional skeletal muscle through muscle hypertrophy and proliferation induced by the intracellular cooling environment.

**SKELETAL MUSCLE HSP70 EXPRESSION IS NOT ASSOCIATED WITH GLYCOGEN AVAILABILITY DURING RECOVERY IN ELITE ENDURANCE ATHLETES.**

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INTRODUCTION: The 70-kDa heat shock protein (HSP70) is a ubiquitous molecular chaperone which is highly inducible by cellular stress such as exercise. HSP70 seems to be involved both in the acute cellular restoration following damaging exercise, and likely also in the long-term adaptations to training.
METHODS: To further understand the role of muscle glycogen content on the expression of HSP70, muscle glycogen was manipulated by consumption of either water (H2O) or a carbohydrate-enriched diet (CHO) during recovery from 4 hours of moderate-intensity glycogen-depleting cycling exercise in fourteen elite endurance athletes (VO2max: 66.2 ± 1.3 ml·kg-1·min-1). Muscle biopsies were obtained from m. vastus lateralis pre- and post-exercise, and after 4 and 24 hours of recovery, and analyzed for HSP70 mRNA expression, as well as HSP70 protein expression and muscle glycogen within the same skeletal muscle fibers using immunohistochemistry.
RESULTS: Exercise reduced muscle glycogen by 59 ± 10% ($P < 0.0001$). After 4hrs of recovery, glycogen approached resting levels in the CHO group (86% of pre, $P = 0.28$) but remained suppressed in the H2O group (41% of pre, $P < 0.001$) (group x time interaction: $P = 0.002$). The expression of HSP70 mRNA (+1.9 ± 0.9-fold, $P = 0.03$) and protein (+247 ± 99 % of pre, $P < 0.0001$) was substantially increased during exercise. During recovery, changes in the HSP70 mRNA and protein expressions followed the same pattern in the H2O and CHO group (group x time interactions: $P = 0.70$ and $P = 0.24$, respectively). After 4hrs of recovery, the HSP70 mRNA expression remained elevated in comparison to pre-exercise levels (H2O: 1.7 ± 0.8-fold, CHO: 1.4 ± 0.4-fold, $P = 0.004$). This was also the case with respect to the HSP70 protein expression which remained at post-levels at this time-point (H2O: 100 ± 23 % of post; CHO: 90 ± 16% of post, $P = 0.24$ in comparison to post). Importantly, the maintenance of the HSP70 protein expression in both groups was evident despite clear differences in muscle glycogen content and accordingly muscle glycogen content did not explain the variation in HSP70 expression at the 4-hour time-point ($r2=0.004$). After 24hrs of recovery, the HSP70 mRNA expression returned to pre-exercise levels (H2O: 0.96 ± 0.4-fold, CHO: 0.91 ± 0.4-fold, $P = 0.55$ in comparison to pre), which was also the case for the HSP70 protein expression (H2O: 136 ± 86% of pre; CHO: 108 ± 60% of pre, $P = 0.48$).
CONCLUSION: In conclusion, muscle HSP70 expression remained elevated during recovery from prolonged exercise in highly trained skeletal muscle, irrespective of glycogen availability.

**CHANGES IN SARCOLIPIN EXPRESSION DURING THE EARLY PHASE OF RESISTANCE TRAINING IN RAT SKELETAL MUSCLE**

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INTRODUCTION: Sarcolipin (SLN) is an important protein in skeletal muscle metabolism and thermogenesis; increased SLN is considered to increase energy expenditure and prevent obesity (1). Previous studies have shown that the expression of SLN in skeletal muscle is increased by chronic resistance training and functional overload, but the changes in SLN expression during the early phase of resistance training remain unclear. Therefore, in the present study, we aimed to determine the changes in SLN expression and expressions of related factors in response to repeated resistance exercise bouts.
METHODS: Male Sprague Dawley rats (n=6 / group) were subjected to resistance exercise elicited by transcutaneous electrical stimulation. Under isoflurane anesthesia, the ankle joint was fixed at 90° and maximal isometric contraction of the gastrocnemius muscle was evoked (the condition of electrical stimulation was set to 100 Hz, 10-30 V). 10 bouts(B) of the exercise were performed on the right gastrocnemius muscle every 48 h. Each bout consisted of 5 sets of 3 s isometric muscle contraction and 7 s rest periods for 10 repetitions with 3 min rest between sets. Gastrocnemius muscle samples were taken 3 hours after the last bout. The left gastrocnemius muscle was served as an internal control. The expression levels of SLN, $Ca^{2+}$/calmodulin-dependent protein kinase II (CaMKII), and Calcineurin (CaN) were measured in each muscle using the western blot analysis.
RESULTS: SLN expression was significantly higher in the exercise leg at 5 B ($P<0.001$) and 10 B ($P<0.001$) compared to the non-exercise control leg. SLN was also significantly higher in the exercise leg at 5 B ($P<0.001$) and 10 B ($P<0.001$) than that in the exercise leg at 1 B. However, there was no significant difference in SLN between the exercise legs at 5 B and that at 10 B. Phosphorylated-CaMKII/Total-CaMKII showed no interaction and no main effect of exercise, although there was a significant positive main effect of time(bout). There was no interaction in CaN expression, but a significant positive main effect of exercise and time(bout) were observed.
CONCLUSION: The expression of SLN in gastrocnemius muscle increased in an exercise bout-dependent manner during the initial phase of the resistance exercise training, reached a plateau at 5B, and did not increase further. And the results indicated that the phosphorylation of CaMKII and the expression of CaN were elevated concomitant with the increase of SLN.

**MODELLING HIGH INTENSITY EXERCISE IN VITRO – THE EFFECT OF PH ON SKELETAL MUSCLE MITOCHONDRIAL BIOENERGETICS**

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INTRODUCTION: With increasing exercise intensity, fuel preference shifts from lipids to carbohydrates. Many factors have been proposed to contribute to this response, including a reduction in intramuscular pH, which has been shown to attenuate carnitine palmitoyltransferase-I (CPT-I) activity and limit lipid oxidation. However, it remains unknown if reductions in pH specifically attenuate lipid metabolism, or if aerobic metabolism is generally affected. Therefore, we aimed to model resting and high intensity exercise conditions in skeletal muscle (pH 7.2 vs 6.8) to examine how pH influences carbohydrate-, lipid-, ADP- and lactate-supported mitochondrial bioenergetics.
METHODS: Mitochondria were isolated from resting hindlimb skeletal muscles from wild type C57Bl/6N female mice. Mitochondrial respiration was performed (Oroboros) in buffers at pH 7.2 or 6.8. Substrates were titrated individually (lipids (palmitoyl-CoA (P-CoA), palmitoyl-

carnitine (PC)), l-carnitine (LC), carbohydrate-linked (pyruvate, succinate, glutamate), ADP and lactate), or in combination. Data was analyzed using a paired Student's t-test and expressed as mean±SEM.
RESULTS: Leak respiration and indices of coupling (ADP/O ratio, OXPHOS inhibition with oligomycin) were not influenced by pH. However, maximal complex I- and II-supported respiration was lower at pH 6.8, reducing respiratory control ratios. While PC-supported respiration was unaffected by pH, there was a trend for a reduction in submaximal P-CoA-supported respiration at pH 6.8 (p=0.10) suggesting the effect of pH is CPT-I specific. Further supporting this notion, submaximal respiration with LC was attenuated, and the ability of M-CoA to inhibit P-CoA-supported respiration was enhanced across a range of M-CoA concentrations (1-20 µM). This attenuating effect at pH 6.8 was not limited to lipids, as respiration with carbohydrate-linked substrates was also reduced (primarily at maximal ranges) by ~25-50%. ADP-supported respiration was pH independent, however, a strong trend (p=0.057) for a reduction in maximal respiration when ADP, succinate and pyruvate were titrated in combination was observed. Considering the mass-action dependence of the near-equilibrium lactate dehydrogenase (LDH) reaction on proton concentration, the role of pH in regulating lactate-supported respiration was also investigated. In the absence of LDH, lactate failed to drive respiration, however, in the presence of exogenous LDH, submaximal and maximal lactate-supported respiration was reduced at pH 6.8.
CONCLUSION: These data suggest that while a reduction in pH may contribute to attenuating CPT-I-dependent lipid metabolism with increasing exercise intensity, pH alone cannot explain fuel shifts considering pH also attenuated respiration with carbohydrate-linked substrates and lactate.

### FAT MASS PARAMETERS AND SERUM METABOLOMIC ADAPTATIONS FOLLOWING HIIT AND MICT IN OBESE OLDER ADULTS.

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INTRODUCTION: Nowadays, the health benefits of physical activity became widely recognized. Older adults are increasingly aware of the beneficial effects provided by aerobic training to maintain the health. The aim of this study is to evaluate the serum metabolomic adaptations correlated to fat mass parameters following High-Intensity Interval Training (HIIT) and Moderate-Intensity Continuous Training (MICT) in obese older adults.
METHODS: 71 obese sedentary elderly men and women completed 12-week HIIT training program or a 12-week MICT training program. Fat mass parameters and serum metabolomic profile (using 4 mass spectrometers) were assessed pre- and post-intervention.
RESULTS: Significant changes of different metabolites were identified following both training modalities. Following HIIT, we observed significant correlations ($p<0.01$) between aspartic acid change and several absolute fat parameters changes (android, gynoid and total fat mass) as well as relative fat mass parameters changes (gynoid and total fat mass). Following MICT, margaric acid change was significantly correlated ($p<0.01$) to the relative total fat mass change.
CONCLUSION: Aspartic acid and margaric acid could be possible useful biomarkers of HIIT and MICT adaptations respectively in geriatric and obese population when fat mass is considered. Further studies are needed to confirm these findings and to understand whether the mechanisms of these adaptations are specific to aerobic training or also influenced by age or obesity status.

### ASSOCIATION BETWEEN CKM RS8111989 POLYMORPHISM AND MUSCLE DAMAGE AFTER MAXIMAL ECCENTRIC EXERCISE

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INTRODUCTION: Muscle damage due to maximal eccentric exercise can result in reduced muscle strength and range of motions (ROM), muscle soreness, and an increased blood creatine kinase (CK) level (1). However, individual differences in these muscle damage indicators, particularly remarkable in CK level, exist and may also be associated with genetic variants (2). Therefore, this present study investigated the association between the individual difference in muscle damage after eccentric exercise and polymorphism of CKM rs8111989, which encodes for skeletal muscle-derived CK.
METHODS: A total of 45 participants, including 29 men (age: 22.5 ± 2.2 years, height: 170.9 ± 6.0 cm, body mass: 67.6 ± 12.4 kg) and 16 women (age: 23.1 ± 1.6 years, height 160.5 ± 4.8 cm, body mass: 57.8 ± 6.5 kg), who had not participated in the daily strenuous exercise of biceps were enrolled in the study. Participants performed five sets of six maximal eccentric elbow flexion exercises. Maximum voluntary contraction (MVC), ROM, muscle soreness, and blood sampling were assessed immediately before and after, as well as 1, 2, 3, and 5 days after eccentric exercise. CKM rs8111989 polymorphism was genotyped using the Taqman approach.
RESULTS: Significant interaction of changes in MVC and CK among CKM genotype groups (AA vs. GA + GG, MVC: $p = 0.015$, CK: $p = 0.009$) were observed. Compared to AA homozygotes, G-allele carriers showed significant reduction in MVC between pre-exercise values (100%)and at 1 day (55.0% vs. 66.9%), 2 days (58.0% vs. 74.8%), and 5 days (64.8% vs. 80.4%) after exercise. Moreover, compared to AA homozygotes, G-allele carriers showed significant differences in CK levels between pre-exercise values and at 3 days (6813.7 U/L vs. 2155.7 U/L) and 5 days (9212.6 U/L vs. 2812.1 U/L) after exercise ($p < 0.05$). However, ROM and muscle soreness were not associated with CKM rs8111989 polymorphism.
CONCLUSION: Our study suggested that CKM rs8111989 polymorphism was associated with muscle dysfunction and CK after maximal eccentric exercise.
(1) Chen, T. C., Huang, G. L., Hsieh, C. C., Tseng, K. W., Tseng, W. C., Chou, T. Y. and Nosaka, K. (2020) Comparison among three different intensities of eccentric contractions of the elbow flexors resulting in the same strength loss at one day post-exercise for changes in indirect muscle damage markers.Eur J Appl Physiol, 120 (1): 267-279.
(2) Yamin, C., Duarte, J. A., Oliveira, J. M., Amir, O., Sagiv, M., Eynon, N., Sagiv, M. and Amir, R. E. (2008) IL6 (-174) and TNFA (-308) promoter polymorphisms are associated with systemic creatine kinase response to eccentric exercise.Eur J Appl Physiol, 104 (3): 579-586.

**ASSOCIATION OF THE GALNTL6 GENE RS558129 POLYMORPHISM WITH STRENGTH AND POWER OUTPUT PERFORMANCE IN ATHLETES**

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INTRODUCTION: A rs558129 polymorphism of the N-acetylgalactosaminyltransferase-like 6 (GALNTL6) gene has been reportedly associated with sports performance. Previous studies have suggested that the GALNTL6 rs558129 polymorphism exhibits high-endurance performance in the C allele[1)] and high-power performance in the T allele[2)3)]. However, replication studies are required owing to the lack of studies. This study was aimed to determine the association of the rs558129 polymorphism of the GALNTL6 with power performance in an anaerobic test (Study 1) and isokinetic knee extension and flexion muscle strength tests (Study 2) in Japanese athletes.
METHODS: In Study 1, 112 athletes (67 men and 45 women) were participated. Subjects performed a 30s Wingate anaerobic test to assess the relative (per body mass) mean power and peak power. In Study 2, a total of 347 athletes, 213 men athletes as cohort 1 and 134 athletes (85 men and 49 women) as cohort 2, were participated. Subjects performed isokinetic knee extension and flexion muscle strength tests. For measurements, the angular velocity was set at 60 °/ s and the repetitions were conducted for three times in each participant. The value of the maximum strength was divided by the weight of each participant. Total DNA was extracted from saliva samples using an Oragene-DNA kit, and the rs558129 C/T polymorphism of the GALNTL6 was analyzed by using the TaqMan SNP Genotyping Assay. The 30s Wingate anaerobic test was analyzed via one-way ANOVA. Meta-analysis of strength in the two cohorts were conducted using the Review Manager.
RESULTS: Study 1 revealed that the relative peak power was significantly higher for the CT + TT genotype compared to the CC genotype (10.00 ± 1.93 W/kg vs. 10.88 ± 1.87 W/kg, respectively, p = 0.009). In addition, the CT + TT genotype had a significantly higher relative mean power than the CC genotype (7.58 ± 1.37 W/kg vs. 8.26 ± 1.50 W/kg, respectively, p = 0.012). The meta-analysis of Study 2 revealed that the relative isokinetic knee extension muscle strength was higher in the CT + TT genotype than in the CC genotype (p = 0.008). However, there were no significant differences in the relative isokinetic knee flexion muscle strength.
CONCLUSION: Our results suggested that GALNTL6 gene polymorphism is associated with strength and power output performance in Japanese athletes.
1) Rankinen T et al., No Evidence of a Common DNA Variant Profile Specific to World Class Endurance Athletes. PLoS One. 2016.
2) Díaz Ramírez J et al., The GALNTL6 Gene rs558129 Polymorphism is Associated with Power Performance. J Strength Cond Res. 2020.
3) Zmijewski P et al., GALNTL6 rs558129: A Novel Polymorphism for Swimming Performance? J Hum Kinet. 2021.

**GENETICS OF (INTER)NATIONAL COMPETING RUNNERS AND CYCLISTS - A SYSTEMATIC REVIEW WITH META-ANALYSIS**

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INTRODUCTION: Aim of this systematic review and meta-analysis was to identify the genetic variants of (inter)national competing runners and cyclists compared to controls.
METHODS: The Medline and Embase databases were searched until 15 November 2021. Eligible articles included genetic epidemiological studies published in English. Runners and cyclists competing at (inter)national level and sedentary controls were eligible for inclusion. Pooled odds ratios based on genotype frequency with corresponding 95% confidence intervals (95%CI) were calculated using random effects models. Heterogeneity was addressed by Q-statistics and I2. Sources of heterogeneity were examined by meta-regression and risk of bias was assessed with the Clark Baudouin scale.
RESULTS: This systematic review comprised of 43 studies including a total of 3815 athletes and 10630 controls in the pooled analysis. Of the 43 identified genetic variants, 13 were replicated in independent studies. Significant associations were found for five polymorphisms. Pooled odds ratio [95%CI] favoring athletes compared to controls was 1.51 [1.22-1.88] for ACE (rs1799752), 1.66 [1.26-2.19] for ACTN3 (rs1815739), 1.75 [1.34-2.29] for PPARGC1A (rs8192678), 2.23 [1.42-3.51] for AMPD1 (rs17602729), and 2.85 [1.27; 6.39] for HFE (rs1799945). Risk of bias was low in 25 (58%) and unclear in 18 (42%) articles. Heterogeneity of the pooled results was low (0-19.1%) except for HFE (71%), GNB3 (80.1%) and NOS3 (76%).
CONCLUSION: (Inter)national competing runners and cyclists have a higher probability to carry specific genetic variants compared to controls.

## Conventional Print Poster

### CP-AP11 Sport technology

**MECHANICAL EXTERNAL WORK OF A FOOTBALL SEASON COMPUTED BY GPS**

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INTRODUCTION: The (positive) mechanical external work (Wext) is the work performed by the muscle-tendon unit to accelerate and lift the body center of mass (Peyré-Tartaruga et al. 2021). It has historically been investigated in steady locomotion, where it was able to explain most of the absolute metabolic cost and its variations (Peyré-Tartaruga et al. 2021). In recent years the mechanical approach has been applied also to unsteady locomotion (e.g. shuttle and sprint running) typical of team sports (Zamparo et al. 2019; Pavei et al. 2019) albeit still using optoelectronic systems, which is a standard for computation, but an unfeasible approach during team sports training or competitions.
METHODS: We used a GPS-tracking system to calculate the mechanical external work performed by various players during official football matches. According to Pavei et al. (2019), positive mechanical work was calculated as the sum of the work to accelerate forward, which can be derived by the velocity profile obtained by the GPS, the speed fluctuations and lift at each support. The players of a football club of the

Italian second division (Serie B) where monitored during the whole football season 2020-2021 (42 games) with a GPS-tracking system (gpexe pro2, sampling at 18.18 Hz). Only players that completed the whole match (90 minutes), goalkeeper excluded, were analysed.
RESULTS: A total of 203 tracks from 20 players were analysed. The positive mechanical work range over the whole 90 minutes was 7.9–15.7 KJ/kg with an average value of 10.8 KJ/kg (1.3 KJ/kg, SD). When expressed as mechanical power (in relation to the whole match time) 1.9 W/kg (0.2 W/kg, SD). The positive mechanical work was different among roles, with center back 9.7 KJ/kg (1.0 KJ/kg, SD), wide back 10.9 KJ/kg (0.7 KJ/kg, SD), midfielder 12.3 KJ/kg (0.9 KJ/kg, SD) and attacker 11.3 KJ/kg (0.7 KJ/kg, SD).
CONCLUSION: We showed for the first time the feasibility to calculate mechanical external work in a competition setting with a GPS-tracking system. The mechanical external work performed by the players reflects the muscle-tendon work that needs to be done in order to move the body. Hence, it accounts for accelerative and constant speed movements and could be a useful metric to monitor the work done by the (muscle-tendon unit of the) players, not just during the match but also during training. Although also the mechanical internal work has been shown to have an impact on the total mechanical work performed by the muscle-tendon unit in both shuttle and sprint running (Zamparo et al. 2019; Pavei et al. 2019), its computation is still challenging for the nowadays tracking systems, and only a fusion with video analysis or multiple magneto inertial measurement units could overcome those intrinsic limitations.
References
Pavei et al. (2019) Scand J Med Sci Sports, 29:1892-1900.
Peyré-Tartaruga et al. (2021) Exp Physiol, 106:1897-1908.
Zamparo et al. (2019) Hum Mov Sci, 13:487-496.

### HEART RHYTHM ASSESSMENT IN ELITE ENDURANCE ATHLETES: A NEW METHOD?

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INTRODUCTION: Cardiac arrhythmias (CA), especially atrial fibrillation (AF), are relatively common among elite endurance athletes. Conventional diagnostic tools for assessment of rhythm disorders suffer from limited availability, limited test duration time, and usability challenges, particularly during the demanding conditions of an elite athlete training many hours each day. In endurance athletes, there is a need for out-of-hospital monitoring and detection of arrhythmias under conditions that are relevant and potentially provocative. The Norwegian patch ECG247 Smart Heart Sensor has been developed to simplify the assessment of heart rhythm disorders. The current study aimed to evaluate the ECG247 Smart Heart Sensor function and practicalities in an elite athlete environment.
METHODS: A total of 13 professional cyclists at the UNO-X Pro Cycling Team were examined continuously with the ECG247 Smart Heart Sensor during a 14-day training camp in Spain, December 2021. All ECG data were automatically analysed by the ECG247 physicians at Sorlandet Hospital Arendal, Norway. Athletes completed a brief questionnaire registering their training (from on-bike monitoring units) and self-assessment of usability parameters after the test.
RESULTS: In 8 of 13 athletes (69% male, age 23+-4 years), two test periods were performed, resulting in a total of 21 long-term tests with continuous ECG monitoring. Average athlete ECG test duration was 144+-47 hours (89+-24hours/test). The athletes had an average of 15+-5 training hours during each test. The ECG quality from all tests was considered satisfactory for rhythm analysis – also during exercise. The reported usability of the ECG247 Smart Heart Sensor was high, and no athletes reported trouble sleeping or training with the sensor attached. The automatic arrhythmia algorithm reported of possible arrhythmia events in 13 (62%) tests; 9 atrial flutter and 4 supratventricular tachycardia. Retrospective thorough manual assessment by physicians revealed normal sinus rhythm in all tests.
CONCLUSION: The ECG247 Smart Heart Sensor allowed for high quality ECG monitoring during intensive exercise in athletes. The integrated arrhythmia analysing algorithm might be better adapted for this user group.

### ANALYZING MOTION CHARACTERISTICS AND METABOLIC POWER OF ELITE MALE HANDBALL PLAYERS

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INTRODUCTION: In complex team sports like handball, analysis of player load (PL) during competition is a challenging task. However, correctly assessing load and physiological requirements underlying successful game performance is critical for efficient training regimes, optimizing performance, and preventing injuries. Recent work analyzed PL using position data of official team handball matches using time on court and distances covered in different velocity zones (1). However, these measures give little insight intro PL because of players frequent accelerations and decelerations. In contrast, estimating Metabolic Power (MP; 2) allows to capture the energy expenditure over time, including the cost of accelerations and decelerations. The present study therefore analyzed PL in elite male handball players using distance covered and MP.
METHODS: Data from 290 male field players of 18 teams during 77 games of the 2019/20 German Men's Handball Bundesliga were analyzed. Position data was collected using a local positioning system at 20 Hz. For every player, total distance, and equivalent distance were calculated. Differences between distance covered and equivalent distance was analyzed with a 2 (distance vs. equivalent distance) by 3 (wings vs. backs vs. pivots) mixed-effects ANOVA. Statistical significance was set at $\alpha = 0.05$.
RESULTS: Statistical analysis for distance covered and equivalent distance revealed statistically significant group by distance interaction effects ($p < .01$). Post-hoc analysis showed a significant group effect between wings vs. backs ($p < .01$; $d = 0.92$), wings vs. pivots ($p < .01$; $d = .92$), but no group effect between backs vs. pivots. Repeated measure effects between distance and equivalent distance were significant for wings ($p < .01$; $d = 0.32$), backs ($p < .01$; $d = 0.25$), and pivots ($p < .01$; $d = 0.23$). Interaction effect for groups and (equivalent) distance were significant for wings vs. backs ($p < .01$; $d = 0.73$), wings vs. pivots ($p < .01$; $d = 0.86$), and backs vs. pivots ($p < .01$; $d = 0.22$), meaning that differences between distance and equivalent distance were greater for wings than for backs and pivots.
CONCLUSION: This is the first study that applied MP to handball. Our results indicate that distance covered underestimates player load of wings because their movement is characterized by frequent high intensity accelerations. Thus, standard approaches relying solely on distance covered are not sufficient to assess PL in handball. The MP concept seems to be a valuable approach to obtain more precise information about PL from position data in handball. Still, the effect of static efforts, e.g. from the pivot fighting for position, on internal PL remains unclear and warrants further investigation.
REFERENCES:
1) Manchado, C, et al. Time-motion analysis during European Championship 2020. Int. J. Environ. Res. Public. Health. 2021, 18, 2787.
2) di Prampero, P & Osgnach, C. Metabolic power in team sports. Int. J. Sports Med. 2018, 39(8), 581-587.

## DISCRIMINATIVE VALIDITY OF A LOWER EXTREMITY INERTIAL SENSOR SETUP TO QUANTIFY BIOMECHANICAL LOAD DURING A STANDARDIZED SOCCER TRAINING DRILL

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INTRODUCTION: Training load quantification could support planning future training and thereby improve player performance. However, current monitoring systems do not monitor lower extremity biomechanical load and thus important information might be neglected. This explorative study assessed the discriminative validity of a new inertial sensor setup [1] to quantify lower extremity biomechanical load during a standardized soccer training drill.
METHODS: National (n = 11) and regional (n = 16) soccer players performed a standardized soccer training drill [2]. Participants wore inertial sensors at the lower extremities. Cumulative joint angular accelerations were used to quantify lower extremity biomechanical load indicators Hip and Knee Load. Additionally, Playerload, high intensity running distance (>15.00 km/h, HIRD), acceleration (>2.78 m/s2, HIAD) and deceleration distance (<2.78 m/s2, HIDD) were used to quantify training load [3]. Between group training load differences were compared using MANOVA tests with Cohen's D effect sizes.
RESULTS: National players had higher Knee Load (984 ± 122 vs. 900 ± 88, ES = 0.82, CI = -0.02 – 1.66, p=0.047), HIRD (83.2 m ± 12.9 vs. 66.4 ± 18.6 m, ES = 1.01, CI = 0.15 – 1.87, p=0.02), HIAD (9.1 m ± 1.3 vs. 6.0 ± 2.3 m, ES = 1.56, CI = 0.64 – 2.48, p<0.001), and HIDD (8.44 ± 2.8 m vs. 3.3 ± 2.6 m, ES = 1.93, CI = 0.95 – 2.9, p<0.001) compared to the regional players. No differences for Hip Load were observed (474 ± 86 vs. 450 ± 69, ES = 0.32, CI = -0.49 -1.13, p = 0.42).
CONCLUSION: Training load and Knee Load differences were observed, but discriminative validity of Hip Load could not be confirmed. Proximal-to-distal sequencing and limited number of passes during the training drill might explain the lack of difference in Hip Load. Future research should examine these differences further in formats with more passing opportunities such as small sided games [4].
REFERENCES:
1. Wilmes, E., et al., Inertial Sensor-Based Motion Tracking in Football with Movement Intensity Quantification. Sensors (Basel), 2020. 20(9).
2. Kelly, D.M., et al., The development of a soccer-specific training drill for elite-level players. J Strength Cond Res, 2013. 27(4): p. 938-43.
3. Bastiaansen, B.J.C., et al., Biomechanical Load Quantification Using a Lower Extremity Inertial Sensor Setup During Football Specific Activities. Sports Biomechanics, 2022: p. 1-16.
4. Dellal, A., et al., Small-sided games in soccer: amateur vs. professional players physiological responses, physical, and technical activities. J Strength Cond Res, 2011. 25(9): p. 2371-81.

## A 12-WEEK CONSUMER WEARABLE ACTIVITY TRACKER-BASED INTERVENTION REDUCES SEDENTARY BEHAVIOUR AND IMPROVES CARDIOMETABOLIC HEALTH IN FREE-LIVING SEDENTARY ADULTS: A RANDOMISED CONTROLLED TRIAL

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INTRODUCTION: Reducing sedentary behaviour significantly improves cardiometabolic health and plays an important role in the prevention and management of CMDs. However, no specific effective strategies have been proposed to combat the negative effects of sedentary lifestyles. Therefore, we aim is to investigate the efficacy of a single component CWAT-only intervention and the added value of a multicomponent (CWATs + motivational interviewing) behaviour change intervention to reduce sedentary behaviour and increase physical activity within sedentary adults.
METHODS: In a three-armed randomised controlled trial, 59 (male/female: 21/38) sedentary adults were randomly allocated to a control group, a CWAT-only group or the CWAT+ group (CWAT + motivational interviewing) for 12 weeks. Physical activity (PA) and SB were assessed using the activPAL3™ accelerometer. In addition, anthropometrics, blood pressure, plasma lipids and insulin sensitivity using an oral glucose tolerance test were assessed at baseline and after the 12-week intervention period.
RESULTS: As compared with the control group, the CWAT+ group significantly reduced time spent in sedentary behaviour (-81 min/day CI[95%]: [-151, -12] min/day) and significantly increased step count (+3117 [827, 5406] steps/day), standing time (+62 [14, 110] min/day), light intensity PA (+28 [5, 50] min/day) and moderate-to-vigorous PA (+22 [4, 40] min/day). Body fat mass (-1.67 [-3.21, -0.14] kg), percentage body fat (-1.5 [-2.9, -0.1] %), triglyceride concentration (-0.31 [-0.62, -0.01] mmol/l), the 2h insulin concentration (-181 [-409, -46] pmol/l), QUICKI (-0.022 [-0.043, -0.008]) and tAUC (-6464 [-26837, -2735] mmol/l*min) were significantly reduced in the CWAT+ group, compared to the control group.
CONCLUSION: A 12-week multicomponent CWAT-based intervention (CWAT + motivational interviewing) reduces sedentary time, increases physical activity levels and improves various cardiometabolic health variables in sedentary adults, whereas self-monitoring on itself (CWAT-only group) has no beneficial effects on sedentary time.

## HEART RATE RESPONSES TO JUMPING LOAD DURING VOLLEYBALL WARM-UP AND COMPETITION

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INTRODUCTION: Heart rate monitoring is a popular tool for quantifying internal load. In combination with monitoring external load on the athlete, the overall workload can be described in detail. In many sports and activities, there is still a challenge in determining the internal-external load relation. The activity during volleyball is characterized by explosive multidirectional movements, such as sprints, dives, and mostly jumps. The relationship between jumping load and HR is especially interesting because the accelerations are short, high intensity pulses, while the heart rate changes more gradually. This research investigates whether jumping acceleration is significantly correlated with heart rate during warm-up and competition gameplay.
METHODS: Eight male volleyball players participated in this study. They were monitored during 4 to 10 competition matches, resulting in 63 measurements. A Zephyr BioHarness 3.0 (Medtronic, Boulder, CO) was used to record 3D accelerometer data and heart rate at 1Hz. Furthermore, video recordings were used to select 40 volleyball spikes and 40 serves during the warm-up as well as the actual match to study individual jumping actions. This way, a total of 160 jumps were studied. Each event was selected based on the fact that it was performed in isolation from other actions within a time window of 30 seconds. Pearson correlation testing was performed between peak acceleration and peak heart rate of each jump.

RESULTS: The jumping actions performed during the warm-up showed a correlation coefficient (rho) of 0,49 (p > 0.001) and 0,62 (p > 0.001) for spiking and serving respectively. These results suggest that the variation in the heart rate during warm-up jumps can be (partially) explained by overall acceleration. Furthermore, the actions performed during competition resulted in a correlation coefficient (rho) of 0,12 (p = 0,45) and 0,21 (p = 0,20) for spiking and serving respectively. This indicates that in the case of actual gameplay, the correlation between internal and external load becomes insignificant although the events are still performed in isolation.
CONCLUSION: Our results are interesting to the ECSS community because they show how activity characterized by jumps can be related to the internal load of the volleyball athlete. The observed differences between warm-up and competition might be due to factors such as stress or fatigue. A more detailed of the workload throughout the match might provide better insights. Furthermore, given the highly variable nature of volleyball gameplay, other methods for quantifying this relationship might have to be considered. For instance, explicitly capturing second-by-second changes and dynamics with time-series analysis seems a suitable alternative.

**AIR QUALITY MONITORING DURING THE SCIENTIFIC TRAIL OF CLECY 2021**

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INTRODUCTION: The Scientific Trail of Clecy was an exploratory study on a trail of 156km and 6000m of elevation gain (D+), between 20 and 46 hours of running, divided into 6 identical laps of 26km each. Some publications have shown that the combined effect of air pollution and exercise could be associated with an increased potential risk on health problems and a reduced performance [1]. But these measures have never been done to our knowledge on ultra-trails.
During this ultra-distance race, we measured different pollutants in order to increase knowledge on the relationship between physical activity and air quality.
METHODS: Fifty-five subjects (43 men and 12 women between 25 and 70 years old, experienced in ultra-trail running events and with no contraindications to the practice of this sport) were included to participate in a trail race. 41 finished the race. To measure the air quality, we set up 2 sensors (Air Quality Transmitter AQT530, Vaisala, Finland) along the route at 1.70m height. These sensors measured gases (nitrogen dioxide (NO2), nitrogen monoxide (NO), carbon monoxide (CO), ozone (O3) as well as particulate matter (PM), fine particles with a diameter < 1µm (PM1), 2.5µm (PM2.5) and 10µm (PM10) and environmental parameters such as temperature (°C), humidity (%RH) and atmospheric pressure (hPa).
RESULTS: The World Health Organization (WHO) provides a recommended reference threshold over 24 hours of 15 µg.m-3, 45 µg.m-3 and 25 µg.m-3 for PM2.5, PM10 and NO2 respectively [2].
For the moment, there is no recommended reference threshold for PM1 because sensors that measure this type of particles are still rare. For all the gases, the concentrations were clearly lower than these thresholds with a maximum average concentration over a period of 24 hours less than 1 µg.m-3.
We obtained maximum average concentration over a period of 24 hours of 3.38 ± 0.33 µg.m-3 for PM1, 8.28 ± 1.48 µg.m-3 for PM2.5 and 12.20 ± 2.15 µg.m-3 for PM10.
The cumulative periods of time above the reference thresholds were 290 minutes and 60 minutes for PM2.5 and PM10 respectively throughout the race.
CONCLUSION: This study demonstrated the possibility to use a network of mobile and compact air quality sensors during a sporting event. Despite a very rural environment, we obtained peak PM values above the reference thresholds defined by the WHO but for a short period of time.
As a perspective we will cross our air quality data with the performance and physiological data of the runners collected during the event.
REFERENCES:
1. Rundell, K. W., & Caviston, R. (2008). Ultrafine and Fine Particulate Matter Inhalation Decreases Exercise Performance in Healthy Subjects. Journal of Strength and Conditioning Research, 22(1), 2-5.
2. World health organization (2021). WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization.

**MODELLING TEAM PERFORMANCE IN ELITE WOMEN'S BASKETBALL THROUGH PRINCIPAL COMPONENT ANALYSIS AND GENERALIZED MIXED MODEL**

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INTRODUCTION: Multicollinearity and confounding bias were two difficulties that plagued researchers in interpreting key performance indicators and predicting basketball team success through performance regression analysis. Multicollinearity leads to high variance estimators of regression coefficients. Confounding bias, especially the team's performance style misleads the causal inference and the estimation of indicator effects. Therefore, the aim of this study was to remove the multicollinearity of the game-related data and identify the key performance indicators that really affect the match outcomes of elite women's basketball.
METHODS: 244 matches were collected from 2010 - 2020 world womens basketball top-level competitions. 1) use principal component analysis (PCA) for reducing the multicollinearity of team game-related statistics in and cluster team's performance styles based on principal components (PCs). 2)compare the impact of a teams own style with that of the opposing team on the match outcome and identify the relationships between PCs and match outcome by using a generalized linear model (GLM) as a baseline model and three generalized mixed linear models (GLMMs) consider different random factors (GLMM1, team's own style; GLMM2, opposing team's style; GLMM3 both teams own and opposing team's styles) as candidate models.
RESULTS: Seven PCs were selected from twenty original game-related variables and five team performance styles were identified according to PCs. The model comparison showed that the opposing teams style has a much greater impact on the outcome of the game than the team's own style. Two-point made, two-point made, and free throw rate had significant effects on the match outcome for all GLM and GLMM analyses while free throw percentage and steals had no significant effect. In terms of defensive rebounds and turnovers, the results of the GLM and GLMM analyses differed. For the GLM and the GLMM considering the teams own style, defensive rebounds had a significant effect on the match outcome, while turnovers had no significant effect. However, for the GLMMs considering the opponents style and both the teams own and opposing team's styles, the effects of defensive rebounds and turnovers on the match outcome were reversed.

CONCLUSION: PCA can effectively reduce the multicollinearity in regression models of team performance analysis in elite womens basketball. GLMM analysis is more powerful to identify the key PCs for teams' success than GLM. When considering the performance styles of the opposing team, turnovers may be a more important indicator than defensive rebounds for the match outcome. Incorporating (instead of ignoring) the styles of team performance on both team sides especially the opposing team's style in the model could improve our ability to describe how technical performance components relate to outcomes and allow sports scientists and coaches to get a better understanding of the success of women's basketball matches.

**RELIABILITY OF DXA FOR THE MEASUREMENT OF TOTAL AND REGIONAL BODY COMPOSITION IN ELITE SOCCER PLAYERS**

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INTRODUCTION: Dual-energy X-ray absorptiometry (DXA) is widely used for the assessment of total and regional body composition. Acquisition of the data can be done automatically with the in-built software however the software may under/overestimate regional parameters (i.e. legs). As such, the data may also be acquired by operator manual adjustment of the regions-of-interest (ROI) but the experience of the operator may influence the accuracy and reliability. In elite football monitoring leg muscle mass is relevant therefore operator adjustment may be required. The aim of this study was to examine the reliability of total and regional body composition when comparing automatic and manual ROI assessment performed by operators with different experience levels.
METHODS: Twenty-four elite soccer players (age 18 ± 1 yrs; height 179 ± 5 cm; body mass 72 ± 5 kg) from an Italian Serie-A team participated in a test-retest study. Tests were performed with Lunar iDXA (GE Healthcare Lunar, Madison, USA) and examined with in-built software (enCORE 17, GE Medical Systems Ultrasound & Primary Care Diagnostics, USA) on two different days. Total body fat mass (FM) and free fat mass (FFM) were examined as total body composition, and free fat mass of right and left legs (FFMR and FFML) were examined as regional body composition parameters. ROI were determined automatically (AROI) and by two operators with low and high experience (Low1 and High1). After two weeks, the operators were asked to do the analysis again (Low2 and High2) on the same images. Reliability was examined as Typical Error of Measurement (expressed as percentage, TEM) and Intraclass Correlation Coefficient (ICC).
RESULTS: The values were within the range 9.7-10.2 kg for FM, 58.8-59.5 kg for FFM, 10.3-12.8 kg for FFMR and 10.2-12.7 kg for FFML. The TEMs were within the range 2.0-2.4% for FM and 0.8-0.9% for FFM for all the assessment. The TEMs for FFMR were 1.4, 4.1, 1.2, 1.6, 1.3 % for AROI, Low1, High1, Low2 and High2 respectively. The TEMs for FFML were 2.0, 3.9, 1.1, 1.3, 1.1 % for AROI, Low1, High1, Low2 and High2 respectively. Low1 showed higher values of TEM for FFMR and FFML. The ICC were within the range 0.99-1.00 for FM, 0.82-0.98 for FFMR, 0.83-0.98 for FFML and 0.99 for FFM.
CONCLUSION: The reliability of total and regional body parameters found in the present group of elite soccer players was similar to the values reported in the literature (1, 2). No significant difference was found between reliability parameters in FM, FFM however the lowest reliability found in Low1 in FFMR and FFML suggested the low experience of the operator have influenced the DXA results in his first assessment. Even if operators are familiarized with ROI customization they need experience to provide reliable outcomes.

## Conventional Print Poster

### CP-BM04 Upper extremity

**COMPARISON BETWEEN NORDIC WALKING AND LIGHT DUMBBELLS BASED EXERCISE ON UPPER BODY MUSCLE ACTIVITY**

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INTRODUCTION: Tough While Nordic walking is generally recommended as an aerobic physical activity, it is often referred to as being suitable for exercising the upper body musculature. The aim of the present investigation was to compare the engagement of upper body muscles during Nordic Walking compared to common resistance training exercises performed with light weights typically proposed in circuit workouts for women.
METHODS: Eight women performed NW at 5.5 km/h without (NW) and with an additional 1kg wrist load (NWL). By using 1kg handheld dumbbells, they were also engaged in biceps curls, (BC), triceps kickback (TK), triceps extensions (TE), frontal rise (FR), and lateral raise (LR) strength training exercises. Muscle activity from Obliquus Externus Abdominis (OEA), Erector Spinae (ES), Anterior Deltoid (AD), Biceps Brachii (BB), Triceps Brachii (TB), Posterior Deltoid (PD) and Latissimus Dorsi (LD) was investigated by surface EMG. EMG amplitude during NW, NWL, and strength training exercises was normalized with respect to EMG amplitude during Maximal Voluntary Contractions (MVC) performed for each muscle, and compared over exercise conditions through one-way ANOVA for repeated measures.
RESULTS: During NW muscular activation for upper limb extensors were 31 ± 16% for TB, 22 ± 7% for PD, and 20 ± 9% for LB; for upper limb flexors were 8 ± 5% for AD and 13 ± 8% for BB; and were 12 ± 5% for ES and 20 ± 5% for EOA. A significant effect of exercise modality on activity level was found for all muscles. NWL condition was associated with a slightly higher activity with respect to NW only for BB.
NW and NWL allowed reaching higher muscles activity with respect to those elicited by most of the investigated dumbbell exercises for OEA, ES, and LD, whose activation is lower than 13%, 8% and 11% of MVC respectively. NW and NWL induced a muscular activation similar to those obtained with specific exercises, TRK and TRE for TB; TRE, TRK and LR for PD.
Only for upper limb flexors, the activation level during specific exercises with dumbbells was found to be superior to for NW or NWL. AD was indeed engaged more extensively during TE (51 ±21%), FR (39 ± 13%) and LR (43 ± 20%) exercise and BB was engaged at a superior level by BC exercise (32 ±10%) with respect to NW and NWL.
CONCLUSION: According to our results, NW can elicit muscle activation similar to exercise with light dumbbells exercise for upper limb extensors extensor and trunk stabilizers, but lower activation for upper limb flexors. The additional load applied to the wrists during NW seems not to be effective in eliciting a greater muscular engagement. Specific exercises should therefore be added to the NW activity when the workouts are aimed at exercising the flexors of the upper limbs. This investigation focused on the average level of muscular activation, NW has a further advantage to include a high number of repetitions than those typically performed in dumbbell-based exercises.

### EFFECTS OF REACHING MAXIMAL SPEED ON UPPER EXTREMITY AND TRUNK KINEMATICS DURING WHEELCHAIR PROPULSION

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INTRODUCTION: Kinematic studies on manual wheelchair (MWC) propulsion commonly describe the upper extremity and trunk movements and the demands posed speed. It has been argued that because speed influences kinematics (e.g., range of motion, joint angles at start of the push phase etc.), different speeds should be considered in analyses of kinematics (1). Most kinematic studies on MWC propulsion are performed at speeds between 1.1 m/s and 1.7 m/s (2), but little research has examined the kinematic demands of propulsion at speeds approaching individuals' maximal speed. This study investigated differences in upper body kinematics at moderate and maximal speeds of wheelchair propulsion.
METHODS: Eighteen able-bodied individuals (8F, 10M, 33±11 yrs., 75.2±11.4 kg) performed an incremental MWC propulsion test on a treadmill, starting at 1.1 m/s (baseline) until they reached their maximal speed (1.9±0.4, range: 1.3-2.5 m/s) at 2.5° incline. An 8-camera Qualisys system tracked the trunk and upper extremities (120Hz). Kinematic data was analysed in Visual 3D (C-motion Inc., Germantown MD). The start of the push phase was identified, and cycles were time normalised. The Statistic Parametric Mapping (SPM) toolbox (3) for Matlab (MathWorks, Natick, MA) compared the excursions for the two speeds through a paired t-test, with the alpha-level set at 0.05. Tests were performed for 3 degrees of freedom (DOF) for the shoulder, 2 DOF for the elbow, and for trunk flexion/extension.
RESULTS: The analysis showed differences between speeds for all analysed joint excursions at some point through the movement ($p<0.05$) . Trunk range of motion showed the largest differences between the speeds (~20° at baseline, ~35° at maximal speed, SPM t-value: -8.10.05) mainly due to more trunk flexion during the push phase (0 – 25% of the cycle). The shoulders were also more abducted throughout the entire movement at maximal speed (SPM t-value: 0.60.05 for most of the cycle). The smallest difference was seen in shoulder internal/external rotation, where only the first 15% of the cycle were different (SPM t-value: -5.9 CONCLUSION: These data indicate that kinematics may differ between baseline and maximal speeds for novice wheelchair users. High-speed wheelchair propulsion seems to require increased involvement of the trunk which likely also affects the rest of the kinetic chain. This can have implications for day-to-day activities as well as sporting performance and should be considered when designing and interpreting studies on wheelchair propulsion kinematics and dynamics. These data also show that researchers should be cautious when selecting speeds for their research since some participants were close to their max speed already at the baseline speed.

### VALIDITY AND RELIABILITY OF SMARTPHONE APPLICATION FOR SELF-MEASURING OF ACTIVE SHOULDER RANGE OF MOTION IN A STANDING POSITION

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INTRODUCTION: Shoulder range of motion (ROM) is one of the most important indicators for shoulder disease severity, function, and physical assessment. The universal goniometer (UG) was used as the gold standard method for ROM measurements. Recently, smartphone applications for ROM measurement have been attracting attention as an alternative method to UG. This study aimed to investigate the validity and reliability of active ROM measurements using a smartphone application goniometer that can be used by patients themselves in a standing position.
METHODS: The dominant shoulders of 19 healthy participants were included in this study. The two observers who are physical therapists used the UG, whereas the participants used a smartphone application goniometer to measure shoulder ROM. A recorder, a physical therapist independent of the observer and the participant, read and recorded the shoulder ROM measurements. The order of measurement movements and devices used was randomized.
RESULTS: The agreement between the smartphone application goniometer and the UG (the percentage of participants whose difference between the UG and application measurements was within ±20% of the mean of the goniometer and application measurements) ranged from 42% to 100%. The intraclass correlation coefficient (ICC 3,1) values for the agreement between the smartphone application goniometer and UG ranged from 0.72 to 0.97, showing significant and approximately perfect correlations.
CONCLUSION: High agreement with the UG showed excellent validity, indicating that the smartphone application goniometer used by participants in the standing position is an excellent method and instrument. The results suggest a simpler, more reliable, practical, and inexpensive method for measuring shoulder ROM required for the prevention of sports disorders and self-care.

### THE XCO ENDURANCE TEST : A NEW TEST TO ASSESS THE ENDURANCE OF ROTATOR CUFF MUSCLES

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INTRODUCTION: Shoulder injuries are common in overhead athletes. External rotators weakness has been often correlated with muscular or articular injuries at shoulder part. Muscle endurance can be defined as the ability of a muscle or a group of muscles to produce strength over a period of time. Since a lot of gestures are performed repetitively and with a high frequency in overhead sports, this quality seems to be interesting to assess in the screening of overhead athletes. Therefore, the objective of this study was to assess the reliability of a new functional test (the Xco Endurance Test) aimed to assess the endurance of rotator cuff muscles in overhead athletes.
METHODS: Thirthy-two healthy volunteers (mean aged 23.0±3.7 years, measuring 179.4±4.9 cms and weighting 75.9±11.5 kgs) were recruited. Eighteen of them practiced an overhead sport at least five hours a week. Fourteen of them did not practice any overhead sport. The Xco Endurance Test was performed on the dominant side, in a seated position, arm at 90° of abduction, with a 900g-Xco in the hand. The objective of the test was to repetitively perform an external rotational movement, with a range of motion of 90°, and return to initial position until exhaustion. The two sessions were organised, separated by seven days. The level of exhaustion during the test was quantified with the the Borg CR10 scale during the exercise. The intraclass correlation coefficient (ICC 2,1) as well as standard error of measurement and minimal detectable change were used to assess the realibility of the test.
RESULTS: The mean duration time of the test was about 222±94 seconds. The relative reliability was very high in all the population, with an ICC about 0.959 [0.917-0.980]. The standard error of measurement (SEM) was about 19.2 seconds, which can be considered as clinically acceptable while the minimal detectable change with 95% of confidence (MDC95) reached 53.3 seconds, which is quite high regarding to the duration of the test. The duration of the test was significantly more important ($p<0.001$) in the overhead in comparison to the non-overhead athletes (255±96 vs 181±76 seconds).

CONCLUSION: The Xco endurance test can be used to assess external rotators endurance in overhead and non-overhead athletes. The importance of the MDC95 can be explained by a learning effect for those who reached a better score or by an eventual global fatigue for those whose score was lower during the second session. Future studies will have to focus on specific populations to provide normative values for the test.

**KEY PERFORMANCE INDICATORS IN BOXING: A 3D MARKERLESS PROTOCOL BASED ON ACTION CAMERAS**

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INTRODUCTION: Marker-based kinematics is hardly compatible with sports movement analysis, especially because it hinders natural movement. Hence, deep-learning based markerless solutions are being developed, such as Pose2Sim [1]. Sports in competition may also be subject to setup constraints, preventing the use of heavy equipment and installation. The use of lightweight action cameras, with post-calibration and post-synchronization, can be pertinent in this context. This study aimed at investigating the accuracy of the Pose2Sim pipeline in such suboptimal conditions. We assessed the measures of key performance indicators in boxing, which involves swift and 3-dimensional full-body movements.
METHODS: One male elite boxer performed 6 repetitions of a boxing sequence composed of 3 punches (jab, high hook, low hook). His 3D motion was captured both with a marker-based protocol, and with a light-weight markerless one. The latter involved 8 GoPro cameras, which were post-calibrated based on the dimensions of the boxing ring, and post-synchronized based on time-lagged correlations of 2D keypoints speeds between paired cameras. The markerless kinematic analysis was then performed with Pose2Sim. Both protocols used the same OpenSim [2] model to optimize inverse kinematics. Displacement of lead foot, pelvis, lead fist, and velocity of lead fist were analyzed for the jab. Rotation of rear foot, pelvis, displacement of rear fist, and velocity of rear fist were analyzed for the hooks. Waveform similarity was assessed with the inter-protocol coefficient of multiple correlation [3]. Time and magnitude of peaks were also compared.
RESULTS: Results from the marker-based and markerless approaches demonstrated excellent waveform similarity (CMC>0.94), and times-to-peak exhibited intervals of under one frame (i.e., 17 ms). Magnitudes-at-peak were very close for displacements (below 6 cm), but not for fist velocity on jab (1.2m/s difference) nor for rotations on hooks (up to 20° difference, e.g. for pelvis rotation).
CONCLUSION: Despite the use of action cameras, and of suboptimal calibration and synchronization procedures, our lightweight markerless protocol gives satisfying results for the analysis of key performance indicators in boxing, especially for limb displacements. Nevertheless, results should be taken with caution for velocity and for rotation measurements. Such a light-weight markerless protocol could be useful in situations where more accurate marker-based approaches are not conceivable, such as sports competitions.

**USING PRINCIPAL COMPONENT ANALYSIS TO EXTRACT KINETIC FEATURES OF THE THROWING UPPER LIMB IN ULTIMATE COMPETITION FOREHAND THROWING MOTION: COMPARISON BY THROWING ABILITY EMPHASIZING DISC SPIN ANGULAR**

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INTRODUCTION: This study was designed to extract the dynamic characteristics of upper-limb motion by determining the angular velocity of disc spin in the action of a forehand throwing during ultimate competition.
METHODS: This study examined data obtained from 10 male players belonging to a university Ultimate game team (1.72±0.04 m height, 62.8±3.6 kg weight, 19.7±1.4 years of age). Each player made 20 forehand throws to constitute 200 total throws for our measurements. An optical 3D motion capture system was used to record the examinee actions. Using inverse dynamic analysis, we calculated the joint moments of the shoulder joint, elbow joint, and hand joint of the throwing arm during operation.
We grouped all the throwing trials, assessing motions by 10 subjects with 20 throws each, into three groups according to the angular velocity of disc spin immediately after DRL, as high, middle, and low groups. We used the angular velocity of the disc spin as our index for evaluation and applied the grouping above to ascertain the dynamic characteristic of these trials generating high angular velocity. Of the 200 data of trials, 13 data were discarded because of failure in data. The remaining 187 data were used for analyses. The angular velocities of the high group (number of samples n = 33) were greater than 60 rad/s. Those of middle group (n = 91) were 60 rad/s for less and greater than 45 rad/s. Those of the low group (n = 63) were 45 rad/s or less.
As a preliminary step of statistical testing, we conducted dimension reduction of data using principal component analysis.
RESULTS: Results the high group showed significantly greater inner rotation moment of the shoulder joint, pronation moment of the proximal radioulnar joint, ulnar flexion moment of the hand joint, and inner rotation moment of the distal radioulnar joint immediately before maximum external rotation (MER) of the shoulder joint compared with the other two groups ($p < .01$).
CONCLUSION: These moments exhibited peaks (extrema). These exertions of moment immediately before MER must have been preparation operations to store energy for quick twist return operation during MER and DRL, suggesting application of a stretch–shortening cycle to boost the disc spinning velocity.
The features in the high group were the following.
1) Strong development of the horizontal abduction moment of the shoulder joint immediately before DRL was inferred as a braking action of the adduction moment of shoulder joint.
2) Peaking of internal rotation moments of the shoulder joint was recognized, as were the pronation moment of the superior radioulnar joint, the flexion moment of the wrist joint, and the pronation moment of inferior radioulnar joint immediately before MER.

**CONTROL IN ACCURATE BASEBALL PITCHING EXPLORED FROM POSITIONAL RELATIONSHIP BETWEEN BALL AND FINGERS**

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INTRODUCTION: Accurately controlling a ball to a target position repeatedly is one of the human specific motor skills. This can be observed as various sports-related skills, such as pitching, kicking, and batting. The final arrival position of the ball can be determined by its physical state at the release or impact, approximately. In baseball pitching, it is known to be necessary to reduce the variability of the ball's release angle especially to reduce the variability of pitch location. However, the body movements that should be performed to control release angles are still unexplained, although previous studies have suggested hand and finger movements are important. We focused on the

positional relationship between the ball and the fingers, which is the point of action the force on the ball that should be considered in terms of possible elements that humans can control, to clarify the characteristics of the body movements for the accurate pitching.
METHODS: Two high-speed cameras (960 fps) were used to capture the pitching motions of 14 skilled pitchers, and the 3D positions of the joints of wrist, index finger, middle finger, and the ball during each pitching of 30 fast balls were obtained using an automatic image recognition technique based on deep learning (DeepLabCut). Speed was defined as the magnitude of velocity vector at the ball release. The release angle was given by the elevation angle θ1 (−90◦ to 90◦) and the azimuth angle θ2 (−90◦ to 90◦) of velocity in polar coordinates.
RESULTS: The time series changes in fingertip positions of index finger and middle finger relative to the ball were compared among the pitchers, and it was found that the pitchers whose fingertips of middle fingers were in contact with the lower part of the ball about 20-30ms before the release showed less variability in release angle.
CONCLUSION: To clarify why correlations between the positional relationship and variability in release angle were found in such time periods, we calculated the time series change in the acceleration of the ball and compared it to these time periods. As a result, the middle finger positions are low when the vertical acceleration direction changes and the time periods are before the peaks of the vertical acceleration. It was thought that the lower middle finger positions before the peaks of the acceleration could have reduced the variability of the middle finger positions at the peaks of the acceleration where a large force occurred just before release, and consequently reduced the variability of the release angles. This suggests that pitchers with low variability in release angles employed movements that positioned their fingers robustly against spatial variability.

### VALIDITY AND RELIABILITY OF THE PERCEPTION NEURON SYSTEM TO QUANTIFY UPPER BODY KINEMATICS

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INTRODUCTION: As one of the most popular IMU-based motion capture system, the Perception Neuron system (PNS) has been widely applied within virtual reality interaction, film effects development and rehabilitation fields [1]. Its validity and reliability to quantify the lower body kinematics during functional movements have been proven [2], but those studies of the upper body are still lacking. Therefore, the aim of this study was to first evaluate the validity and reliability of the upper body kinematics provided by the PNS through comparison to a gold-standard optical system and then verify if the system accuracy depends on the task complexity and movement speed [3].
METHODS: Seven male adults (age: 23.28±1.25 years, height: 176.14±8.01cm, weight: 76±7.46 kg) participated in this study after signing informed consent forms. Upper body kinematics were collected simultaneously at 100 Hz by the PNS and a passive optical motion capture system (OptiTrack, Natural Point, USA) with ten high-speed cameras. Participants were required to perform both simple and complex tasks at fast and slow speeds, with the simple task defined as movements occurring in only one plane while the complex one in multiple planes. The simple task included 8 single DOF (degree of freedom) movements of the trunk (3), shoulder (3), and elbow (2). The complex task was to lift a 2.5 kg box over the shoulder [4]. To verify the reliability of the PNS, two sessions of testing were required, with the sensors being re-worn, reflective markers re-taped and recalibrated before each session.
RESULTS: Validity: High-level consistencies were observed for all joint kinematics in all planes across all simple tasks with the coefficient of multiple correlation (CMC) values of 0.86-0.99, the root mean square error (RMSE) of the two systems ranged from 3.6 to 11.3, and the mean neutral to peak range of motion differences (systematic bias) were all below 7.7. In the complex task, all plane joint kinematics had equally high consistency, with CMC values of 0.76-0.97, the RMSE was ranged from 2.1 to 12.3, and the systematic bias were all bellow 11.3. Reliability: All between-session intraclass correlation coefficient (ICC) of the angle from all motions were good to excellent for the PNS (ICC between 0.83 and 0.97) in simple and complex tasks, and these results were basically consistent with those from the optical system. Paired t-test revealed that the movement speed had no significant effect on these values ($p>0.05$) while the task complexity did ($p<0.05$) and the more complex task resulted in greater bias, but still acceptable (CMC>0.75) .
CONCLUSION: The PNS could accurately quantify upper body kinematics in different tasks regardless of the task complexity and movement speed. Our results suggest that the PNS is suitable for assessing upper body kinematics and could provide participants with accurate enough motion kinematics for further analysis.
1. Neuron P (2018) 2. Shuai Z et al. (2022) 3. Walmsey et al.(2018) 4. Bolsterlee B et al.

### PHYSIOLOGICAL TREMOR AS A RESULT OF TIREDNESS RELATED TO MANUAL ACTIVITIES REQUIRING PRECISION

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INTRODUCTION: Physiological tremor is defined as involuntary oscillations of individual parts of the body of healthy people resulting from the interaction of mechanical and nervous factors (Tomczak et al. 2014). Increased muscle tremor, limited motor skills and weakened eye-hand coordination may reduce the precision of activities. Physiological tremor can interfere with precise hand control in professional musicians and surgeons, as well as can impair motor performance in professional athletes. Tremor as a symptom accompanying fatigue can be treated as information about its intensity. The purpose of the study was to assessment of the impact of fatigue with manual activities requiring precision on the parameters of physiological tremor.
METHODS: 20 women and 20 men (25-35 years old) participated in the study. Fatigue was induced during a three-hour (180 minutes) two-handed upper limb coordination test. The test consisted of three stages. The first step lasted 30 minutes, the second 60 minutes (2 x 30 minutes continuously) and the third 90 minutes (3 x 30 minutes continuously). The accelerometric method using an acceleration measuring kit was applied to analyse tremor. Dominant and non-dominant hand physiological tremors were measured before exercise and after 30, 90, and 180 minutes of exercise.
RESULTS: The average waveforms of the spectral density function of the physiological tremor power were similar in shape to all subjects. They showed similar proportions of individual components and the correspondence of frequencies for which maxima occur. There were no statistical differences between dominant and non-dominant hand in the frequency range 1-5 Hz ($p=0.99$) and 8-14 Hz ($p=0.21$). The greatest increase in the amplitude of physiological tremor was observed after 30 minutes of the task duration for woman and after 180 min of exercise for men. For dominant hand in woman group there was a significant difference between subsequent measurements for 1-5 Hz ($p = 0.01$) as well as 8-14 Hz ($p = 0.03$).
CONCLUSION: Physiological tremor increased during performing manual activities. This phenomenon may influence psychomotor performance, deteriorating the ability to perform tasks requiring movement precision.
References:

1. Tomczak A, Gajewski J, Mazur-Różycka J. Changes in physiological tremor resulting from sleep deprivation under conditions of increasing fatigue during prolonged military training. Biol Sport. 2014; 31:303-308.

## Conventional Print Poster

### CP-SH02 Talent identification and development

#### MORPHOLOGICAL AND PHYSIOLOGICAL PREDICTORS FOR SELECTION AT NATIONAL AND LEAGUE STATUS FOR YOUTH SOCCER PLAYERS

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INTRODUCTION: Identifying talent with relevant physical predictors to establish players at the elite level has always been topical for soccer and sport science departments. But due to the large number of factors responsible for performance, there is still no consensus for the selection of key objective tests. However, the professionalisation of youth soccer has resulted in increased physical requirements of the players. Therefore, the aim of the study was to examine physical predictors to differentiate players who have reached the highest level (national team) of youth elite soccer compared to non-selected peers.
METHODS: Male youth players category U16 and U17 (n=32) from an elite academy were recruited (age, 15.74 ±0.58 y; stature, 177.3 ±5.9 cm; body mass, 64.9 ±6.7 kg). Isokinetic strength of knee extensors (KE) and flexors (KF) were measured (Cybex NORM®, Humac, USA). Vertical ground force reaction (VGR) and total impulse (TI) during countermovement jump were calculated (Kistler AG, Switzerland). Acceleration (0-5, 5-10, 10-20 m), change of direction (505R, 505L) and flying linear test (F10 and F20) by photocells were measured (Timer Browing system, Utah, USA). A treadmill v-VO2max was recorded (Cosmos, Germany). Body fat by bioimpedance was determined (Tanita Corp, Japan). Somatic maturity status was determined using peak height velocity (PHV). Predictors were classified into three blocks: speed (0-5 m, 5-10 m, 10-20 m, 505P, 505L, 10F, 20F, v-VO2max), strength (KE, KF, VGR, TI) and somatic (stature, body mass, % body fat, PHV). Binary logistic regression with stepwise forward likelihood method was utilised (entry and removal of model was set at $p < 0.05$). Based on the criteria of success in the national team, the players were classified into two groups: non-national team (NNT, n=17) or national team (NT, n=15). Pearson's correlation coefficient determined associations among variables.
RESULTS: Significantly higher values of acceleration 0-5 m and v-VO2max in NT compared to the NNT group were found (5.07 ±0.15 vs 4.85 ±0.16 m•s-2; 4.68 ±0.23 vs 4.50 ±0.20 m•s-1, $p<0.05$). Significantly lower times on 10F, 20F and 505L in NT compared to NNT group were found (1.17 ±0.04 vs 1.22 ±0.04 s; 2.34 ±0.06 vs 2.45 ±0.11 s; 2.26 ±0.07 vs 2.35 ±0.09 s, $p<0.05$). Significant high (r=0.7-0.9) correlations were found (0-5 m vs F20; 505R vs 505L; stature vs body mass, $p<0.001$). Significantly moderate (r=0.5-0.7) and negative correlation among blocks was found (VGR vs F20, $p<0.01$). Final model identified two significant variables (505L and 10F, $p<0.05$), which predicted correctly NT from 86.7% and NNT from 88.2% ($X2=21.62$, $R2=49.1$ %, $p<0.001$).
CONCLUSION: These findings indicate that speed abilities compared to strength and somatic characteristics favour success in youth soccer at a national level. Soccer coaches should continue to focus on important predictors of performance in the development of elite talent.

#### COMPARISON OF THE RELATIVE AGE EFFECT BETWEEN ELITE VERSUS SUB-ELITE LEVEL IN YOUTH FOOTBALL PLAYERS

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INTRODUCTION: The relative age effect (RAE) is a well-known phenomenon that has been observed in many sports. In this context, elite level football is amongst the fields of interest that have been studied frequently (Deprez et al., 2013). Thus, the level of competition is one of the factors affecting the RAE. Earlier studies showed that the RAE is more pronounced in higher competition levels, which is explained by an increase in selection pressure (Jackson & Comber, 2020). At the same time, elite academies have access to higher qualified coaches and extensive scientific resources regarding the selection of talents. For this reason, one would expect weaker RAE at elite level. To gain further sport specific insight, this study aims to compare the prevalence and magnitude of the RAE between elite and sub-elite level in youth football.
METHODS: A total number of 1.728 football players from age groups U10 to U19 representing a certified academy of a professional club of German Bundesliga (n=876) and a cohortof a sub-elite club of German 4th division (n=852), respectively, for subsequent seasons between 2015/16 – 2020/21 served as data pool. Birth dates were collected, differences between the observed and expected birthdate distributions were analysed using chi-square and Cramer's V was used to estimate the magnitude of effect sizes according to age groups.
RESULTS: The findings reveal birthday asymmetry in both elite and sub-elite cohorts, with a greater extent in elite level (e.g. 1st half year U10: 73.4% in elite versus 64.4% in sub-elite). While elite level players show a consistent significant RAE across all age groups (each $p<0.05$) with medium to large effect sizes, there is no RAE for age groups U10 to U15 in sub-elite level found (each $p>0.05$). However, there is a significant RAE in U17 ($p<0.05$) and U19 ($p<0.05$) with medium effect sizes in sub-elite level.
CONCLUSION: The findings confirm earlier results of consistent prevalence and magnitude of RAE in youth elite football players. The comparison shows that the effect is much more pronounced in elite level than in sub-elite level, supporting the line of argumentation that selection pressure has a strong impact on the magnitude of RAE. Further studies including additional factors (e.g. maturation, physical and psychological dimensions) are needed to gain more insights on this phenomenon.
References:
Deprez, D., Coutts, A., Fransen, J., Deconinck, F., Lenoir, M., Vaeyens, R., & Philippaerts, R. (2013). Relative age, biological maturation and anaerobic characteristics in elite youth soccer players. International Journal of Sports Medicine, 34(10), 897-903.
Jackson, R. C., & Comber, G. (2020). Hill on a mountaintop: A longitudinal and cross-sectional analysis of the relative age effect in competitive youth football. Journal of Sports Sciences, 38(11-12), 1352-1358.

### ANALYSIS OF GROUP COHESION THROUGH VARIABLES RELATED TO EXPERT PERFORMANCE IN FOOTBALL

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Introduction
Expert performance in sport is developed through deliberate practice in accordance with a social and relational system. The theoretical model developed by Carron and collaborators structures group cohesion via a dynamic process that settles the cohesion of a group towards the social and towards the task. Group cohesion can be essential in sports teams with a bidirectional relationship of complexity according to different variables related to expert performance.
Methods
The study included 876 football players, 219 women and 657 men, aged between 13 and 40 years (M = 18.96, SD = 4.54) and with a mean experience of 10.45 years competing. The instrument used was the Group Environment Questionnaire (GEQ), translated and validated into Spanish as the Cuestionario de Ambiente de Equipo (CAE). The data collection was achieved by an expert researcher in the sports facilities, in a group and prior to the training session. Participation was voluntary with informed and anonymous consent. The study was carried out in accordance with the Declaration of Helsinki. Data analysis was performed using the statistical package IBM SPSS v.26. The data normality and homogeneity of the variances of the groups were checked.
Results
Univariate Mancova tests (age as covariate) showed significant differences in Group Integration-Social ($p=0.034$; $\eta2=0.010$) by performance level with a very slight effect. The averages kept stable and there was only a decrease in the international performance. The univariate contrasts of the Manova proved significant differences between the sport category groups in Individual Attractions to the Group-Social ($p=0.025$; $\eta2=0.009$), with a very slight effect. The trend decreased a bit in scores from cadet to senior. The correlations of the GEQ with temporal variables related to expert performance showed coefficients lower than 0.10 with the four GEQ scales, except in Individual Attractions to the Group-Social, which had a negative and significant coefficient with Age (-0.13, $p<0.001$).
Discussion
In group cohesion, studies with soccer players of various performance levels (amateur, semi-professional and professional) were observed but differences between groups were not analyzed (similar results are seen in volleyball studies); however, regarding the category there are no previous references. There is controversy, in previous studies, about the correlations of temporal variables with group cohesion. In this study, a fairly stable trend towards the task and towards the social is observed (except for international level), both valued as the performance and category of the sports team increase. Group cohesion and its perception, especially towards the task, seem to establish a relationship, complex and controversial, with performance, deliberate practice and intervention in team sports, so it would be interesting to delve into the analysis of competitive performance and other variables.

### PHYSIOLOGICAL DEMANDS OF MEN ACADEMY RUGBY UNION PLAYERS AT NATIONAL LEVEL

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INTRODUCTION: To make training effective, it is necessary to calibrate them according to the demands of the competition. While there is some data on senior elite and national level, there is little information about the physiological demands of a match in men academy rugby union players at national level. The aim of this study was to characterize the match activity of under 19 years old academy rugby union players in order to prescribe accurate trainings.
METHODS: Thirty-one male academy rugby players of the U19 national championship, (mean age: 16.8 ± 0.7 years, mean body mass: 81.4 ± 17.6 kg, mean height: 179.4 ± 7 cm) have been monitored during 11 competitive matches with GPS. Sixteen players were monitored per game with a least three players per position groups. The total distances, number of accelerations, peak velocity and the distance at high velocity (>21 km.h-1) were quantified. Position groups were defined as the forwards and the backs. The data obtained correspond to a specific position activity over an entire match. Forty-two sequences were included for forwards and thirty-nine for backs.
RESULTS: Backs travelled more distance over the game than forwards (5022±432 vs. 5480±565m, $p<0.05$). The number of acceleration (>2.5m. s-1) for the forwards and backs were 18 ± 9 vs. 26 ± 9 times ($p<0.05$), respectively. Higher high velocity running was achieved by the backs compared to forwards (26.3 ± 2.9 vs. 29.2±2.3 km.h-1, $p<0.05$). Backs covered greater distance at high velocity compared to forwards (140 ± 119 vs. 280 ± 114m, $p<0.05$, respectively).
CONCLUSION: These results suggest that the physical demands are specific to the positions and should be considered by coaches. It will be possible to create optimized position-specific training programs in U19 men rugby players at national level.

### INJURY AND HEALTH PROBLEMS IN GRASSROOTS YOUTH SOCCER PLAYERS: A STUDY OF PREVALENCE, SEVERITY AND ASSOCIATED DEMOGRAPHIC AND PSYCHOSOCIAL FACTORS

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Introduction
Youth grassroots soccer is associated with a wide range of health benefits, but participation still poses a risk of injury and health problems. Yet, epidemiological evidence of injury and health problems prevalence and severity in the grassroots setting during a regular season is limited. Therefore, the purpose of the present study was twofold. First, the aim was to describe the prevalence, severity, and location of injuries and health problems in a large cohort of youth grassroots soccer players. Second, we wanted to investigate the relationship between prevalence of injury and health problems, and possible associated demographic (e.g., age, gender, number of training and match hours/week) as well as psychosocial factors (e.g., peer and coach autonomy support, social support).
Methods
Young soccer players (N = 588, Mage = 15.7 years; SD = 1.4) playing for teams (U14-U19) registered for the 2021 season in Agder county in Norway were recruited for this study. The Oslo Sports Trauma Research Centre (OSTRC) questionnaires on health and injury problems were used to record health problems and severity, while a modified practice history questionnaire was used to record training data. Classification and Regression Trees (CRT) were used for the data analyses. We analyzed the relationship between the independent variables and

four outcome variables (e.g., total health problems, total substantial health problems, injury problems, and substantial injury problems), resulting in four decision trees.
Results
The prevalence of all health problems was 76% (54% for only injuries), with 31% (23% for substantial injuries) experiencing substantial health problems. Girls reported higher prevalence (83%) of total health problems than boys (73%). Of anatomical areas, the knee displayed the highest prevalence (29%, 11% substantial) in this study. Girls reported more knee problems (37% vs 26%), while boys displayed more groin problems (18% vs 6%). The CRTs revealed low levels of peer autonomy support to be the main factor in three of the CRTs, with it being the only significant factor for both health and substantial health problems. For injuries, the group with low levels of peer autonomy support, along with higher amount of football activity and being a female player, showed the greatest prevalence of injuries. Regarding substantial injuries, players with more match time (> 3 hours a week) showed the greatest prevalence.
Conclusion
The results revealed the magnitude of health and injury problems in grassroots youth soccer, documenting a substantial impact of problems in this population. It also showed peer autonomy support to be the main associated factor for health and injury problems, with football activity, match time, and gender also being possible factors of importance. Researchers and practitioners are advised to take multiple factors into account when investigating or trying to prevent health and injury problems in young grassroots soccer players.

## A SURVEY EXAMINING ABOUT THE STATUS OF COMPLIANCE OF PITCH COUNT RECOMMENDATIONS AND JAPANESE LITTLE LEAGUE BASEBALL COACHES KNOWLEDGE OF IT, 9 YEARS COMPARISON

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INTRODUCTION: Pitch limit recommendations for preventing throwing injuries have been developed. The previous study was conducted 9 years ago and examined the level of knowledge and compliance with these recommendations among coaches of young baseball teams similar to this study. Over the years, the rules for baseball elbow prevention efforts and pitching restrictions have changed, and the current actual situation regarding baseball elbow disorders in youth baseball associated with it has not been adequately studied. This study was designed to compare the current situation and changes in coaches knowledge and compliance with 9 years ago.
METHODS: Coaches of youth baseball teams in Kyoto Prefecture responded to a questionnaire assessing their knowledge of and compliance to the recommendations. They also responded on the coachs age and coaching history. The ratio of coaches who had correct knowledge of the pitch count recommendations and who complied with these recommendations was calculated. Subsequently, the relationship between these ratios and coach age and years spent coaching baseball was analyzed using the unpaired t test.
RESULTS: In total, 213 baseball coaches participated in the study and 197 (80 teams) with no missing items were analyzed. 53.3% of coaches had correct knowledge of the recommendations. Among them, 43.8% (including non-respondents) complied with them. Those who did not comply with them (49.3±2.8 years old, 10.9±10.6 years) are significantly older($p=0.005$) and have longer($p=0.0068$) coaching experience than those who complied (43.2±6.1 years old, 5.5±3.9 years). The numbers in brackets indicate the coachs age in the former and coaching history in the latter.
CONCLUSION: The pitch limit recommendation for school-age baseball in Japan changed from "no more than 70 pitches per day and 300 pitches per week" to "no more than 50 pitches per day and 200 pitches per week" from the previous study (2013). Coaches knowledge of the recommendations increased compared to 39.8% in the prior study. The compliance with them had also increased compared to 28.3% in the prior study. In Kyoto Prefecture, the participants of this study, an initiative to prevent pitching injuries is being implemented by prefectural baseball federations. Once a year, physical findings and screening test of the elbow and shoulder joints are obligatory. As workshops are also held regularly for prevention, it is possible that coaches knowledge of the injury has developed as a result of their participation in these workshops, and that this may have changed the rate of knowledge and compliance with the recommendations. The older the coaches were and the longer they had been coaching, the lower level of the compliance with them. Older coaches may refer to their own past experiences to guide them and may fail to comply with the recommendations. In the future, it is considered necessary to have knowledge and comply with the recommendations regardless of age and years spent coaching baseball .

## RELATIONSHIP BETWEEN ANTHROPOMETRICS COMPOSITION, SPECIFIC FIELD TESTS AND THROWING BALL VELOCITY OF MALE TEAM HANDBALL PLAYERS: TECHNOLOGY FOR ASSESSMENTS TOOLS OF QATAR HANDBALL FIRST PROFESSIONAL L

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INTRODUCTION: Anthropometric parameters, physical motor test, and throwing ball velocity have been identified as fundamental in order to determine the success of the performance in handball helping in the optimal design of physical fitness programs 1,2. This study examined the relationships between the physical fitness, anthropometry, and throwing ball velocity of first-division male team handball players in Qatar sate.
METHODS: Thirty-two male team handball players (age: 25.5 ± 5.55 years; body mass: 92.9 ± 11.7 kg; height: 1.87 ± 0.07 m; BMI: 26.6 ± 3.72 kg/m2; body fat: 19.5 ± 4.56%) were recruited from the Qatar handball first professional league. The anthropometry and physical performance (yo-yo intermittent recovery test (Yo-Yo IR1), squat and countermovement jumps (SJ and CMJ), T-half test for change-of-direction (COD) ability, sprint tests (15 and 30 m) and handball jump throw velocity) were measured.
RESULTS: Only the body fat was significantly correlated with some performance parameter (jump throw: $p<.0.01$; $r=-0.746$). The t-half test ($p<.0.001$; $r=-0.668$) and Yo-Yo-IR 1 ($p<.0.001$; $r=-0.603$) followed. The position specific analysis revealed two relevant ($\eta p2 \geq 0.20$) differences for the parameters jump throw ($\eta p2=0.20$) and sprint 30 m ($\eta p2=0.20$). In both parameters, pivots showed the highest performance levels (jump throw: 33.5 ± 2.93 m/s; sprint 30 m: 4.03 ± 0.03 s). In contrast, goalkeepers (jump throw: 25.7 ± 4.97 m/s) and backs (sprint 30 m: 4.56 ± 0.39 s) demonstrated the lowest performance level. No relevant position specific differences were observed regarding CMJ ($\eta p2=0.09$) and SJ ($\eta p2=0.08$). In both tests, pivots showed the highest performance level, whereas backs were the players with the lowest level of jumping performance.
CONCLUSION: The above results could be useful for coaches and trainers, to develop position-specific training concepts as they are based on tests, which reflect the specific characteristics of individual playing categories. These findings could be added to the international literature and assist in recognizing the unique nature of training regimen needed to team handball practice and training prescription.
1Hermassi et al, Front Bioeng Biotechnol. Jun 21;7:149. (2019)

2Granados, et al., J. Strength Cond. Res. 27, 723–732. (2013)

**THE CURRENT LANDSCAPE OF YOUTH MULTI-SPORT TRAINING: ATHLETE AND PARENT INSIGHT DATA**

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INTRODUCTION: The intent to improve a youth athlete's ability is developed through structured focused training in the competencies within their sport. To date there is little evidence around how multi-discipline youth athletes organise their training load (TL) outlook in a multitude of sports.
METHODS: The aim of this study was to analyse the daily TL, distribution and wellness in aspiring 10- 15yr old pentathletes (n=31) over 152+-35 days. Athletes completed daily reports documenting sport mode, session duration, session rate of perceived exertion (sRPE) and wellness (sleep, stress, mood, fatigue, muscle soreness). Parental understanding of training periodisation was used to contextualise the athletes training patterns (n¼15) through semi-structured interviews
RESULTS: Weekly training duration was 5 h 59 min+-3 h 38 min. The swimming discipline dominates the overall time spent training (50.5%). Pentathlon specific TL was significantly higher in the 14–15 yrs (3000+-1207 AUT) in comparison to 10–11 yrs (1837+-874 AUT). Weekly micro TL fluctuations showed significant peaks on the weekend compared to Tuesday and Friday ($p<0.05$).Wellness scores were significantly worse on Monday to Wednesdays ($p<0.05$), compared to Fridays. Parent interviews suggest a multitude of coach input from solo disciplines over a typical week, with little inter-coach discussions.
CONCLUSION: In conclusion there is little structure on a micro or macro level in youth pentathletes training showing multiple-coach input with little coach crossover. Implications for the training/competition is based around convenience/holidays/availability of resources rather than overall individual development, which suggests the potential need for an early specialisation approach to support athletes within this style of multi-discipline sport.

## Conventional Print Poster

### CP-PN07 Vitamins and hydration

**VDBP, FREE 25-(OH)D LEVELS AND MARKERS OF PSYCHOPHYSICAL STRESS IN PROFESSIONAL FOOTBALL PLAYERS**

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INTRODUCTION: It has been proposed that serum free 25-hydroxyvitamin D (25-(OH)D) may better reflect vitamin D action than total 25-(OH)D based on the free hormone hypothesis. Vitamin D plays an active role in muscle inflammatory response, protein synthesis, and regulation of skeletal muscle function. Strenuous muscle contractions during exercise may induce mechanical muscle damage. Thus, monitoring of psychophysical stress markers in athletes may help to tailor training/competition and recovery regimes to optimize performance. Therefore, the aim of our study was to check the relationship between free 25-(OH)D levels and blood count, iron, ferritin, testosterone (T), cortisol (C), creatine kinase (CK), liver enzymes (ALT, AST) and high-sensitivity C-reactive protein (hs-CRP) in professional football players.
METHODS: Professional male football players (n=35, 26.8±4.8 yrs, body fat 17.6±3.2%) participated in the study. Total 25-(OH)D was assessed using LM-MS/MS. Free 25-(OH)D concentration was evaluated by calculation, using serum albumin and vitamin D binding protein (VDBP) levels. The following biochemical parameters using standard automated technique were assessed: blood count, iron, ferritin, T, C, CK, ALT, AST and hs-CRP. The T/C ratio was calculated by dividing the two hormone levels both expressed in nmol/l. Multiple regression was performed to analyse association between VDBP, free, bioavailable 25-(OH)D and biochemical, hormonal parameters. Statistically significant models were adjusted for age, body mass and body fat. A statistical level of $p< 0.05$ was accepted.
RESULTS: Our study showed decreased serum total 25-(OH)D levels (26.1±4.3 ng/ml) in 63% of the professional players. In studied football players, there was significant correlation between serum VDBP concentrations and cortisol levels ($p<0.001$). There was no correlation between total 25-(OH)D levels and studied variables. Serum free 25-(OH)D inversely associated with hs-CRP ($p<0.028$) and cortisol ($p<0.034$) concentrations. Serum bioavailable 25-(OH)D significantly correlated with hs-CRP ($p<0.017$) levels.
CONCLUSION: Based on the results of our study, we concluded that to check some of psychophysical stress parameters (hs-CRP, cortisol) in athletes measuring free, bioavailable 25-(OH)D may provide a better index of vitamin D status that total 25-(OH)D levels in such situations. Furthermore, seems justified to monitor the levels of vitamin D, cortisol and testosterone in professional football players could be decisive in the development of more specific supplementation and injury prevention strategies.

**VITAMIN D METABOLITES STATUS, BODY COMPOSITION AND PHYSICAL ACTIVITY IN HEALTHY MEN AND ATHLETES**

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INTRODUCTION: The potential effects of vitamin D in athletes has received considerable attention in the literature. However, little is known about vitamin D metabolites and its association with body composition and physical activity level. Therefore, the primary purpose of our study was to assess circulating vitamin D metabolites concentration in healthy men and outdoor, indoor athletes by considering the behaviour of their physical activity. The second aim was to determine the relationship between metabolites of vitamin D and body fat, physical activity, training volume in studied groups.
METHODS: Sixty six participants (26 healthy men – control, 24 football players – outdoor, 16 judoists – indoor) took part in the study. Vitamin D metabolites (25-(OH)D3, 25-(OH)D2, 24,25-(OH)2D3, 3-epi-25-(OH)D3, 1,25-(OH)2D) were assessed using LM-MS/MS. Skinfold thickness was measured with a Harpenden skinfold calliper and percentage body fat was assessed using seven site method (triceps, chest, abdominal, suprailiac, midaxillary, subscapular, front thigh). Physical activity was evaluated using the International Physical Activity Questionnaire (IPAQ). Multiple regression was performed to analyse association between vitamin D metabolites levels and skinfold thickness, physical activity and training volume. Statistically significant models were adjusted for age, body mass and body fat. A statistical level of $p< 0.05$ was accepted.

RESULTS: Vitamin D metabolites did not differ between the studied groups. In the group of healthy men was a significant negative association between serum 25-(OH)D3 and biceps (p<0.033), abdominal (p<0.025), suprailiac (p<0.041) skinfold thickness. 24,25-(OH)2D3 levels inversely correlated with midaxillary (p<0.038), biceps (p<0.015), subscapular (p<0.032), abdominal (p<0.008), suprailiac (p<0.007) skinfold thickness, body fat (%) (p<0.018) in control. There was inverse association between serum 3-epi-25-(OH)D3 and abdominal (p<0.04), suprailiac (p<0.047) skinfold thickness in healthy men. In group of football players 25-(OH)D3 levels correlated with midaxillary (p<0.003), biceps (p<0.011) skinfold thickness. Serum 24,25-(OH)2D3 associated with biceps skinfold thickness (p<0.016) in outdoor athletess. In football players, there was association between 3-epi-25-(OH)D3 levels and midaxillary (p<0.014), biceps (p<0.025), subscapular (p<0.009) skinfold thickness. Serum 25-(OH)D2 correlated with physical activity level (p<0.025), training volume (p<0.027) in outdoor athletes. In group of judoists, serum 25-(OH)D2 was correlated with physical activity level (p<0.008).
CONCLUSION: Based on the result of our study, we concluded that 25-(OH)D3, 24,25-(OH)2D3, 3-epi-25-(OH)D3 circulating concentrations of these metabolites are linked with skinfold thickness and body fat. The different relationship between vitamin D metabolites and skinfold thickness in healthy men and outdoor athletes might be related with different lifestyle physical activity.

**THE EFFECT OF VITAMIN D ACTION IN SKELETAL MUSCLE ON BONE AND MUSCLE PERFORMANCES**

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INTRODUCTION: Vitamin D endocrine systems are required for normal bone metabolism and calcium homeostasis, which even affects skeletal muscle performances by sustaining locomotive function. In the next step, the involvement of vitamin D actions on the crosstalk between systemic calcium metabolism and muscle function should be uncovered. Since ATP sustains skeletal muscle contraction that is triggered by the binding of calcium ion to the muscle protein, we investigated whether vitamin D action altered ATP metabolism in skeletal muscle.
METHODS: Firstly, vitamin D action in skeletal muscle was manipulated in mice by crossing skeletal muscle-specific cre (creatine kinase cre) mice with VDR flox mice, phenotype of the motor functions such as locomotor activity, muscle morphology, and bone histology were assessed. Furthermore, the effect of vitamin D on ATP metabolism in skeletal muscle cells were evaluated with cultured C2C12 cells. To analyze ATP metabolism in cultured cells, the protein levels of both Cx43, a promoter of ATP transport, and ENPP1, an eliminator of ATP, were evaluated by western blot analysis. Moreover, whether cellular ATP/ADP contents were responded to the blockade of ATP release, cultured C2C12 cells were treated with the Gap26 peptide, a specific antagonist to Cx43.
RESULTS: Compared to wild-type mice, lacking VDR activity in skeletal muscle decreased locomotor activity, whereas gross phenotype such as body weight was comparable between two strains. The composition of muscle fiber types and the muscle cross-sectional area were not affected by VDR activity. As bone phenotype, bone mineral density examined by micro CT analysis was decreased, and that was supported by the results of an increased in osteoclast activity in mice lacking VDR. As results of in vitro study, 1,25 (OH)2D3 stimulation increased ENPP1, but decreased Cx43 during myogenic differentiation. Also, the ratio of ATP/ADP at every 24-hour in cultured skeletal muscle was decreased by 1,25(OH)2D3 stimulation in a dose-dependent manner. In addition, inhibiting Cx43 by Gap26 peptide resulted in an increased intracellular ratio of ATP/ADP in C2C12.
CONCLUSION: The present study indicated that the local VDR action in skeletal muscle sustained motor functions in mice. The reduction of bone mass due to an accelerated bone resorption was involved in the phenotypes by lacking VDR activity in mice. Also, treatment of 1,25 (OH) 2D3 regulates the supply and the elimination of intracellular ATP was confirmed in vitro in this study. These results describe the physiological roles of 1,25 (OH) 2D3 action in entire locomotor organs. Further, 1,25 (OH) 2D3 treatment increased ENPP1 expression in C2C12 cells likely reduced the risk of ectopic calcification in muscle tissue instead of decreased in ATP/ADP ratio. In conclusion, the vitamin D action in skeletal muscle plays a role in maintaining motor function and bone mass, one of the mechanisms of this action involves the regulation of local ATP metabolism in skeletal muscle.

**HYDRATION AND FLUID REPLACEMENT KNOWLEDGE, ATTITUDES AND BEHAVIOURS OF GAELIC FOOTBALL PLAYERS**

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INTRODUCTION: Euhydration is required for optimal health and sporting performance. Significant dehydration has been associated with impaired cognitive function and sporting performance and an increased perception of effort. Invasion team sports, such as Gaelic football, are characterised by intermittent high-intensity bouts of activity over a prolonged period and have been associated with potentially high sweat rates. Given the physically demanding nature of Gaelic football training and competition, adequate fluid intake is essential for optimal health and performance. Therefore the aim of this study was to investigate hydration and fluid replacement knowledge, attitudes and behaviours of Gaelic football players.
METHODS: One hundred and seventy-five Gaelic football players (m=85, f=90; mean age: 24±6.4 years; mean playing history: 15±5.8 years) playing at club (n=97), college (n=28) and elite (n=50) level were recruited. Participants completed a modified version of a previously validated survey [1]. The 59 question survey involved 4 sections including (1) background demographic information and (2) knowledge, (3) attitudes and (4) behaviour towards hydration and fluid replacement and was completed online. The maximum score obtainable in each of section 2, 3 and 4 was 17, with higher scores indicating positive hydration knowledge, attitudes and behaviours.
RESULTS: Players' mean hydration knowledge score was 12.9±1.7 (75.9%±9.7%). Almost 80% of players had a knowledge score of 12 (70%) or more. Only 4.5% (n=8) of players scored 100%. The mean attitude and behaviour scores were 12.2±2.2 (72%±12.8%) and 12.2±1.8 (71.9%±10.6) respectively. No significant differences were observed for knowledge, attitudes or behaviour between gender or playing level. Significant correlations were observed between knowledge, attitude and behaviour scores (p<0.05). Almost one-third (65.3%) of players did not know that consuming a sports drink is recommended when exercising for more than 60 minutes while almost one-half (47.2%) did not know that sports drinks are better than water at restoring muscle glycogen.
CONCLUSION: Although both male and female Gaelic football players had a good knowledge of general hydration further education is required around sports drinks and their use and role. Further education is also warranted on hydration guidelines and requirements and monitoring of hydration status.
References
Nichols PE, Jonnalagadda SS, Rosenbloom CA, Trinkaus M. Knowledge, attitudes, and behaviors regarding hydration and fluid replacement of collegiate athletes. Int J Sport Nutr Exerc Metab 15: 515–527, 2005.

### THE EFFECT OF COMBINED FOOD AND WATER INGESTION VERSUS WATER INGESTION ALONE ON HYDRATION STATUS AT REST

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INTRODUCTION: Maintaining and/or restoring a euhydrated hydration state is important for athletes in their preparation for, and recovery from exercise. Ingestion of beverages containing carbohydrates have shown to reduce urine production and promote prolonged fluid retention (1), but it is yet to be seen if there is an equivalent response when the carbohydrate is ingested as a solid food alongside water. Therefore, this study investigated the effect of combined water and food ingestion versus water alone on hydration status at rest.
METHODS: Twelve subjects (6 males, 6 females, 28 ± 5 y, body mass index (BMI) 26 ± 6 kg/m2), ingested either 1 L of water (WAT) or 1 L of water and an oat bar (WAT+F) over a 30 min period. The oat bar contained oats, sugar, olive oil and honey totalling 100 g carbohydrate and a minimal water content (~9 g). Urine output, serum osmolality and subjective feeling scales (0 = no symptoms, 10 = extreme symptoms) of hunger, thirst, stomach fullness and gastrointestinal (GI) comfort were measured at baseline, post-ingestion and at 1, 2 and 3 h post-ingestion. Two-way repeated measures ANOVA were used to analyse data containing two-factors (trial x time), and paired t-tests or Wilcoxon signed rank tests, as appropriate, were used to analyse data containing one factor. Data presented as mean ± SD.
RESULTS: Total urine output was not different between trials (WAT: 1135 ± 247 g, WAT+F: 1049 ± 216 g, P = 0.236). Greatest urine output was produced at 1 h before progressively decreasing at 2 and 3 h post-ingestion (P < 0.001). Serum osmolality was not different between trials (P = 0.118) and did not change over time (P = 0.459). WAT+F decreased sensations of hunger immediately post-ingestion (baseline: 5 ± 2, post-ingestion: 1 ± 1, P = 0.014) before returning to baseline values by 3 h. Hunger was lower in WAT+F vs WAT from post-ingestion onwards (P < 0.022). Stomach fullness scores post-ingestion increased from baseline in both trials but were greater in WAT+F (8 ± 2) compared to WAT (4 ± 2, P = 0.015). There were no time x trial interaction effects for thirst (P = 0.938) or GI comfort (P = 0.212).
CONCLUSION: The ingestion of food containing 100 g of carbohydrate alongside water did not improve fluid retention, and therefore improve hydration status at rest, compared to the ingestion of water alone. Further research is required to guide hydration practices for athletes when food is coingested. Specifically, this should explore the nutritional composition of the food, such as the addition of sodium, in aiding fluid retention.
1. Maughan et al. (2016) Am J Clin Nutr, 103 (3), 717-723

### 24-HOUR FLUID BALANCE AND SWEAT LOSSES IN LACROSSE PLAYERS TRAINING TWICE-DAILY

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INTRODUCTION: Hydration status is important for lacrosse athletes as dehydration >2% body mass impairs intermittent exercise/skills performance. Athletes with training sessions in close proximity (e.g. training twice a day) must adequately rehydrate to avoid starting exercise dehydrated. Few studies have examined 24-h fluid balance in athletes training twice-daily and little is known about the fluid losses incurred during lacrosse training. Thus, this study measured 24-h fluid balance in lacrosse players training twice-daily.
METHODS: Twenty four-hour fluid balance and sweat loss was estimated in 22 university-level, British lacrosse players (8 males, 14 females; 21 ± 2 years). During testing (07:00-07:00) participants maintained their usual fluid and food intake, completed a weighed food diary and collected all urine produced. Participants completed two bouts of 1.5-h (males) or 2-h (females) of lacrosse practice (males: 12.6 ± 0.5°C, 70.0 ± 3.6% humidity; females: 21.1 ± 0.5°C, 55.6 ± 0.9% humidity) separated by 2-h rest. Participants provided a first-morning urine sample each day, as well as pre and post training sessions. Nude body mass was measured before and after training and corrected for food/drink consumed and urine/faeces produced during training to determine sweat losses. A sweat patch was applied to the right scapula and analysed for sweat sodium concentration. Data are presented as mean ± standard deviation.
RESULTS: Sweat rate was relatively low, but higher in males vs females (0.55 ± 0.38 L/h vs 0.31 ± 0.13 L/h; P=0.01). However, there was no difference in the volume drank during exercise (males: 382 ± 183 mL/h; females: 303 ± 216 mL/h; P=0.23). There was no difference in sweat sodium concentration (males: 45.5 ± 14.0 mmol/L; females: 37.3 ± 13.4 mmol/L; P=0.11). Dehydration at the end of each lacrosse practice was minimal, but greater in males vs females (0.40 ± 0.65% vs 0.01 ± 0.41%; P=0.02). Only one male athlete lost >2% body mass during training. Body mass at 24-h vs 0-h was lower for males (80.76 ± 7.96 vs 81.42 kg; P<0.01) but not different for females (0-h: 64.45 ± 11.60; 24-h: 64.55 ± 11.54; P=0.31). Waking urine specific gravity was not different between days for males or females (day 1: 1.0168 ± 0.0082; day 2: 1.0178 ± 0.0083; P=0.60).
CONCLUSION: The current hydration practices of the lacrosse players included in this study were generally appropriate. Only one male exceeded 2% dehydration at the end of practice with no females exceeding 1% dehydration indicating ad-libitum drinking was sufficient to maintain hydration status and that dehydration is unlikely to impair performance during training. Females maintained body mass over 24-h however this decreased in males, possibly indicating negative fluid balance. Waking urine specific gravity was >1.020 for 6 of 22 and 9 of 20 participants on days 1 and 2, respectively, indicating some players might be under-hydrated despite maintaining hydration status in training.

### REPLENISHING EXERCISE-DEPLETED CARBOHYDRATE STORES USING RECOVERY DRINKS DOES NOT AFFECT SHORT-TERM ENERGY BALANCE RESPONSES

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INTRODUCTION: Exercise is a commonly used tool to favour weight management. However, compensatory responses have been shown to recover most of the energy expended during exercise. The mechanisms by which these compensations happen are not well established. Based on the glycogenostatic theory of energy intake control, reductions in the body´s glycogen stores could trigger increases in energy intake. Thus, carbohydrates replenishment after prolonged overnight-fasted exercising, where glycogen has been reduced, could help to reduce energy compensation. Therefore, the purpose of the present study was to compare the effects of post-exercise high-carbohydrate (HC) and high-fat (HF) recovery drinks on short-term energy balance components in normal-weight people.
METHODS: 12 physically active participants took part in this double-blinded randomised crossover study (10 men, 2 women; age 21 (±2.3) years; VO2peak 56 (±6.4) ml·kg·min-1; body fat 14.38 (±5.68) %. Each participant completed two experimental trials: an overnight-fasted 75-minute running bout with a controlled recovery period during which a recovery drink was provided and a 2.5-day free-living follow-up

period. After the exercise bout, participants consumed one of two isocaloric recovery drinks (HC: 92.2% carbohydrate, 7.3% protein, 0.5% fat; HF: 7 % carbohydrate, 5.3% protein, 87.7% fat; energy content: 1065 (±144) Kcal) designed to replace the energy expended during exercise. Also, they wore an Actiheart device to assess activity energy expenditure (AEE) during the recovery period and for the next 2.5 days. Participants were also provided with food (125% of their estimated energy needs) for the next 2.5 days and asked to eat "as much or as little as they want". A resting metabolic rate (RMR) assessment was performed in the morning on exercise visits. Cumulative energy intake was calculated based on the food energy provided less the food leftovers. Cumulative- AEE and total energy expenditure (TEE) were obtained after the input of the RMR on the Actiheart software.
RESULTS: The mean cumulative energy intake during the free-living follow-up period was 10,521 (± 2,007) in HC and 10,560 (±2,303) kcal in HF (p=0.915). Cumulative TEE was 7390 (±1,480) and 7058 (±1,174) kcal for HC and HF, respectively (p = 0.208). Cumulative AEE was 2345 (±340) Kcal and 2108 (±375) kcal for the HC and HF conditions, respectively (p = 0.098).
CONCLUSION: After exercising, HC or HF recovery drinks did not differentially impact upon short-term effect on energy balance components (cumulative energy intake, AEE and TEE). These results may indicate that a carbohydrate-based energy replacement would not attenuate an energy compensation and that glycogen stores are not strongly implicated in short-term energy balance regulation after exercise.
Funding source: ANID, Chilean National Scholarship programme for graduate studies, CEL00010922.

**SELF-REPORTED SEVERE GASTROINTESTINAL SYMPTOMS ARE NOT PREVALENT IN ELITE FEMALE SOCCER PLAYERS**

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INTRODUCTION: Gastrointestinal (GI) symptoms during exercise are common in female athletes (Parnell et al, 2020). The prevalence and severity of symptoms varies between athletes, yet common symptoms can negatively impact performance and exercise completion. Pre- during- and post-exercise nutritional intake may be altered in an attempt to reduce GI symptoms and prevent performance detriments (Parnell et al, 2020). However, most research has been conducted in female endurance athletes, with limited data in team sport athletes. Therefore, the aim of this study was to identify the prevalence and severity of GI symptoms, and nutrition habits, in elite female soccer players.
METHODS: In this cross-sectional study, elite female soccer players (n= 106) from English, Spanish, and Italian leagues (n= 23, 73, 10 respectively) completed a GI symptom prevalence and nutrition habit questionnaire. Players rated the number and severity (1 (very mild) to 10 (extremely severe)) of GI symptoms experienced during soccer training and matches. Any symptom rated >4 was classified as severe. Questions on pre-exercise nutrition habits and food/drink avoidance were also included. Chi-square tests were used to determine relationships between nutrition habits and number of GI symptoms.
RESULTS: During training and matches, 20% and 13% of players experienced one GI symptom, and 8% and 12% of players reported experiencing two GI symptoms, respectively. Five players (5%) reported experiencing three or more symptoms during both training and matches. During training, flatulence (n=12), bloating (n=12), heartburn (n=11) and belching (n=11) were the most common symptoms. Eight players ranked the severity of the symptom as severe. During matches, bloating (n=15), flatulence (n=8), defecation (loose stool) (n=7), and stomach pain (n=6) were the most common symptoms. Ten players ranked the severity of the symptom as severe. A total of 28% and 35% of players reported regularly avoiding certain foods/drinks to prevent GI symptoms; this was most commonly high fat foods. Caffeine was frequently ingested prior to both training and matches but was not associated with the number or severity of GI symptoms experienced ($X2(8,n=110)=8.9$, $P=0.350$).
CONCLUSION: Most (70%) elite female soccer players do not experience GI symptoms during training and/or matches. The severity of GI symptoms experienced during training and matches was generally low but highly individual. The impact of mild GI symptoms on soccer specific performance warrants further investigation.

## Conventional Print Poster

### CP-MH09 Ageing and exercise interventions

**EFFECTS OF A REAL-TIME VIDEOCONFERENCE-BASED EXERCISE PROGRAM ON THE MUSCULOSKELETAL PAIN OF ELDERCARE WORKERS: PRELIMINARY RESULTS OF A RANDOMIZED CONTROLLED TRIAL**

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INTRODUCTION: The prevalence of musculoskeletal pain is high among eldercare workers. Exercise interventions have been shown to be able to reduce musculoskeletal pain in the workplace. However, exercise interventions in eldercare workers are scarce, and none of them have used the videoconference modality. Thus, the aim of this study is to assess the effects of a real-time videoconference-based exercise (RVE) program on the musculoskeletal pain of eldercare workers.
METHODS: A randomized controlled trial is being carried out (ClinicalTrials.gov code: NCT05050526). Inclusion criteria are the following: formal eldercare workers, aged 18 years or more, minimum 3 months of experience in the profession, employment contract until the date of study completion. Eldercare workers are randomly assigned in a 1:1 ratio to a control or experimental group. Participants in the control group do not receive any intervention, and participants in the experimental group take part in a 12-week supervised RVE program consisting of two weekly 45-minute sessions. Primary outcome measure is average pain intensity in the low back during the last 7 days, measured by an 11-point numerical rating scale. Secondary outcomes include validated questionnaires and tests to collect additional measures of musculoskeletal pain (average intensity, worst intensity, frequency and interference with work for pain in the low back, neck, shoulders and wrists/hands), psycho-affective state (happiness, anxiety, depression, burnout, sleep quality, health state), work-related variables (work ability, work performance, physical exertion at work, absenteeism), and physical fitness (muscle performance of lower limb, upper limb and trunk). Assessments are conducted at baseline, at 3 months (post-intervention) and 1 year (follow-up) from the beginning of the

intervention. Intervention effects are analyzed with a group by time ANCOVA including baseline measurements as covariate. The level of statistical significance is set at p <0.05.
RESULTS: 42 participants have completed the baseline and 3-month (post-intervention) assessments. A non-significant effect favoring the experimental group has been observed for the average intensity of pain in the low back (p=0.140). Significant effects favoring the experimental group have been observed for the interference with work of pain in the low back (p=0.003), average intensity, worst intensity, frequency and interference with work of pain in wrists/hands (p=0.028, p=0.035, p=0.045 and p=0.021, respectively), physical exertion at work (p=0.042) and muscle performance of the upper limb (p=0.027).
CONCLUSION: The RVE program seems to be able to improve several parameters of musculoskeletal pain in eldercare workers. Additionally, improvements in physical exertion and upper limb performance have been observed. However, it is necessary to increase the sample until reaching the required size to draw definitive conclusions.

### EFFECTIVENESS OF EXERCISE INTERVENTIONS TO IMPROVE LONG-TERM PATIENT-RELEVANT COGNITIVE AND NON-COGNITIVE OUTCOMES IN PATIENTS WITH MILD COGNITIVE IMPAIRMENT - PRELIMINARY RESULTS

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INTRODUCTION: Patients with Mild Cognitive Impairment (MCI) have an elevated risk of developing dementia and burden of disease may be substantially reduced by delaying its onset. The aim of this project is to systematically review the literature to assess the effectiveness of exercise interventions according to patient relevant endpoints to improve long-term cognitive and non-cognitive outcomes in patients with MCI. Study registration: CRD42021287166
METHODS: MCI patients were involved in a workshop prior to study selection to define outcomes most relevant to them. Searches were performed in MEDLINE, Embase, CINAHL, SPORTDiscus, CCTR (Cochrane) and PsycInfo from 1995 to November 2021. Eligible were RCTs comparing 6-months+ exercise interventions with sham-exercise or active (but not physically active) controls. Studies were included if they reported any patient-relevant cognitive and non-cognitive long-term (12 months+) outcome in adults (50+ years) with MCI (all causes). Study selection, data extraction, risk of bias assessment was conducted in dual-review mode. Reporting quality of the exercise interventions was assessed using the Consensus on Exercise Reporting Template. Meta-analyses are planned if studies are homogeneous enough otherwise results will be presented narratively. Project data will be made available open access (10.5281/zenodo.5589277). Research findings will be translated into a patient-friendly video format for dissemination through Alzheimer Gesellschaft Hessen to reach patients and families concerned.
RESULTS: MCI patients rated non-cognitive, motivational and behavioural endpoints as well as psychosocial and physical functioning as most important outcomes to include in research. From 3986 studies identified, 13 studies were included at the time of abstract submission. Authors will have finished data extraction, synthetization and analysis by July 2022. Final results will be presented at the conference. The results will inform professionals in primary care about the effectiveness of exercise interventions and facilitate the translation from those research findings with a good reporting standard of exercise intervention details into evidence-based exercise recommendations for patients with MCI.
CONCLUSION: To enhance practical relevance of systematic reviews, we conducted an evidence synthesis that 1) gauged the extent of potential research waste caused by inadequate reporting of exercise intervention details and caused by reporting patient-irrelevant outcome parameters and 2) included both cognitive and non-cognitive outcomes to understand whether exercise effectively improved the health of MCI patients in the long run, as exercise regimens in real life are to be maintained and initiated by patients themselves. We made every effort to ensure that the results of this work are based on data that is both relevant to MCI patients and that general practitioners and their teams are able to apply in their practice routines to recommend exercise to those at risk of dementia.

### IMPLEMENTATION OF A MULTICOMPONENT INTERVENTION FOR THE PREVENTION AND REDUCTION OF PHYSICAL STRAIN IN ELDERLY CARE

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INTRODUCTION: Health promotion is of particular relevance in the care of the elderly due to the increasing number of multimorbid residents, resulting in high physical and psychological strain associated with an increasing prevalence of back pain. Therefore, workplace health promotion programs for this target group are of utmost interest to secure the work capacity (van Hoof et al., 2018). The present study investigates the effects of ergonomics training (10 weeks) and back fitness training (12 weeks, BASE program; Wollesen et al., 2016) on ergonomic movement behavior, strength endurance of the lumbar extensors, low back pain, and functional impairment caused by back pain.
METHODS: The randomized controlled trial was conducted in two nursing homes and included n= 22 in the intervention and n= 20 nurses in the control group. The analysis combined physical tests with questionnaires (Progressive Isoinertial Lifiting Evaluation, PILE-Test; Biering-Sørensen-Test; Visual Analog Scale Pain, VAS; Oswestry Disability Index, ODI). Group differences were tested using Chi2-Tests, ANOVA, and Linear Mixed Models (SPSS 27).
RESULTS: The analysis showed significant differences between the intervention and control group in the lifted weight during the PILE-Test (95% CI, 1.378-7.810, p= .006) with fewer terminations due to dysfunctional posture (Chi2= 9.531, p= .002). In addition, the analysis revealed significant differences between both groups in back pain (95% CI, -1.987 - -0.034, p= .043). However, there were no differences in the functional impairment caused by back pain (ODI) and the test time regarding the Biering-Sørensen-Test.
CONCLUSION: The tailored multicomponent program (ergonomics plus strength training) improved intervention group nurses' lifting performance, illustrated by higher lifted weight and increased test aborts due to muscular fatigue. In addition, the analysis showed positive effects on back pain. The positive results are essential to derive specific recommendations for effective prevention in elderly care nurses. Furthermore, the results can be completed in future research with additional strategies for pain reduction, ratio prevention, and work situations.
REFERENCES
van Hoof, W., OSullivan, K., OKeeffe, M., Verschueren, S., OSullivan, P., Dankaerts, W. (2018). The effi-cacy of interventions for low back pain in nurses: A systematic review. International Journal of Nurs-ing Studies, 77, 222–231.

Wollesen, B., Menzel, J., Lex, H., & Mattes, K. (2016). The BASE-Program—A Multidimensional Approach for Health Promotion in Companies. Healthcare, 4 (4), 91.

**THE IMPACT OF MULTIMORBIDITY PATTERN ON PHYSICAL ACTIVITY AND PHYSICAL CAPACITY IN OLDER ADULTS PARTICIPATING IN A YEARLONG EXERCISE INTERVENTION**

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INTRODUCTION: Multimorbidity compromises physical activity (PA) and physical capacity (PC). Exercise may improve both, but the impact of multimorbidity pattern on these benefits is sparsely studied in older adults. The aim was to determine the impact of multimorbidity pattern on development of PA and PC during a yearlong exercise intervention, and on PA one-year post-intervention.
METHODS: Participants were 314 physically inactive community-dwelling older adults (60% women, 74.4±3.8 years) who did not have severe chronic conditions compromising exercise safety. Physician-diagnosed conditions were classified into 17 categories. Obesity was assessed with body mass index (BMI). Current PA was assessed with a one-item, 7-scale questionnaire at baseline (bl), 6 months (6m) and 12 months (12m), and after one-year follow-up (fu). PC measurements included five-time chair-stand time and six-minutes walking distance (6MWD) at bl, 6m, and 12m, and maximal isometric knee extension strength (KE) at bl and 12m. Intervention included supervised (twice weekly) and home-based progressive strength, balance, and walking exercises. Generalized estimating equation models were used to analyze the impact of multimorbidity pattern including chronic conditions as a predictor cluster and obesity on development of outcomes over time in men and women separately, adjusted for age.
RESULTS: Participants had on average two chronic conditions and BMI 27.9±4.7 kg/m2. Multimorbidity pattern had a small but significant impact on development of PA and all PC outcomes across all time-points in men (Chi-squared for multimorbidity-by-time interaction=28.90 to 358.87, df=18, p<0.001 to 0.050) and women (Chi-squared=26.92 to 111.40, df=16, p <0.001 to 0.042), except chair-stand at 6m in women (p=0.277). Time-point specific effect sizes ranged from <0.01 to 0.03.
Among men, diabetes associated with greater increase in PA at all time-points (condition-by-time interaction B=0.74 to 1.17, p=0.002 to 0.033). At 12m, chronic musculoskeletal disorders associated with less improvement in 6MWD (B=-23.42, p=0.043) and arthritis with less improvement in KE (B=-2.83, p=0.015). Among women, pulmonary disease associated with less increase in PA at all time-points (B=-0.60 to -0.86, p=0.003 to 0.005). At 12m, arthritis associated with less increase in PA (B=-0.49, p=0.018), but with greater improvement in chair-stand (B=-1.41, p=0.007). Hyperlipidemia associated with greater and cardiovascular disease with less improvement in KE (B=1.59, p=0.037 and B=-2.54, p=0.006, respectively).
CONCLUSION: Multimorbidity pattern had a significant yet very small impact on physical activity and physical capacity in a yearlong exercise intervention among community-dwelling older adults without contraindications for exercising. The impact of specific conditions varied by sex and outcome, but most conditions had no impact on the intervention effects. Multimorbid older adults may benefit from multicomponent exercise almost as much as healthier peers.

**HOW TO ENHANCE SPATIAL ORIENTATION IN NURSING HOME RESIDENTS: DEVELOPMENT AND FEASIBILITY OF A MULTICOMPONENT SPATIAL ORIENTATION TRAINING**

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INTRODUCTION: Spatial abilities, including orientation in and navigation through the environment, are known to deteriorate with age. While spatial orientation skills maintain relatively safe in familiar environments, they decrease notably in unfamiliar environments with increasing age (Colombo et al., 2017). Due to multimorbidity, some older persons need to be hospitalized in nursing homes and therefore experience an unfamiliar environment. Studies showed that their range of action is limited, leading to low physical activity and social interaction, and, as a consequence a lack of physical and cognitive stimulation (Schrempft et al., 2019).
METHODS: Since cognitive-motor training counteracting the decline of spatial orientation abilities has been rarely implemented for nursing home residents, a two-step process for the development of such training was conducted:
As a first step, a systematic literature search was conducted on spatial orientation interventions and exercises for healthy older adults. In the next step, six existing spatial orientation exercises were specifically adapted to the nursing home residents needs and integrated into an established group cognitive-motor training program. The training was monitored using systematic observations by an independent person, addressing the training modalities, comprehensibility of instructions, exercise performance, motivation, and the duration of performance of each orientation exercise. Additionally, pre-and-post measurements of mobility and life satisfaction were conducted.
RESULTS: N=40 nursing home residents (87.3 ± 7 years, 80 % female) participated in a total of 24 training sessions (twice per week, 45-60 minutes each) to promote spatial orientation. The feasibility analysis revealed that future interventions should consider that instructions of demanding spatial tasks should be accompanied by an example task, trainers should be encouraged to adjust task complexity and materials on an individual basis, acceptance of the training should be promoted among nursing staff, and surroundings with as little disturbance as possible should be selected for training. A positive trend was discerned for mobility and life satisfaction, comparing pre-and post-training data.
CONCLUSION: This trial resulted in an everyday-like, target group-specific training program for the promotion of spatial orientation abilities. To evaluate the training's effects a three-arm controlled-randomized trial is corrently conducted in 18 nursing homes. This study is expected to be completed by the end of 2022.
References:
Colombo, D., Serino, S., Tuena, C., Pedroli, E., Dakanalis, A., Cipresso, P., & Riva, G. (2017). Egocentric and allocentric spatial reference frames in aging: A systematic review. Neuroscience and Biobehavioral Reviews, 80, 605–621
Schrempft, S., Jackowska, M., Hamer, M., & Steptoe, A. (2019). Associations between social isolation, loneliness, and objective physical activity in older men and women. BMC public health, 19(1), 1-10.

### TWO-WEEK REDUCED PHYSICAL ACTIVITY HAS LIMITED NEGATIVE EFFECTS ON FUNCTION AND HEALTH IN OLDER ADULTS

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INTRODUCTION: Punctuated declines in physical activity of older adults has been posited as a key factor accelerating the progression of sarcopenia [1], but direct assessment of this phenomenon in experimental settings is sparse with two studies out of three showing decreases in lean leg mass but no detriment in functional capacity after 2-week step-reduction (~1000 daily steps) [2]. The present study determined the effects of a 2-week step-reduction (simulating periodic low physical activity) then 4-week training period on functional capacity, body composition, and metabolic health in healthy, physically active older adults.
METHODS: Accelerometers tracked daily steps of 66 healthy older adults (72.6±2.7y) throughout the study. Participants were randomized into a step-reduction/gym training (intervention) group (n=32) or a control group (n=34); who continued living as usual. After the two-week period, intervention participants then underwent 4 weeks of gym-based training 4 times per week. Measurements were performed at baseline (PRE), after two weeks (MID), and after six weeks (POST) of the study. Functional capacity was assessed by maximal bilateral isometric leg extension force (MVC), 5 × sit-to-stand (STS), 10-step stair-climb, and normal and maximal 4m walking speed. In a fasted state, body composition was assessed by dual-energy X-ray absorptiometry and metabolic health by clinical blood biomarkers.
RESULTS: Significant Time(3)*Group(2) interactions were observed for step count ($F = 86.5$, $P < 0.001$), MVC ($F = 4.96$, $P = 0.009$) and HDL-C concentration ($F = 3.467$, $P = 0.041$). In the intervention group, steps decreased from PRE to MID (8287±2907 to 2261±718, $P < 0.001$) and rebounded at POST (6328±2214, $P < 0.001$), as did HDL-C (PRE to MID: 1.61±0.37 to 1.53±0.36 mmol/L, $P = 0.045$; MID to POST: 1.68±0.37mmol/L, $P = 0.002$). MVC did not change PRE to MID but increased from MID to POST (1925±591 to 2213±703N, $P = 0.001$). No other significant interaction was observed, although STS was close to being significant (Time*Group: $F = 3.031$, $P = 0.059$), with the intervention group improving MID to POST (8.3±1.2s to 7.9±1.1s, $P < 0.001$).
CONCLUSION: Two weeks of low daily steps (<2500) did not deteriorate total body composition nor performance of functional capacity measures, but MVC and STS were improved by gym-based training. Of the blood-based markers, HDL-C was most responsive to both physical inactivity and re-activity. Thus, it appears that short-term reduced physical activity (e.g. due to illness, inclement weather, quarantine) is not majorly detrimental to older adults' health status. Changes observed in HDL-C after step-reduction are reversible and maximal functional performance is improved through systematic, supervised training.
REFERENCES:
1. Oikawa et al. 2019. Front Nutr. 24:6:75.
2. Bowden Davies et al. 2019. Ther Adv Endocrinol Metab. 10:1-15.
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### PHYSICAL ACTIVITY CAN INFLUENCE FUNCTIONALITY, MUSCLE MASS AND QUADRICEPS STRENGTH IN COMMUNITY-LIVING OLDER PEOPLE WITH OSTEOARTHRITIS

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INTRODUCTION: Autonomy loss related to age is associated with joint function loss, mostly due to several pathologies that compromise their mobility and physical activity, such as osteoarthritis (OA). The aim of this study was to analyze the presence of OA in an elderly Portuguese population study and identify the influence of physical activity levels on functionality, muscle mass and quadriceps strength.
METHODS: A prospective, observational secondary analysis of data from the "Sarcopenia Screening Study in the Algarve Region" was performed. This study had the purpose of studying the effects of sarcopenia on fall risk, body composition, general health, and quality of life in older people and it was funded by the European Regional Development Fund (FEDER) through the PSL Project – Programme for a Long-lived Society (0551_PSL_6_E) - INTERREG V-A Cooperation Program, Spain-Portugal, (POCTEP), 2014-2020.
The quadriceps strength was calculated through the peak torque (PT) on a Humac Norm® dynamometer, the Lower Extremity Functional Scale (LEFS) was used to measure the functional level, the % of muscle mass was measured by bioimpedance, and Physical Activity Scale for Elderly (PASE) was used to measure the physical activity level (PAL).
RESULTS: Community-dwelling older adults (n = 217) were analyzed mean age 75.3±0.4 years (73.3% female; 26.7% male). In the studied sample pain comes as the most common health problem (73%) followed by osteoarthritis (60.4%) and hypertension (60%). Analyzing the subjects that met the NICE diagnose criteria for OA (n=131) with the 2 step-cluster classification multivariate technique, two large groups of OA patients (G1, n=73 and G2, n=58) strongly differentiated were created, hierarchically due to level of PAL and age.
Through a t-test we captured significant associations ($p \leq 0.05$) between the previous profile G1 (PAL=104.5±6.0) and G2 (PAL=169.4±8.2) with functionality (46.1±13.2; 53.6±14.2), % of muscle mass (22.9±3.7; 25.1±4.3) and quadriceps strength (51.8±20.6; 67.2±26.7). It was interesting to verify that both groups have moderate/severe pain most of the days and overweight, without significant differences.
CONCLUSION: Although both G1 and G2 subjects state to have the same level of pain and same body mass index, through the cluster analyses it was possible to verify that the G2 subjects are physically more active. Being physically active has a positive influence on functionality, % of muscle mass and quadriceps strength in elderly community living subjects. Our results show that although none of our subject were enrolled in any special exercise program for OA patients, general community exercise programs and active daily lifestyles have also a positive effect on physical health in OA elderly subject. It is essential to reinforce the importance of physical activity in maintaining functional capacity.

### IMPACT OF 14 DAYS OF HEAD-DOWN TILT BED REST, AND AN EXERCISE COUNTERMEASURE, ON MUSCLE PROTEOMICS IN OLDER ADULTS

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INTRODUCTION: The muscle is a highly plastic tissue and adapts quickly to contractile activity or lack thereof. Hence, long-term immobilization, as can be the case in the context of hospitalization, often leads to muscle atrophy and loss of function. Aging individuals are particularly at risk and the repercussion of long-term immobilization can alter one's autonomy. Previous studies have shown a complex proteasomal activity during early and late bed rest in young healthy male participants, but the impact of an exercise countermeasure on the

proteasomal activity of bedridden older adults has never been determined. The objective of this study was thus to verify how a head-down tilt bed rest (HDBR), with and without an exercise countermeasure, affected the proteasomal activity during the mid and late stages of bed rest. Furthermore, we wanted to determine how the changes in muscle strength correlated with changes in proteasomal activity.
METHODS: Healthy older adults (male: 9; female: 11) aged 55 to 65 years old underwent 14 days of 6˚ HDBR. Participants in the experimental group were engaged in an exercise countermeasure and participated in an hour of daily exercise comprising continuous aerobic, high-intensity interval aerobic and both upper and lower-body strength training. The control group remained inactive but received manual therapy from a trained physical therapist to limit discomfort. An isoenergetic diet, with a protein intake of 1.2g/kg/day was given to participants, and energy expenditure associated to exercise was accounted for. Muscle strength of the knee extensors was taken at baseline and after HDBR. Muscle biopsies were taken on the vastus lateralis at baseline, 8 days into and on the last day of HDBR. Muscle proteomic was analyzed through liquid chromatography and tandem mass spectrometry.
RESULTS: A total of 20 individuals (control: 9; Exercise: 11) completed the bed rest period. Fourteen days of HDBR resulted in a 13,7 ± 8,7% decline in knee extensor strength in the control group and a 9,8 ± 8,8% decline in the exercising group (p=0.348). Proteasomal activity has not yet been fully analyzed and the full data will be presented at the ECSS conference.
CONCLUSION: One hour of daily exercise does not seem to be sufficient to mediate the loss of muscle function induced by 14 days of HDBR. Proteasomal activity will inform how cellular processes are affected by exercise during the mid (day 8) and later (day 14) stages of bed rest. Better understanding these cellular processes in bedridden older adults will help tailor new interventions to limit the deleterious impact of long-term immobilization.

## Conventional Print Poster

### CP-SH03 Cognition

#### THINK AND DO. MOTOR RATHER THAN COGNITIVE PERFORMANCE IS IMPAIRED IN DUAL-TASK SITUATIONS IN PRE-SCHOOL CHILDREN.

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The ability to perform two tasks at the same time, also known as dual-tasking, is crucial to cope with many tasks of our daily life. Most importantly, we have to take in and process a lot of information, and make decisions on the go (e.g. during walking, playing, and working). While growing evidence suggests that our dual-tasking ability is impaired in late adulthood, little is known of how young children perform in dual-tasking situations. The present study examined whether preschool children are able to deal with dual-task demands, and whether they would prioritize motor or cognitive demands during dual-task situations. Thirty-two preschool children (20 girls, mean age = 71.6 ± 4.0 months) were tested individually in their daycare facilities. All participants completed a manual dexterity task (Purdue Pegboard) under single and dual-task conditions. In dual-task conditions, children were confronted with either a working memory task (n-back) or an attention and inhibition task (AX-CPT task) that had to be performed concurrently to the motor task. Our data revealed that manual dexterity performance was negatively affected by both the n-back task (mean difference = 1.84; Cl: 0.92, 2.77; $p < 0.001$) and the AX-CPT task (mean difference = 1.52; Cl: 0.39, 2.63; $p = 0.002$). However, while also AX-CPT performance was reduced under dual- as compared to single-task conditions ($p < 0.001$), n-back task performance was not affected during dual-tasking ($p = 0.69$). These results suggest that preschool children are able to deal with dual-task demands with dual-task costs being between 7.6% and 9.4% for the motor task. As expected, motor performance was more affected by dual-task demands than cognitive performance, what may be explained with the nature of the tasks, the developmental stage of the children or the bottleneck theory. Considering the latter, the fact that both manual dexterity and working memory performance were reduced when being performed simultaneously provides further evidence that both are functionally linked at this age and draw on the same neuronal resources.

#### PROFICIENCY DIFFERENCES IN ANTICIPATION SKILLS REVEALED BY NEWLY DEVELOPED COGNITIVE-MOTOR TASK

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INTRODUCTION
In many sports, players gather information in a changing external environment and accurately anticipate their opponents' and teammates' following actions. Integrating time-varying information over time and reflecting it in anticipation is essential for superb performance. Here, the present study examined the differences in anticipation accuracy between expert and novice football players by focusing on the temporal changes in anticipation using a task to anticipate the course of a pass in football.
METHODS
Twelve students (males football players belonging to the first division of the Kanto University Football League in Japan) participated as the expert group. Twelve students (males with no specialized football experience) participated as the novice group. Nineteen videos were created using actual football game scenes. Each video duration was 10 s. The final scene in each video was stopped at the moment the player made a pass. After stopping a video, the participants were required to quickly anticipate the player to be passed and move their cursor using a pen-tablet toward the player within 2000 ms. Temporal changes in cursor position were obtained as the coordinates of a cursor projected on display. The distances between the cursor and the correct player to be passed were calculated at nine temporal segments (-2000, -1500, -1000, -500, 0, 500, 1000, 1500, and 2000 ms, where 0 ms indicates the timing when the video stopped). We compared the distances between the expert and novice players. A two-way ANOVA (2 [skill group] × 9 [time segment]) for the distances was performed. The correct response trial was defined as the distances within 50 pix at 2000 ms. A Pearsons correlation analysis was performed between the distance at 0 ms and the correct response rate among participants to examine the relationship between the early anticipations and the final responses.
RESULTS
The expert players moved closer to the correct ball receiver at 2000 ms ($p < .05$) compared to novice players. Moreover, the experts moved closer to the correct ball receiver at the start of the response period (0 ms) compared to the novice players ($p < .05$). There was a signifi-

cantly negative correlation between the distance at 0 ms and the correct response rate ($r = -0.50$, $p < .05$), indicating that the closer to the correct ball receiver at 0 ms, the higher the task accuracy.
DISCUSSION
The results indicate that expert soccer players complete their anticipations earlier than novice players. Moreover, the relationship between cursor position in the early task phase and the final anticipative accuracy suggested that narrowing down potential options earlier using information (such as game flow and players' placement) is essential for high anticipative accuracy within a limited time frame. Future studies are required to clarify the details of information gathering and movement preparation to achieve faster and more flexible anticipations.

### HOW OPEN- AND CLOSED SKILLS ATHLETES ADAPT DECISIONS TO AN UNCERTAIN ENVIRONMENT WITH AND WITHOUT A STRESSFUL CONDITION.

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INTRODUCTION: Athletes must decide their actions under stressful situations. These abilities could also be transferred into a general domain (1, 2). Thus, the present research analyzed the decision-making processes of athletes in an uncertain environment and how they acted when exposed to stressful situations.
METHODS: Participants:
24 élite open-skills athletes (OSA; M age = 17.71 ± 1.02 y.o.), 13 élite closed-skill athletes (CSA; M age = 21.40 ± 3.55 y.o.) and 36 non-athletes ( (M age = 23.56 ± 1.57 y.o.) were recruited.
Instruments:
A reinforcement learning probabilistic task (3) with three levels of uncertainties (i.e., low, medium, and high) was employed. Participants had to score as many points as possible. The task was performed, in counterbalanced order across participants, two times: one in standard condition (SC) and one Under Pressure (UP). Heart rate was monitored. Several indexes, such as the Spatial Error (i.e., the ability to predict future events), the Gain (the ability to maximize the score), and the implicit decision confidence (through the bet on the decisions), were evaluated to examine the possible differences among the sport type (OSA vs CSA). The confounding factor of fluid intelligence was controlled (Raven-APM [4]) due to the possible relation between intelligence and decision-making.
Data analysis:
Linear mixed-effect regression for each index was performed. The independent variables were: sport type, condition, and level of uncertainty. Intelligence was set as a covariate variable. The subject was the random effect. Heart rate and mental effort analysed the effect of stressful condition.
RESULTS: Mental effort and heart rate analysis reported that they were higher in UP compared to SC. Spatial Error results revealed an effect of intelligence ($p < .001$) only when the uncertainty was low and in SC ($p < .05$). Even if the triple interaction level of uncertainty x sport type x condition was significant ( $p < .001$), sport type did not influence the ability of predicting events ($p > .05$). Gain results revealed triple interaction level of uncertainty x sport type x condition was significant ( $p < 0.01$). However, the post-hoc analysis highlighted an improvement of the score from SC to UP condition in the low uncertainty environment for the control group; while in medium uncertainty for OSA. Confidence analysis highlighted triple interaction level of uncertainty x sport type x condition was significant ($p < .001$). Post-hoc results showed that only OSA modulated the bet between the two conditions when the uncertainty was low and high ($p < .05$).
Conclusion
Sport type did not influence the performance of this perceptual-decision task. However, the perception of the risk changed in UP. Specifically, OSA seemed to behave conservatively when exposed to a stressful situation. Moreover, the results indicated that intelligence could help to predict events.
1Voss et al.(2010);2Chaddock et al.(2011);3Larsen&Coricelli(2017);4Raven(199)

### EFFECT OF ATTENTIONAL FOCUS ON MENTAL EFFORT IN MOVEMENT EXECUTION: A META-ANALYSIS

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INTRODUCTION: The majority of academics agree that mental effort is undesirable and that it originates from limitations in our subjective ability to exert control over task execution [1], but fortunately, external focus (EF; i.e., concentration on the intended movement effect) has been demonstrated to be more cost-efficient than internal focus (IF; i.e., concentration on the body movements) in mental efforts during movement execution [e.g., 2, 3, 4]. The present study aimed to synthesize previously available research investigating the intervention of EF vs. IF on mental effort during movement execution and to explore one perplexing issue about the effect (i.e., is the attentional focus effect in mental efforts the same between the experienced and novices?)
METHODS: This meta-analysis was performed based on the PRISMA guidelines [5]. Original research publications were searched in four electronic databases (APA PsycINFO, PubMed, SPORTDiscus, and Web of Science). Peer-reviewed research was considered eligible if it met all of the following criteria: (a) the participants were all healthy individuals, with an average age of more than 18 years; (b) an EF instruction was employed; (c) an EF was compared to an IF; (d) after the movement execution, the mental effort was measured immediately (e.g., ratings of perceived execution, mental demand, self-reported effort, and subjective rating of execution). The risk of bias in eligible studies was assessed using the Cochrane Risk of Bias Tool (RoB 2.0). A random-effects model was performed to pool Hedge's g with 95% confidence intervals. Subgroup analysis was performed to compare the attentional focus effect between different skill levels (the experienced vs. novices).
RESULTS: Overall, sixteen studies with 414 participants were found to meet the inclusion criteria. Results demonstrated an EF condition cost less mental efforts than an IF ($g = 0.210$, 95% CI [0.059, 0.361], $p = .006$) in the process of performance execution. The subgroup analysis suggested the cost advantage of EF in mental efforts might be weaker in novices ($g = 0.070$, 95%CI [-0.145, 0.284], $p = .524$) than that in the experienced ($g = 0.314$, 95%CI [0.126, 0.503], $p = .001$).
CONCLUSION: Although the reported attentional focus effect in managing and alleviating mental efforts is small, the result is significant in theory and practice, which reveals the instruction of external focus could be developed into reducing execution effort costs, making optimal use of the limited mental efforts, and promoting movement economy in motor control.
REFERENCES:
1) Shenhav et al., Annu Rev Neurosci, 2007

2) Lohse & Sherwood, Front Psychol, 2011
3) Hill et al., J Sport Exerc Psychol, 2017
4) Schücke et al., J Sports Sci, 2009
5) Page et al., Int J Surg, 2021

**VISUAL PERCEPTION IN ROCK CLIMBERS**

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As climbers ascend, their perspective change, as it does their perception of the holds they use to climb up the route; the visual system is persistently perceiving and processing information. The purpose of this study was to examine the visual perception in expert climbers through a psychophysical optical test in a cross-sectional study. Given the lack of research, we adopted a cross-sectional design whereby authors suggested that either (a) the climbers for whom the difference between their on-sight and red-point climbing levels was small (similar on-sight and red-point levels) would perform better at the psychophysical optic tests. That is, the visual hardware system would be further developed in climbers whose on-sight climbing skills are similar to red-point skills. Or, the opposite, that (b) the climbers for whom the difference between their on-sight and red-point climbing levels was large (better red-point climbing levels) would perform better at the psychophysical optic tests. That is, the visual hardware system would be further developed in climbers whose climbing skills are better. Twenty-eight male participants with an IRCRA best on-sight level between 18-27 and a best red-point level between 18-29 completed a series of psychophysical optic tests assessing their visual field, visual acuity, and contrast sensitivity. Climbers were divided into those whose rock climbing level gap between on-sight and red-pointed best leads was small (on-sight 20.17 +/- 1.80; red-point 20.50 +/-2.02) and those whose climbing level gap was large (on-sight 21.86 +/-3.23; red-point 24.21 +/-3.4). The group whose climbing level difference was large had more years of training experience (10.36 +/-6.18 years) and best red-pointed lead level (24.21 +/-3.4 IRCRA) than those whose climbing level difference was small (6.25 +/-2.63 years of training and 20.50 +/-2.02 IRCRA red-pointed level). Better visual perception outputs were produced by the group of climbers with a large difference between climbing levels in visual field tests; no differences were observed between the two groups for visual acuity and contrast sensitivity tests. Overall, findings indicate that best climbers performed better at the visual perception tasks testing their visual field. Regarding our visual field findings, we found an interesting difference between the performance of climbers at both tests (lower vs. upper). The group with a large difference between on-sight/red-point level showed superior upper visual field perception than those whose difference between climbing levels was small; thus, better climbers had a more-developed upper visual field than their counterparts. Such better perception from best climbers is discussed given (1) the greater time they spend coercing the visual system during practicing and (2) the specific complexity of the stimuli as they are confronted to harder routes where holds are less perceptible and the time to find best hold sequences is constrained.

**THE ROLE OF AGE IN THE EVALUATION OF HEAVINESS PERCEPTION**

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Background
Physiological aging causes changes to motor and sensory systems that impact on the individual's functional independence. Muscle weakness is one of the mostly documented and it is at the origin of impairments in instrumental activities of daily living (IADL) (1), also because it determines proprioceptive dysfunctions (2), which likely alter the sense of effort and heaviness (3). Lifting an object is a common IADL, as well as observing an individual as he moves an object and passes it to us. In order to receive the object without getting hurt, the individual must be able to predict its weight and implement compensatory strategies. An altered sense of effort and heaviness might impair the ability to judge the weight of an object moved by another person. The purpose of this study is to clarify the role of age in the perception of object weight when looking at an individual performing an IADL.
Methods
Thirty-seven participants were enrolled and assigned to two groups according to their age, young adults (n=19, mean age = 24±5 years) and older adults (n=17, mean age: 74±7 years). The ability to perceive the heaviness was evaluated by means of a weight-discrimination task during which participants observed a couple of videos showing an actor lifting a box in a concentric and eccentric condition. The observer had to evaluate in which video the box was heavier. The video showed 7 different loads (0, 2.5, 5, 7.5, 10, 12.5, 15 kg). The 7.5kg-video was shown in every trial as the reference stimulus. A psychometric curve was built with participants' responses. The parameters of the curve were computed to describe the performance of the two groups. Young and older adults' performances were statistically compared by means of the Mann-Whitney test.
Results
In concentric condition, the upper asymptote, which gives information about the ability to discriminate the heavier loads, was significantly lower (p=0.026) in the older adults. In the eccentric condition, the lower asymptote, which gives information about the ability to discriminate the lighter loads, was significantly higher in the older adults (p=0.026) as well as the slope of the curve, which provides clues about the ability to discriminate both light and heavy loads) (p=0.014).
Conclusion
The present results showed that the perception of object heaviness in older adults compared with young subjects is altered. These findings suggest that age plays a key role in weight perception, affecting the ability to adequately assess loads.
Bibliography
1. T. Rantanen, et al., Muscle strength as a predictor of onset of ADL dependence in people aged 75 years. Aging Clin. Exp. Res. 14, 10–15 (2002).
2. A. A. Butler, et al., Muscle weakness impairs the proprioceptive control of human standing. Brain Res. (2008).
3. U. Proske, S. C. Gandevia, The Proprioceptive Senses: Their Roles in Signaling Body Shape, Body Position and Movement, and Muscle Force. Physiol. Rev. 92, 1651–1697 (2012).

### EXPLORING THE IMPACT OF DIVERSE STRESS FACTORS (MENTAL & PHYSICAL FATIGUE) ON LOWER COGNITIONS (ATTENTION, ANTICIPATION, AND VISUAL PERCEPTION) IN HEALTHY, ACTIVE, YOUNG ADULTS.

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Various studies have shown that physical and mental stress can have a detrimental effect on decision-making behavior and executive functions in athletes. However, existing findings are still ambiguous in how far stress negatively affects lower cognitions like attention and visual perception. Therefore, the aim of the present study was to explore the impact of different stress factors (mental and physical fatigue) on lower cognitions in healthy, active, young adults. 30 participants (21 men, nine women, Mage 22,8; SD = 2,35) completed three different fatigue conditions over a three-week period: no fatigue, mental fatigue (30-minute Stroop-Test) and physical fatigue (gradual individual stress test up to exhaustion on an ergometer). Cognition functions were assessed after completion of each fatigue protocol. Lower cognitions were tested using the Posner-Reaction-Task (attention), a Stop-Signal-Task (inhibition/anticipation), and a Pattern-Comparison-Task (visual perception). First, our data confirmed a significant reduction in perceived physical and mental performance in physical and mental fatigue conditions respectively. Performance in mental and physical fatigue conditions differed significantly from the no fatigue condition after stress was induced (VAS mental-performance: $F(2,58) = 19.86$, $p = <.001$, $\eta2 = .406$; BORG-Scale: $F(2, 58) = 66,95$, $p = <.001$, $\eta2 = .698$). A repeated-measures ANCOVA revealed a significant condition effect for inhibition/anticipation (SSRT integration) in the stop-signal task ($F(1.5, 50) = 3.66$, $p = .047$, $\eta2 = .128$), but no significant differences between conditions for attention ($F(2, 50) = 1.403$, $p = .255$, $\eta2 = .053$) and visual perception ($F(2,52) = .891$, $p = .416$, $\eta2 = .033$). The significant effect on inhibition/anticipation performance (i.e., lower performance following physical fatigue) and the absence of effects on other lower cognitions indicates that mental and physical fatigue have a lower impact on lower cognitions than what has previously been shown for higher-order cognitive functions like decision-making and executive functions.

### IS COGNITIVE PERFORMANCE RELATED TO THE SPEED OF UNPLANNED CUTTING MOVEMENTS IN HEALTHY MALES?

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INTRODUCTION: Evidence suggests that team sport athletes with low baseline cognitive scores are at higher risk of sustaining non-contact knee injuries during landing and cutting maneuvers that involve a time-constrained decision-making component (Wilke et al. 2020). While previous studies have focused primarily on biomechanical risk factors of unplanned landings (i.e., visual cue indicating landing side/cutting direction shown only during jump/run), it is largely unclear how cognitive performance relates to speed of task execution. This study investigated potential relationships between cognitive measures and reaction times (RTs) of unplanned cutting movements.
METHODS: Ten healthy males (age: 30±9 years; BMI: 26 Kg/m2) performed 64 drop-landings from a 60 cm box on a force plate immediately followed by an unplanned cut to one of four yellow light sensors positioned in semi-circular order (20° and 60° to both left- and right-hand sides from a participant's midline) and 150% of the participant's leg length. A blue light sensor placed in front of the box underneath the participant's non-dominant foot was deactivated by their take-off, which in turn triggered the yellow light stimulus (random order) during the fall. Upon landing, they needed to deactivate the yellow light stimulus rapidly by performing a subsequent cut directly in front of the corresponding sensor. The cut-landing needed to be performed with the right or left foot according to the sensors hemifield. Cutting RTs for each direction were measured as time between the deactivation of both stimuli. Peak vertical ground reaction forces (pVGRF) and contact times (latency to cut off from force plate) were recorded via force plate. All parameters were analysed for successful trials (cut-landing with correct foot and stabilising it >2 sec). PC (PsyToolkit) and pen-and-paper tests were used to assess selected cognitive measures, like simple and choice RT, short-term memory (Corsi), cognitive flexibility and working memory (Trail-Making-Test).
RESULTS: From 651 trials in total, 435 trials (67%) were successful. There was a significant relationship (Pearson`s $r=0.65$, $p=0.04$) between slower mean choice RT (413±51 ms) and longer contact times (503±59 ms). Cutting RTs (881±89 ms) and pVGRF (70±15 N/Kg) were not significantly correlated with any cognitive measure ($p>0.05$).
CONCLUSION: Slower cognitive choice RTs may prolong the initiation of complex motor reactions (e.g., cutting upon landing) under time-pressure, which may predispose athletes to injury during play. However, the potentially confounding influence of individual available response times during the fall (i.e., the time between yellow light sensor trigger and landing) is unclear, so the observed relationship must be interpreted with caution.
REFERENCES:
Wilke, Groneberg, Banzer, Giesche (2020): Perceptual–Cognitive Function and Unplanned Athletic Movement Task Performance: A Systematic Review. Int J Environ Res Public Health. 2020 Oct; 17(20): 7481; doi: 10.3390/ijerph17207481.

### WORLD CLASS AND INTERNATIONAL ELITE ATHLETES' AND COACHES' PERCEPTIONS OF MENTAL DEMANDS IN BEACH VOLLEYBALL

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INTRODUCTION: In elite sport mental skills are essential for success. To develop optimal mental skills for an athlete it is essential to understand the mental demands that are critical in each sport (Taylor, 1995). Furthermore, it is essential to have knowledge about the individual athletes' exclusive needs and skills, and how they respond to the potentially unique mental demands and challenges they face in their sport. The aim of this study was to investigate how World Class and elite beach volleyball players and coaches perceive the mental demands in their sport, and how they prepare for and respond to these demands.
METHODS: Nine players (3 females and 6 males) and 4 coaches (1 female and 3 males) from the Norwegian national representative teams participated in individual semi-structured face-to-face interviews exploring perceived mental demands in Training, Competition and Relationships in high performance teams. The interviews were transcribed and coded using an inductive thematic analysis (Braun et al., 2016).
RESULTS: Three themes emerged in the Training context as 'presence', 'passion' and 'self-regulated learning' with presence then including subthemes of 'focus', 'resilience', & 'energy level', and self-regulated learning including subthemes of 'mastering', and 'knowledge development'. Five themes emerged in the Competition context as 'presence', 'fear & doubt', 'shared mental model', 'cope with pressure', and

'balance'. Two themes emerged in the Relationships in high performance teams context as 'intra-team cooperation' and 'inter-team cooperation', with intra-team cooperation including three subthemes of 'communication', 'trust & safety', and 'wellbeing & friendship'.
CONCLUSION: This study increases our understanding of the mental demands encountered by world class and elite beach volleyball players from the perspective of both the athletes and their coaches. Appreciation of the themes could enable coaches, and sport psychologists to optimize training sessions, competitions and relations using mental skill development strategies. Whilst the degree of the perceived mental demands could vary for each athlete, and notwithstanding the fact that individual adaptation is necessary for an athlete's best possible performance, psychological interventions that help athletes better understand and subsequently manage these unique mental demands could contribute to more optimal performance.
References:
Braun, V., Clarke, V., & Weate, P. (2016). Using thematic analysis in sport and exercise research. In B. Smith & A. C. S (Eds.). Routledge Handbook of Qualitative Research in Sport and Exercise, (pp. 191-205).
Taylor, J. (1995). A conceptual model for integrating athletes needs and sport demands in the development of competitive mental preparation strategies. The Sport Psychologist, 9, 339-357

**DO ENERGY EXPENDITURE DIFFERENCES ACROSS WORK POSTURES INFLUENCE COGNITIVE PROCESSING SPEED? A COUNTER-BALANCED RANDOMISED CROSS OVER TRIAL**

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INTRODUCTION: Anecdotal evidence link occupational sedentary behaviour, low energy expenditure (EE) and cognitive dysfunction. Nevertheless, EE across different work postures including active workstations remains unclear and its influence on cognitive processing speed is yet to be established. We aimed to investigate differences in EE across various work postures and their influence on cognitive processing speed.
METHODS: In our counterbalanced randomised trial, sixteen desk-based employees performed simulated work tasks (typing, reading and cognitive tasks) in three different work positions (sitting, standing, walking) on three different days. EE was measured for three days consecutively for 30-minutes in each simulated position using indirect calorimetry. Processing speed was assessed through computer-based choice reaction times during each work posture. The outcome variables of interest (EE, reaction times and accuracy) were compared between work positions using repeated measures ANOVA and Pearson correlation.
RESULTS: Walking EE in walking was higher (5.57 ± 0.45 Kcal) than sitting (1.07 ± 0.12 Kcal) and standing (1.88 ± 0.42 Kcal). Total EE was significantly higher in walking than standing (35.17 ± 6.86 Kcal) and sitting postures (41.37 ± 8.46 Kcal). We did not find any significant differences in reaction times between different work postures except within standing work conditions (60.22 ±13.97 ms). Accuracy was found to be reduced in walking compared to sitting (0.76 ± 0.83%) and standing (0.43 ± 0.09%) but not reached significance.
DISCUSSION: Our study observed a significant increase in VO2 and METs in the walking group without a significant reduction in cognitive processing speed compared to prolonged sitting and prolonged standing groups during simulated work tasks. Excessive occupational sitting is found to be associated with low EE which leads to obesity and other metabolic risks such as hyperglycemia, hyperinsulinemia or hypertriglyceridemia. These metabolic derangements are found to have a negative influence on the brain glucose metabolism, hormonal balance (cortisol, BDNF) and brain vascular functions which in turn are speculated to influence cognitive performance and work productivity in workplace settings. Hence, replacing occupational sitting with standing or walking is speculated to be a successful strategy to combat the negative consequences on cognitive functions by increasing EE and reversing metabolic derangements during the typical working hours.
CONCLUSION: Though significant differences in EE were observed between work postures, walking or standing at work did not affect the cognitive processing speed.

**PREFRONTAL ACTIVITY OF SOCCER PLAYERS DURING GENERAL AND SPORT-SPECIFIC COGNITION IN MOTION**

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Prefrontal activity of soccer players during general and sport-specific cognition in motion
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Abstract
INTRODUCTION: To elucidate the underlying mechanisms of athletic expertise in cognitive tasks, studies examining the activity in the prefrontal cortex (PFC) could contribute (Tan et al., 2019). The importance of both general and sport-specific perceptual-cognitive abilities in team athletes has been demonstrated in several studies (Cole et al., 2017). However, these cognitive demands have not yet been studied in movement-intensive situations. The aim of this study was to analyze the prefrontal activity of soccer players during general and sport-specific cognitive tasks in motion.
METHODS: 37 semi-professional male soccer players (24.8 ± 4 yrs., age range 18 – 33 years) performed two cognitive tests requiring selective attention and decision-making in a general and a sport-specific task in motion (Witty SEM, Microgate, Italy). Meanwhile, the prefrontal activity was recorded using functional near-infrared spectroscopy (fNIRS) (NIRSport, NIRx Medical Technologies LLC, USA). Differences of prefrontal activation in general and sport-specific cognitive tasks were analyzed using a paired t-test.
RESULTS: Significant differences in prefrontal activity (oxyhemoglobin) between the general and the sport-specific cognitive task were found in thirteen out of twenty-one channels with increased activity during the general cognitive task (Ch.1: p=.04, Ch.2: p=.03, Ch.3: p<.01, Ch.4: p<.01, Ch.6: p=.04, Ch.8: p=.03, Ch.11: p=.04, Ch.12: p<.01, Ch.13: p<.01, Ch.15: p<.01, Ch.17: p<.01, Ch.20: p=.04, Ch.21: p=.05).
DISCUSSION: Our study indicates that the prefrontal cortex is more activated during the general cognitive task compared to the sport-specific cognitive task. This could be based on learned automatisms of experts in the field of sport-specific cognition in motion. These results seem in line with earlier research on novel and automated cognition (Sanchez-lopez et al., 2014) and the "repetition suppression theory" (Auksztulewicz & Friston, 2016) indicating lower prefrontal activity during familiar processes. However, further research is needed to clarify the prefrontal involvement on expertise in cognitive tasks in motion.
LITERATURE:
Auksztulewicz, R., & Friston, K. (2016). Repetition suppression and its contextual determinants in predictive coding. Cortex, 80, 125–140.

Cole, M. W., Braver, T. S., & Meiran, N. (2017). The task novelty paradox: Flexible control of inflexible neural pathways during rapid instructed task learning. Neuroscience & Biobehavioral Reviews, 81, 4–15.
Sanchez-lopez, J., Fernandez, T., Silva-pereyra, J., Mesa, J. A. M., & Russo, F. Di. (2014). Differences in Visuo-Motor Control in Skilled vs . Novice Martial Arts Athletes during Sustained and Transient Attention Tasks?: A Motor-Related Cortical Potential Study. PloS One, 9(3), 1–9

## Conventional Print Poster

### CP-AP06 Monitoring in team sports

#### CHARACTERISTICS OF SPECIFIC INTENSE ACTIONS DURING TOP-LEVEL TEAM HANDBALL MATCHES

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INTRODUCTION: To best prepare players for team sport games such as elite team handball, it is paramount to understand the physical load and the position specific differences. The investigation of physical load in team sports have mainly been focusing on traditional tracking variables, such as distance in various speed zones and number of accelerations (Povoas et al., 2012; Manchado et al., 2021). To better understand the underlying mechanisms of specific intense actions, this study aims at describing the characteristics of various specific intense actions during top-level team handball games.
METHODS: Specific intense actions (sprints (>22 km/h), accelerations, decelerations, change of direction (CoD) and jumps) were extracted from 30 male top-level handball players (height: 193±5 cm, weight: 98±10 kg) during 6 handball matches. A total of 4300 specific intense actions – 418 sprints, 1669 accelerations, 1108 decelerations, 269 changes of directions, and 836 jumps were investigated. Participants were divided into three playing positions: pivot, back, and wing for investigating positional differences. Data were analyzed using a linear regression model. To adjust for multiple comparisons, Tukey's post hoc test was used. A significance level of 0.05 was chosen.
RESULTS: On all measured parameters, backs and pivots only differed in jumping height (0.21±0.18 m and 0.17±0.18 m respectively; $P<0.001$) and jumping distance (1.31±0.91 m and 1.26±0.92 m, respectively; $P<0.05$). During sprints, wings covered 14.7±5.0 m per sprint which was more ($P<0.001$) than both pivots (10.5±2.6 m) and backs (10.6±3.7 m). Pivots displayed lower magnitude of deceleration (1.4±0.6 m/s2) than both wings (2.1±0.8 m/s2; $P<0.001$) and backs (1.8±0.8 m/s2; $P<0.05$), and wings also showed greater magnitude of deceleration than backs ($P<0.05$). In contrast, no differences were observed between positions of magnitude of acceleration during CoD. During accelerations wings displayed longer duration (1.1±0.3 s) compared to both pivots (1.0±0.3 s; $P<0.001$) and backs (0.9±0.2 s; $P<0.001$). Additionally, pivots also displayed longer duration than backs ($P<0.001$). Maximum acceleration was higher in wings (2.9±0.5 m/s2) compared to pivots (2.6±0.4 m/s2; $P<0.001$) and backs (2.6±0.4 m/s2; $P<0.001$), but with no difference between pivots and backs.
CONCLUSION: Analysis of 4300 specific intense actions revealed great positional differences during top-level team handball matches, but with large variation of most parameters. Investigation of specific intense actions beyond traditional tracking variables reveal new insides to the demand of handball.

#### EFFECTS OF BIRTH QUARTER ON BODY WEIGHT, SLEEP QUALITY, FITNESS MEASURES AND NATIONAL AND REGIONAL RANKING POSITION: A PRESELECTION OF YOUTH ANDALUSIAN PADEL PLAYERS

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INTRODUCTION: Relative age effects (RAEs) appears affect physiological and physical aspects in a variety of sports, both at youth and adolescent level [1]. Children born early in the selection year are more likely to experience success and to sustain participation, which can influence the dropout of the other athletes. Despite that, little is known about the influence of RAEs on physical parameters in youth padel players. Hence, the aims of the study were to test: 1) whether the relative age effect (RAE) was prevalent in the pre-selection of young (10-18 years) Andalusian padel players, and 2) whether anthropometric, sleep quality, national and regional ranking and fitness measures vary according to birth date distribution in elite youth padel players.
METHODS: For the present study a pre-selection of youth padel players of the Andalusian Padel Federation (n = 69, 10-18 years old) were analysed. Body weight, sleep quality, national and regional ranking and fitness characteristics (Dominant-arm Hand Grip and Abalakov Jump) were measured. Chi-square tests were used to test the observed and expected birth distribution across the sample of players. A one-way analysis of variance ANOVA was used to compare all anthropometrical, sleep quality, performance and fitness variables across birth quarters for each age group.
RESULTS: Of the pre-selected players, 63,77% were born in the first half of the year, specifically 50%, 75%, 68,75% and 61,9% for the U12, U14, U16 and U18 categories, respectively. No significant differences were found in any of the anthropometric, sleep quality, skill level and fitness characteristics of the regional squad players born across different quarters.
CONCLUSION: Compared with early born, late born players did not seem to be different in anthropometric, sleep quality, national and regional ranking and fitness characteristics in youth elite padel players. Studies with a much larger sample are needed to obtain more conclusive results.
[1] António J. Figueiredo, Manuel J. Coelho-e-Silva, Sean P. Cumming & Robert M. Malina (2018): Relative age effect: Characteristics of youth soccer players by birth quarter and subsequent playing status, Journal of Sports Sciences, DOI: 10.1080/02640414.2018.1522703

#### PHYSICAL AND CARDIOVASCULAR DEMANDS PLACED ON COLLEGIATE DIVISION II WOMEN'S BASKETBALL PLAYERS – PRELIMINARY ANALYSIS FROM A SINGLE SEASON

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INTRODUCTION: Monitoring the physical and cardiovascular demands that players are exposed to during games can help guide the training process and optimally prepare each player for game demands (1). The purpose of this investigation was to quantify the physical and cardiovascular game demands during a single season.

METHODS: Sixteen games during the 2021-2022 season were monitored using inertial movements units (Catapult S5, indoor mode, Catapult Sports Innovations) and integrated heart rate monitors (Polar). Four female division II (D2F) players (23+0.89 years) identified as guard or forward who met the criteria of participating in at least 10 live minutes per game were included in this preliminary analysis. Average game duration (DUR), average player load (PL), player load per minute (PL/min) and duration spent above 85% of the HRmax (% HI HRZ) were extracted from the data collected. Means and standard deviations along with 95% CI were calculated for each metric at the group and individual level.
RESULTS: The pooled results for the four players were 1) DUR of 29.9+7.33mins (CI: 28.09 to 31.75 min), 2) PL was 488.8±147.94 (CI:410 to 567), 3) PL/min was 8.03±1.61 (CI:7.17 to 8.89) and 4) %HI HRZ was 31.6+8.6 (CI: 27.04 to 36.21).The individual analysis for each included player identified the following: For Player 1, 1) DUR was 33.6+3.9 mins (CI: 31.62 to 35.76), 2) PL 685+430 (CI: 456.1 to 915.4), 3) PL/min 9.7+6.5 (CI: 6.25 to 13.19) and 4) %HI HRZ 50.5±10.5 (CI: 44.96 to 56.17). For Player 2, 1) DUR was 31.75+4.98 (CI: 29.1 to 34.4), 2) PL 411+101 (CI: 356.98 to 465.15), 3) PL/min 6.95+0.74 (CI: 6.17 to 7.73) and 4) %HI HRZ 50.9+3.34 (CI: 33 to 69). For Player 3, 1) DUR was 30+5.07 (CI: 28.11 to 33.52), 2) PL 404+138 (CI: 330.44 to 477.81), 3) PL/min 6.6+1.7 (CI: 5.73 to 7.56) and 4) %HI HRZ 9.06+0.9 (CI: 4 to 14). For Player 4, 1) DUR was 23.4+9.4 mins (CI: 18.41 to 28.46), 2) PL 454+166 (CI: 365.42 to 542.58), 3) PL/min 8.46+0.62 (CI: 8.13 to 8.8) and 4) %HI HRZ 12.12+9.56 (CI:7.03 to 17.22).
CONCLUSION: For the pooled results, these data indicate that D2F guards and forwards were exposed to an average DUR of 29.9 mins /game and %HI HRZ of 31.6%. The findings for DUR and %HI HRZ are consistent with recent data in NCAA Division I women's basketball (2). At the individual level, guards or forwards demonstrated variable responses on each metric which can be dependent on internal and contextual factors and requires more investigation. For practitioners, these data may be useful for optimizing training programs on a weekly basis for forwards/guards. While a recent study (2) suggested that to mimic in-game intensities, conditioning protocols can aim to engage players in >85% HRmax workloads, understanding in-game physical demands such as average PL and PL/min may be of importance as well and warrants further investigation.
1 Garcia, Feb (2021) 2 J. Sanders, April (2021)

**PHYSICAL DEMANDS OF FOOTBALL SPECIFIC DRILLS IN DIVISION II COLLEGIATE FEMALE FOOTBALL PLAYERS**

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INTRODUCTION: GPS wearable technology allows practitioners to access data that may ensure the drills selected in training mimic the external and internal demands seen in matches1. The purpose of this study was to categorize common practice drills by comparison to match demands.
METHODS: Match and practice data for 11 NCAA Division II Women's Football players who played in 13 conference matches was collected using Catapult S5 GPS devices and integrated Heart Rate Monitors (Polar). Each player's average distance (D), duration (DUR, min), acceleration (ACC) and deceleration (DEC) efforts, high speed distance (HSD), and percent duration spent above 85% HRMax (%HI HRZ) was collected for each match and practice in season. Possession (P), shooting (SH), short-sided games [SSG] (classified as <6v6 and field dimensions smaller than half field), and big scrimmages [SCR] (≥7v7) drills were analyzed. All data were then expressed in relative terms as average percentage of match demand.
RESULTS: With respect to relative match demands for D, the largest average accumulation occurred in SCR (25%) followed by P (16%), SSG (14%), and SH (8%). For relative DUR, SCR (36%) demonstrated the largest average DUR followed by P (28%), SSG (26%), and SH (22%). Findings for relative ACC efforts were SCR (31%) followed by SSG (24%), P (16%), and SH (13%). Similar findings for relative DEC efforts were observed, SCR (32%), SSG (23%), P (7%), and SH (7%), respectively. The data indicated that, for relative HSD, SCR provided the largest relative HSD at 22%, followed by SSG (9%), and P and SH each providing 3%. The results for %HI HRZ indicated that relative to match %HI HRZ, SCR showed the highest value at 56% followed by SSG (51%), P (28%), and SH (18%).
CONCLUSION: Big scrimmages accumulated the highest amount of HSD as a percentage of game values as well as the highest percentage of ACC and DEC. SSG, while accumulating <10% of HSD relative to match HSD, provided moderately high amounts of ACC and DEC efforts. It is also notable that SSG provided the second largest relative %HI HRZ. These findings are consistent with previous work in elite football players showing that D, HSD, and ACC and DEC increase with pitch size2,3. Studies in professional football have also shown no difference in heart rate between short, medium and large area games 4. These findings shed light on the physical and metabolic internal demands of different football drills and may be useful for the practitioner when considering practice planning and return to play. To optimize training session drill structures, the physical and metabolic demands of matches must be understood to achieve the intended physiological and performance adaptations in training. Further investigation to improve the classification of drills into high, medium, and low intensity relative to match demands as well as drill manipulation on the observed metrics is needed.
1. Curtis et. al. (2018) 2. Gaudino et. al. (2014) 3. Campos et. al. (2017). 4. Little & Williams (2006).

**HUMAN MOVEMENT VARIABILITY IN SPIKE MOVEMENT WITH VOLLEYBALL CONSTRAINT IN DIFFERENT GAME POSITIONS OF FEMALE ELITE PLAYERS**

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INTRODUCTION: In volleyball, the volleyball spike approach movement (SM) represents one of the more sophisticated attack actions and the spike after it, is the most important ability to win a game (1). The use of nonlinear tools like entropy can be a good alternative to explore the nature of human movement and its relationship with coordinative development (2), reflecting changes in movement variability (MV) during the movement execution and overt time. SM oscillations can be evaluated through entropy calculation techniques (3) that allow to identify variability from a spatiotemporal perspective. In general, change in movement complexity with practice find that, the complexity of the attractor dynamics (pattern of expected values of the movement) could be reduced as a function of practice (4), furthermore, athletes manage to reduce the variability of their sports movements (5), in volleyball game position puntas are the player who realizes more SM in practices and competition during a season (6)
The aim of this study was to identify the differences in human movement variability (MV) between game position in SM with and without ball constraint.
METHODS: One WIMU(Realtrack systems) were placed in a belt to forty eight female first division players in 4 different game positions: Punta(Mean ±SD: Age16,83±3,62; Height: 1,76±0,06; Weight: 65,95±7,15), Central (Mean ±SD: Age 18,42±3,40; Height: 1,82±0,03; Weight: 72,57±6,39), Colocadora (Mean ±SD: Age 17,00±3,51; Height: 1,77±0,02; Weight: 68,67±5,03), Libero (Mean ±SD: Age 19,80±3,37; Height:

1,71±0,04; Weight: 63,88±5,39) who performed SM in both conditions (with ball and without ball). The players performed an eight minutes standardized warm-up after which they realized four sets of six SM, two of them with ball and two of them without ball in random order, completing eight series performed in two sessions on different days. The human movement variability was analysed with entropy values in Sample Entropy (SampEn).
RESULTS: The SampEn response variable was analysed using a Mixed linear Model, where with or without ball is the main variable explanatory and, game position as a secondary variable explanatory. In SampEn without ball (Punta=0,153; Central=0,156; Colocadora=0,155; Libero=0,163) with ball (Punta=0,072; Central=0,079; Colocadora=0,074; Libero=0,081). Without ball there is no difference between positions, with ball position Punta is different to Central (p = 0,0117) and to libero (p = 0,0019).
CONCLUSION: At game position as a constraint, the MV decreases significantly between the position Punta and the rest of game positions, as in the conditions of the study, we could consider the Puntas probably are who realizes more SM in practices and competition (6), up to 40,000 during one season (7).

## USA BASEBALL SYSTEM: EXAMINING MICRO-LEVEL PRACTICES AGAINST A GLOBAL MODEL FOR INTEGRATED DEVELOPMENT OF MASS AND ELITE SPORT

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INTRODUCTION: This study was designed to help and improve international baseball performance as well as increase domestic sport participation in the United States. Over 200 sources of literature on sport delivery systems from 28 Australasian, North and South American, Western and Eastern European countries were analyzed to construct a globally applicable model of high performance skiing and snowboarding integrated with mass participation, comprised of the following seven elements across three levels:
Micro level (operations, processes, and methodologies for development of individual athletes):
1. Talent search and development,
2. Advanced athlete support.
Meso level (infrastructures, personnel, and services enabling sport programs):
3. Training centers,
4. Competition systems,
5. Intellectual services.
Macro level (socio-economic, cultural, legislative, and organizational):
6. Partnerships with supporting agencies,
7. Balanced and integrated funding and structures of mass and elite sport.
METHODS: The above model was used to design a questionnaire of 54 statements reflecting desired practices. 54 statements were validated by 12 international experts, including executives from sport governing bodies and academics who published on high performance and sport development. 2,000 baseball professionals' email addresses were collected from various sources, including web pages of national and regional skiing and snowboarding associations, college and university athletics as well as high school and club skiing and snowboarding teams. Completed online questionnaires were returned by 100 coaches from all key regions of the country for a response rate of 5%. Additionally, 6 regional administrators were interviewed to suggest possible sport system improvements.
RESULTS: Despite the significant resources available to US baseball, respondents were not satisfied with many current practices. More consistent Olympic performance and growth of national and international baseball participation have great unrealized potentials and can be achieved through further advancements of baseball programs domestically and globally. More than half of the open responses regarding talent search and development indicated the need for standardized USA Baseball coaching so that training and development of young athletes could lead to more opportunities for those less fortunate who cannot afford private coaching.
CONCLUSION: In conclusion, we have learned from the respondents that there needs to be more developmental programs available through public organizations. Grassroots programs need to be better structured and coaching needs to be equated with abilities rather than financial and political influence. To improve advanced athlete support, coaching and training methodologies should focus on less experienced baseball athletes to ensure all participants receive equally sufficient support, particularly via such grassroots programs as Babe Ruth Baseball, Cal Ripken Baseball, Dixie Youth Baseball and Dixie Boys Baseball.

## PHYSIOLOGICAL DEMANDS AND IMPACT OF A SIMULATED BEACH VOLLEYBALL TOURNAMENT ON ELITE MALE AND FEMALE ATHLETES

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INTRODUCTION: Beach Volleyball (BVB) is a high intensity sport that requires sprinting and jumping. A BVB tournament often involves several consecutive days of multiple games a day, separated by as few as 2 hours, in which case fatigue might impair performance.
METHODS: 12 national team adult BVB players (8 males: height 190.9±5.1 cm, weight 83.9±8.7 kg, %fat 8.7±0.6, age 22.5±5.3 years; 4 females: height 175.3±10.9 cm, weight 68.2±10.4 kg, %fat 18.3±2.2, age 19.5±1.9 years) were tested for blood lactate (La), countermovement vertical jump (CMJ; with shoes on hard floor, hands on hips) and 4m and 8m sprint (barefoot on sand) before and after 2 games separated by 2 hours to simulate a single day tournament. Total number of jumps and RPE (Borg 1-10) was also recorded. Teams were instructed to strategically attack the same opponent player throughout all matches to increase that player's physiological load.
A repeated measures ANOVA test was used to reveal differences in CMJ, 4m, 8m sprint times, and La between pre and post-match 1 and 2, between pre match 1 and pre match 2, and between pre-match1 and post-match 2.
RESULTS: There were no statistically significant differences in CMJ height or sprint speed between any of the time points sampled. No differences were found between males and females, between defenders and blockers, and between the 2 players in the same team.
La was higher post-match 2 compared to pre-match 1 (3.1 vs 1.2 ml/L, $p<0.001$, Cohen's d=1.2) and post-match 2 compared to pre-match 2 (3.1 vs 1.9, $p<0.05$. d=0.81).
RPE was higher post-match 2 compared to post-match 1 (6.9 vs 5.2, $p<0.005$, d=1.18).
Total number of jumps was significantly higher during the second match compared to the first match (63.7±18.06 vs 56.1±20.25, p=0.008, d=1.08).
CONCLUSION: Discussion: Although higher La and RPE values were recorded, both performance measures were not significantly affected by a simulated BVB tournament. CMJ is often used as a measure of neuromuscular fatigue (NMF). NMF may also be detected by more sensi-

tive tests, however, these performance indices were selected as they reflect the required actions performed in a VB match and may influence match success. Our results support results from previous studies in BVB.
Conclusions: We concluded that NMF was not apparent following 2 BVB matches, and performance was not significantly hindered. Future studies should investigate NMF and performance during a longer tournament (2-3 days) and ideally be performed during a real tournament and not a simulated one.

**REVIEW OF THE WORLD RUGBY 'TEST METHOD 01' FOR THE DETERMINATION OF THE CRITICAL FALL HEIGHT IN ARTIFICIAL TURF RUGBY SURFACES. A PILOT STUDY.**

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INTRODUCTION: Mechanical properties of the surface are significant to the performance and safety of the athlete in rugby union, a close-contact team sport in which players occasionally fall headfirst to the ground during various events of the game such as scrums and tackles. Consequently, one of the properties regulated on artificial turf rugby surfaces is the determination of the Critical Fall Height (CFH). This test evaluates the magnitude of the impact that a player would suffer on the head when falling to the ground from a certain height.
During the test, a 4.6kg-head-form falls freely to the ground recording the magnitude of the impact in HIC (Head Injury Criteria) units. The CFH is the height at which the HIC equals 1000.
According to the current test method, the CFH is calculated by performing drop tests from 4 different heights and obtaining the HIC for each of them, with 2 HIC values below 1000 and 2 above. The 4 height-HIC data pairs must also meet the following restrictions: (i) There is a maximum difference between highest and the lowest drop heights (1m); (ii) There is a minimum difference between consecutive drop heights (15cm); (iii) There should be no HIC value contained in a range around 1000 (975-1025). Once the 4 height-HIC data pairs are obtained, a linear regression model is used to calculate the CFH.
The objective of this study was to review the current method to check if it could be simplified or improved in any way. The method is considered improved if its repeatability increases, that is, if the percentage of outliers (%out) obtained during multiple tests decreases.
METHODS: A pilot study was performed on 7 artificial turf rugby fields. In each of them, one complete 3-drop procedure was performed initially to obtain a first estimate of the CFH (CFH0). Then, the procedure was repeated on each surface at 50mm intervals, from 600mm below to 600mm above CFH0. All possible combinations of 4 height-HIC data pairs with 2 HIC values below and above 1000 were obtained, with no other restriction applied at this stage. The %out obtained under these conditions was considered the reference value (%outref) to be improved with the application of restrictions (i) to (iii). Then, the %out obtained by restricting the aspects mentioned above (%outi, %outii, %outiii) was investigated. Finally, the %out obtained by applying the linear or quadratic fit (%outlin, %outcuad) was investigated.
RESULTS: Results are presented for each restriction: (i) %outi improves %outref. %outi is reduced as the total distance between drop heights decreases; (ii) %outii improves %outref. %outii is reduced as the distance between consecutive drop heights increases; (iii) %outiii worsens %outref. %outiii is reduced as the restricted area around 1000 decreases. Also, %outcuad improves %outlin.
The %out could be reduced from 1.08 (current method) to 0.15 by adapting test restrictions.
CONCLUSION: A thorough review of the current test method could improve its repeatability and decrease the % of atypical results.

## Conventional Print Poster

### CP-PN08 Muscle function and damage

**EFFECTS OF INTERMITTENT EXERCISE ON THE POWER-DURATION RELATIONSHIP**

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INTRODUCTION: Knowledge of the parameters of the hyperbolic power-duration relationship, the critical power (CP) and the curvature constant (W', which represents a fixed work capacity above CP), permits the prediction of both continuous and intermittent sprint exercise performance [1]. Recently, we have shown that during prolonged constant-work-rate, heavy-intensity exercise, there is a time-dependent reduction in both CP and W' [2]. However, the effect of prolonged intermittent sprint exercise, such as that which occurs in team sports like football, rugby and field hockey, on the parameters of the power-duration relationship, and the rate of W' recovery between high-intensity exercise bouts (W'REC), has yet to be examined. The primary purpose of this study was therefore to investigate the influence of high-intensity intermittent exercise on CP, W', and W'REC.
METHODS: Following ethical approval, thirteen (9 male, 4 female) team sport players completed a repeated all out sprint test without prior exercise (baseline), and immediately after a 40-min (40-IST), and an 80 min (80-IST) intermittent sprint test on a cycle ergometer. The repeated all-out sprint test consisted of a 3-min all-out test (3MT), for determination of CP and W', and a 2-min all-out test (2MT) that enabled the assessment of W'REC during the 90-s rest period separating the all-out tests. The IST was composed of a repeating 2-min block of exercise that included a 6-s all-out sprint, 100 s active recovery, and 20 s of rest to mimic the demands of team sports.
RESULTS: Work done during the 2nd half of the 80-IST (338 ± 60 kJ) was significantly lower than the mean for the first 40 min of the IST ($P<0.05$). For the 3MTs, total work done was significantly lower during the 40 3MT (50.1 ± 9.8 kJ) compared to the baseline 3MT (53.5 ± 10.2 kJ; $P<0.05$), and the 80 3MT (47.7 ± 10.4 kJ) was significantly lower than both the baseline 3MT ($P<0.001$) and the 40-3MT ($P<0.05$). There were no differences ($P>0.05$) in CP between the baseline 3MT (222 ± 52 W), 40-3MT (222 ± 57 W) and 80-3MT (213 ± 49 W). However, W' was significantly lower during the 40-3MT (10.1 ± 4.0 kJ; $P<0.01$) and 80-3MT (9.1 ± 3.5 kJ; $P<0.001$) compared to the baseline 3MT (13.5 ± 4.0 kJ). There was no difference in W'REC following the 40-IST (0.07 ± 0.02 kJ·s-1) and 80-IST (0.07 ± 0.02 kJ·s-1) compared to control (0.08 ± 0.02 kJ·s-1; all $P>0.05$).
CONCLUSION: Prolonged intermittent sprint exercise of at least 40 to 80 min in duration, such as that which occurs in team sports like football, rugby and field hockey, reduces W' without altering CP or W'REC. These findings provide new insight into the determinants of fatigue during prolonged intermittent sprint exercise.
REFERENCES
[1] Jones et al. 2010. MSSE, 42(10): 1876-1890.

[2] Clark et al. 2019. JAP, 127: 726-736.

### ADAPTATIONS TO CHRONIC RESISTANCE EXERCISE ON THE RATE OF STRENGTH INCREASES AND MUSCLE ARCHITECTURE IN MIDDLE AGED MEN

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INTRODUCTION: Ageing has long been associated with reductions in strength and lean body mass, potentially due to cellular changes such as decreases in muscle fiber numbers and size, reduced response of satellite cells, changes in myofilament quality, as well as neural changes such as lower agonist activation and higher antagonist co-activation (1). Maintaining higher levels of muscle mass across the lifespan are associated with positive QOL outcomes. Resistance exercise (RE) has been consistently demonstrated to increase muscle size and strength in both younger (YA) and older adults (OA), yet ageing can attenuate the hypertrophic response of muscle groups to resistance training (2). There is still paucity in the data on the relative contribution of neural and morphological factors to gains associated with RE. Research tends to focus on extremes (YA vs OA) in order to view ageing effect yet excluding middle aged means rate of change with ageing is often overlooked. The aim is to assess the contribution of neural and architectural adaptations to strength gains
METHODS: N = 19 active, MAA (46.84±5.20 y) who were naïve to RE completed the study. At baseline, MT (muscle thickness) of and AOP (angle of pennation) of the m. vastus lateralis were assessed via ultrasonography. Maximal isometric voluntary contraction (MVC) and Rate of Force Development (RFD) were assessed using a Biodex System-3 isokinetic dynamometer (Biodex Corp., Shirley, NY, USA). A 10RM protocol during the barbell back squat was used to determine lower limb strength. Participants followed a 10-week progressive RE programme, two times per week. Participants returned 48-120 hours after the final exercise session of the intervention for reassessment of all measures
RESULTS: Paired Samples T-test revealed there was no sig. increase on both VL MT ($p = 0.983$) which remained at 24.2±2.3 mm (baseline = 24.2±3.2 mm), and VL AOP ($p = 0.166$) which increased to 17.1±1.9 mm from 16.4±2.9 at baseline, an increase of 4.3% over 10-weeks. Cohen'd illustrates a small effect size for VL MT ($d = 0.005$). Interestingly, Cohen's d shows a moderate effect size on VL AOP (0.33). 10RM significantly increased ($p < 0.0005$) by 33.63±10.26 Kg. Training had a large effect on 10RM ($d = 3.33$). A trend towards significance was observed in MVC ($p = 0.077$), with a moderate effect size ($d = 0.430$). RFD significantly increased ($p = 0.004$) with a large effect size ($d = 0.753$)
CONCLUSION: Similar to YA, progressive resistance training in MAA leads to an increase in strength. The findings of this research display that a 10-week resistance exercise program does not create significant changes in muscle architecture, however neural adaptations can be seen to improve MVC and RFD. It appears that the rate of increase in MVC is higher in YA displaying an increase 11.2%, whereas the current MA men increased by 5.2% over the same time period (3). RFD improves at a quicker rate in MA adults from the current findings. MA adults increased RFD by 20.5% whereas YA increased by 10.5%

### CIRCULATING MICRORNAS LEVELS AFTER EXERCISE-INDUCED MUSCLE DAMAGE AND THE REPEATED BOUT EFFECT

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INTRODUCTION: The neuromuscular system is able to quickly adapt to exercise-induced muscle damage (EIMD), such that it is less affected by subsequent damaging exercise, a phenomenon known as the repeated bout effect (RBE). Circulating muscle-specific microRNAs (myomiRs) may potentially predict the long-lasting maximal voluntary contraction (MVC) torque deficit (>24h), an indicator of EIMD. The aim of the present study was to investigate (1) how plasma myomiR levels are modified by the RBE and (2) whether plasma myomiRs are relevant to predict the long-lasting MVC torque deficit.
METHODS: Nineteen participants performed two identical bouts of loaded downhill walking separated by 2 weeks. MVC torque, creatine kinase (CK) activity, myoglobin (Mb) concentration and myomiR levels were measured before and up to 48 h after the exercises. Correlation and multiple regression analyses were performed to assess the ability of these markers to predict the largest MVC torque loss beyond 24 h post-exercise.
RESULTS: As MVC torque, CK activity and Mb concentration, some myomiR levels (hsa-miR-1-3p, hsa-miR-133a-3p) were less affected after the second bout of exercise compared to the first bout. CK, Mb and several myomiR levels (hsa-miR-1-3p, hsa-miR-133a-3p, hsa-miR-206) were correlated to the long-lasting MVC torque loss. The multiple regression showed that the best combination included some myomiRs, Mb and CK.
CONCLUSION: Some myomiR levels were less increased after the exercise 2 compare to the exercise 1, indicating the presence of the RBE. Measurement of myomiRs levels concomitantly to Mb concentration and CK activity could improve the prediction of long-lasting MVC torque deficit.

### INTRAMUSCULAR INJECTION OF MESENCHYMAL STEM CELLS ACCELERATES BOTH MUSCLE PROTEIN ANABOLIC RESPONSE AND CATABOLIC SYSTEMS AFTER ACUTE BOUTS OF RESISTANCE EXERCISE IN MICE

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INTRODUCTION: Skeletal muscle mass is regulated by the net balance between muscle protein synthesis and breakdown. Resistance exercise is a strong intervention to accelerate muscle protein synthesis and induce skeletal muscle atrophy, and there are growing strategies to promote its effectiveness. Mesenchymal stem cells (MSCs) are multipotent cells and have been reported to have the capacity to secrete growth factors including insulin-like growth factor 1 which is known to stimulate muscle protein synthesis (1). Recently, we reported that intramuscular injection of MSCs enhances muscle protein synthesis (2). The present study aimed to investigate the effect of intramuscular injection of MSCs on muscle protein synthesis and breakdown-related factors after an acute bout of resistance exercise in mouse skeletal muscle.
METHODS: Male C57BL/6J mice were divided into placebo and MSCs groups (N = 6, respectively). All mice were intramuscularly injected with either MSCs (2.0 × 106 cells suspended in 20 µL PBS) labeled with green fluorescence protein or a vehicle-only placebo into right gastrocnemius muscle under isoflurane anesthesia. Two or seven days after the injection, all mice performed a single bout of resistance

exercise (consisting of 3s × 10 reps × 5 sets maximal isometric contractions elicited by transcutaneous electrical stimulation) on the right gastrocnemius muscle. Three hours after the exercise bout, muscle samples were collected. The left gastrocnemius muscle in each group was kept sedentary and served as the control. Muscle protein synthesis (MPS) was measured by the SUnSET method.
RESULTS: MPS was increased in the exercised muscles in both groups, while MPS in the MSCs group was significantly higher than that in the placebo group at 7 days after the injection ($P < 0.05$). The expressions of phosphorylated p70S6K (Thr389), rpS6 (Ser240/244), 4EBP1 (Thr37/46) were increased in the exercised muscles in both groups ($P < 0.05$), and the increase of rpS6 and 4EBP1 in MSCs group were significantly higher than those in the placebo group at 7 days after the injection ($P < 0.05$). On the contrary, protein ubiquitination was increased in the exercised muscles only in the MSCs group at both 2 and 7 days after the injection ($P < 0.05$).
CONCLUSION: The present results suggest that the intramuscular injection of MSCs activated not only MPS but also the protein catabolic system in mouse skeletal muscle.
1. Tögel F. et al., American Journal of Physiology Renal Physiology 292, F1626-F1635 (2007).
2. Takegaki J. et al., Scientific Reports 11, 1-11 (2021).

**RESPONSE OF MUSCLE BIOMARKERS TO DETERMINE THE EXTENT OF MUSCLE DAMAGE AFTER A REPEATED MAXIMAL 40M SPRINTS**

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INTRODUCTION: Perform a high intensity exercise induced muscle damage, altering the muscle functions and performance, incrementing the risk of injuries. It has been demonstrated that repeated sprint exercise trigger muscle damage process (1) but it's unclear the magnitude of this damage. The changes on different serum markers can indicate the states of the cells and muscle fibre structures, which may determine the extent of the damage. While changes in CK may indicate membrane disruptions (2), changes in mitochondrial CK (sMtCK) concentration reflect muscle cell organelle disruption (3), and the changes in titin concentration may suggest muscle sarcomere structure damage (4).
METHODS: Amateur football player males (n=17, 23 ± 0.7 years, BMI 23.7 ± 0.4) and females (n=4, 24 ± 2 years, BMI 21.5 ± 1.2) performed 10 repeated maximal 40m sprints with a rest of 3 minutes between repetitions. Changes on force generating capacity (FGC), as an indirect markers of muscle damage, and serum levels of muscle enzymes (CK, sMtCK and titin) were measured at baseline and immediately after, at 24-, 48- and 72-hours post-exercise. Participants who did not recover at 72h baseline force values, were classified as responders (n=10) and those that recover baseline values as non-responders (n=10). One-way repeated measure ANOVA (time), Friedman and Wilcoxon test was used to identify changes from baseline on the different parameters analyzed. Data are presented as mean ± SEM and the level of significance was set at $p < 0.05$.
RESULTS: Repeated maximal sprints result in loss of strength of more than 20% on responders group at +48h and remained unrecovered +72h following exercise. Serum CK increased significantly from baseline (225,9 ± 20,1 ng·mL-1) until peak at +24h (516,8 ± 36,7 ng·mL-1) on responders and from baseline (121,9 ± 13,0 ng·mL-1) until peak at +24h (349,6 ± 25,2 ng·mL-1) on non-responders, indicating membrane disruption. sMtCK values also increased significantly from baseline (34,3 ± 7,0 ng·mL-1) until peak at +24h (91,6 ± 12,5 ng·mL-1) on responders and from baseline (24,3 ± 8,6 ng·mL-1) until peak at +24h (58,1 ± 9,3 ng·mL-1) on non-responders, reflecting cell organelle alterations. Both parameters remained unrecovered at +72h following exercise in both groups. Titin values didn't increase respect baseline, which leads us to assume that there was not damage on sarcomere structure.
CONCLUSION: A set of repeated maximal 40m sprint, performed by amateur footballers, is expected to produce moderate EIMD, with a membrane and organelle disruption, and a loss of muscle strength on responders, that is not recovered at 3 days after exercise.
REFERENCES
1. Selcen et al., Biomedical Human Kinetics, 2019, doi: 10.2478/bhk-2019-0021.
2. Baird et al., J Nutr Metab, 2012, doi:10.1155/2012/960363
3. Carmona et al., Int J Sports Med, 2019, doi:10.1055/a-0808-4692
4. Kanda et al., PLoS One, 2017, doi:10.1371/journal.pone.0181623

**EFFECTS OF NOCICEPTIVE AND MECHANOSENSITIVE AFFERENTS SENSITISATION ON VASCULAR RESPONSIVENESS FOLLOWING EXERCISE-INDUCED MUSCLE DAMAGE**

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INTRODUCTION: Mechanoreflex hypersensitivity plays a significant role in cardiovascular diseases, where it may lead to dysregulated responses and decreased exercise capacity. More recently, studies have also suggested that it may be altered in pain-related diseases where nociceptive sensitisation and mechanical hyperalgesia is present. Indeed, the increased sympathetic activation due to the combination of mechano and nociceptive sensitivity may interfere with the peripheral haemodynamic, and being responsible of the aberrant cardiovascular response in these conditions. The present proof of concept study aimed to test the separated and combined effects of mechanoreflex activation and nociception through exercise-induced muscle damage (EIMD) on vascular responses to single passive leg movement (sPLM).
METHODS: Eight healthy young males undertook four experimental sessions, in which performed a sPLM manoeuvre on the dominant limb while in each specific session the contralateral was: a) in a resting condition (CTR), b) stretched (ST), c) resting after EIMD called delayed-onset-muscle-soreness (DOMS) condition, or d) stretched after EIMD (DOMS+ST). EIMD, used to induce DOMS in the following 24-48h, consisted of several maximal voluntary eccentric contractions of the non-dominant leg (~200-250). Femoral blood flow (FBF) was assessed using a doppler ultrasound while mean arterial pressure (MAP), heart rate (HR) and cardiac output (CO) were assessed non-invasively beat by beat via finger photoplethysmography. Leg vascular conductance (LVC) was calculated as FBF/MAP.
RESULTS: Resting FBF and LVC were decreased only in the DOMS+ST condition (Δ:-26ml/min and -50ml/mmHg/min respectively) and MAP, HR, CO, and SV were increased in ST and DOMS+ST compared with CTRL. Marked decreases of delta peaks and AUC for FBF (Δ: -146ml/min and -265ml respectively) and LVC (Δ: -8.66ml/mmHg/min and ±1.7ml/mmHg respectively) were found only DOMS+ST compared with CTRL. All, $p<.05$.

CONCLUSION: These results suggest that the combination of mechanoreflex and nociception reduces leg blood flow and increases central hemodynamic responses during sPLM. However, the effects of mechanoreflex activity or nociceptive sensitisation alone seem to not be sufficient to exert a significant reduction in peripheral haemodynamics.
References:
S. J. Ives et al., The Mechanoreflex and Hemodynamic Response to Passive Leg Movement in Heart Failure. Medicine & Science in Sports & Exercise 48, (2016).
N. Nakamura et al., Muscle stiffening is associated with musclemechanoreflex-mediated cardioacceleration. Eur J Appl Physiol 122, 781-790 (2022).
M. Venturelli et al., Heart and musculoskeletal hemodynamic responses to repetitive bouts of quadriceps static stretching. J Appl Physiol (1985) 127, 376-384 (2019).
T. Peçanha et al., Increased sympathetic and haemodynamic responses to exercise and muscle metaboreflex activation in post-menopausal women with rheumatoid arthritis. J Physiol 599, 927-941 (2021).

## STRENUOUS EXERCISE RESPONSE OF SALIVARY HUMAN NEUTROPHIL PEPTIDES 1-3 (HNP1-3), SERUM HNP1-3 AND BLOOD NEUTROPHILS IN YOUNG MALE SUBJECTS

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INTRODUCTION: In the field of athletics, the risk of upper respiratory tract infection (URTI) is one of the most important problems in athletes. Salivary human neutrophil peptides 1-3 (HNP1-3) have anti-virus activity, thereby preventing URTI. HNP1-3 are predominantly expressed in neutrophils. There is only one report about HNP1-3 in response to exercise. However, this response did not examine immediately after exercise. The aim of this study was to examine salivary HNP1-3 with serum HNP1-3 and neutrophils responses to strenuous exercise.
METHODS: Ten healthy young male subjects (23.4 ± 0.6 years) participated in this study. The subjects performed exercise experiment (exercise on a cycle ergometer at 75% VO2max for 60 min) and control experiment (non-exercise). Saliva and blood samples were collected pre exercise (7:30 A.M.), post exercise (8:30), post 1 h (9:30), post 2 h (10:30), and post 3 h (11:30), after the bout of exercise. HNP1-3 concentrations were measured by the enzyme-linked immunosorbent assay. Counts of neutrophils were obtained using an automated cell counter.
RESULTS: In the exercise experiment, salivary HNP-1-3 concentration didn' t significantly change after exercise. Otherwise, serum HNP1-3 concentration were significantly increased at post 2h and 3h after exercise compared with immediately after exercise ($p < 0.05$) and neutrophils count were significantly increased at post1h, post2h and post3h after exercise ($p < 0.05$). In the control experiment, serum HNP1-3 significantly decrease at 10:30 compared with 7:30. Otherwise, salivary HNP1-3 and neutrophils count didn't change.
CONCLUSION: In this study, salivary HNP1-3 didn' t significantly change after exercise, whereas serum HNP1-3 and neutrophils gradually increased after the exercise. Therefore, there might be the time lag between increased serum HNP1-3 and neutrophils responses to strenuous exercise.

## EFFECTS OF RESISTANCE EXERCISE-INDUCED HYPERURICEMIA ON POSTPRANDIAL GLUCOSE AND LIPID METABOLISM IN HEALTHY YOUNG MEN

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INTRODUCTION: Hyperuricemia is a risk factor in the development of gout and is highly associated with cardiovascular diseases and type 2 diabetes. In vivo and vitro studies, elevated uric acid (UA) increases production of reactive oxygen species and causes endothelial dysfunction, which may impair insulin signaling pathway. On the other hand, UA is a major antioxidant in the human plasma. Increased UA levels after acute resistance exercise (RE) has been reported, but whether RE-induced hyperuricemia would impair postprandial glucose and lipid metabolism has yet to be thoroughly understood. Therefore, this study aimed to explore the effects of acute RE-induced hyperuricemia on postprandial glucose and lipid metabolism in healthy young men.
METHODS: Healthy young men (n = 11; age 23 ± 2 years, body mass index 22 ± 2 kg/m2) conducted a randomized crossover counterbalanced trial involving two different loads of RE (moderate (MOD): 4 sets × 8 repetition × 70% of 1 repetition maximum (1RM), LOW: 4 sets × 16 repetition × 35% of 1RM) and sedentary control (CON). Meal test was performed an hour after each trial. Blood samples were collected at the corresponding time points.
RESULTS: Uric acid levels were significantly increased in MOD and LOW from post 30 to meal 120 min ($p < 0.05$). In comparison with CON, higher total area under the curve (AUC) of uric acid was observed in both exercise trials (MOD: +33.0%, LOW: +25.3; $p < 0.05$). No differences were observed in postprandial AUC of glucose, postprandial AUC of insulin, postprandial insulin resistance and secretion index, postprandial AUC of triglycerides, and postprandial AUC of nitrate/nitrite (NOx) between the three trials ($p > 0.05$).
CONCLUSION: Acute RE-induced hyperuricemia seems not to impair postprandial glucose and lipid metabolism in healthy young men.

## CP-MH10 Physical fitness

### HEALTH RELATED QUALITY OF LIFE CHANGES IN A TRAINING PROGRAM BASED ON HIGH-INTENSITY TRAINING UNDER HYPOXIC CONDITIONS

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INTRODUCTION: Mental disorders are an important source of disability that cause a decrease in HrQoL (Henares Montiel et al., 2020). It is estimated that in Spain and in the rest of European countries more than 25% of the population will suffer some mental health problem throughout their lives (Alonso et al., 2004). In this sense, regular physical activity has been reported how an effective tool to control emotions and even reduce the risk of mental disorders (Yan et al., 2020), inducing a potential direct and indirect effect on hippocampal thought brain derived neurotrophic factor (BDNF) production (Loprinzi & Frith, 2019; Rasmussen et al., 2009). However, higher BDNF concentrations have been reported after higher intensity of exercise (Chang et al., 2012; Jiménez-Maldonado et al., 2018). In addition to exercise, experiments in animals revealed that hypoxia conditioning may promote the expression of BDNF in the adult's hippocampus as well (Zhu et al., 2010). In this context, new strategies that sustain the benefits achieved in detraining periods are essential and the inclusion of hypoxic conditions during the HIIT program have been proposed like an effective strategy to achieve greater short-term and long-term health benefits (Camacho-Cardenosa et al., 2018). Therefore, the aim of this study was to determine the effect of 12-weeks of HIIT under hypoxic conditions following by 4-week detraining period on health-related quality of life and functional fitness of women adult health.
METHODS: Eighty-two participants were randomly assigned either to (1) experimental group (EG; n = 41), in which interval training under normobaric hypoxic conditions (17% of FiO2) was performed or to (2) the control group (CG; n = 41) in which interval training under normoxia was performed. Within one week before (pre), after (post) and four weeks after (det) the intervention health-related quality of life (through SF-36) and functional capacity: upper body strength (via "arm curl" test), lower body strength (via "chair stand" test), agility (via "8-foot- up and go" test) and aerobic capacity (via "6-minutes walking" test) and haemoglobin level were evaluated.
RESULTS: Compared to control group, after 12 weeks of training, the number of repetitions in the "Chair Stand tests" was significantly improved by 9.85% in EG vs 0.8% in the CG ($p = 0.033$). Compared with baseline, a significant improvement was observed on the number hand curls (+14.96%; $p < 0.001$), number of stands (+26.20%; $p = 0.011$), and agility (-4.94%; $p = 0.006$) in EG after 36 sessions of exercise. Additionally, when the exercise protocol was ceased, the distances walked during the 6-minutes's walk test was significantly extended of + 2.92% ($p = 0.05$), the number of hand curls remained increased by 16.03% ($p < 0.001$)
CONCLUSION: HIIT and normobaric hypoxia may be a promising strategy for improve the health-related quality of life in health women adults, with an additional benefit for maintaining the improvements even after training cessation.

### INTRACELLULAR BODY WATER AS A PREDICTOR OF ANAEROBIC PERFORMANCE IN CROSSFIT® ATHLETES

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INTRODUCTION: Body composition and its relationship to physical performance in athletes from different sports has been broadly studied. Hydration status and body fluids distribution has gained interest for showing association with certain health and performance variables. The purpose of the present study was to correlate intracellular (ICW) and anaerobic performance in CrossFit® (CF) athletes and develop multiple regression models.
METHODS: Thirty-four athletes (20 male; 14 female) volunteer to participate in this study (Age 32.55 ± 5.34 year; Height 171.29 ± 7.77 cm; Body Mass 73.88 ± 11.58 kg; BMI 25.13 ± 2.44). Intracellular (ICW) expressed in l were estimated by bioelectrical impedance analysis (Inbody 770, Cerritos, CA, USA). Anaerobic performance was tested by the Wingate test (WG), determining peak (WGPP), mean (WGXP) and minimal (WGMP) power values. Pearson correlation coefficient was used to define the association between variables and stepwise multiple regression analysis to determine their relationship.
RESULTS: ICW showed significant correlation with WGPP ($r = 0.90$, $p < 0.001$), WGXP ($r = 0.95$, $p < 0.001$) and WGMP ($r = 0.65$, $p < 0.001$). Two equations models, explained by intracellular water, were developed for peak and mean power: WGPP = -341.0015 + 37.7110 * ICW, R2-ajusted= 0.80, SEE= 3.2942 W, $p < 0.001$: WGXP = -277.5285 + 28.3841 * ICW, R2-ajusted= 0.89, SEE= 1.7095 W, $p < 0.001$.
CONCLUSION: Our results showed moderate to very-large correlation between ICW and anaerobic performance values. In summary, we can conclude that ICW is a strong predictor of anaerobic performance in CrossFit® athletes, explaining over 80% of power values.

### PHYSICAL FITNESS TESTS AND TRAINING INTERVENTIONS FOR JAPANESE ELITE PARA BADMINTON PLAYERS

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INTRODUCTION: Paralympic badminton has been adopted at the 2020 summer Paralympics in Tokyo. Paralympic badminton can be categorized into wheelchair athletes and standing athletes. So far there has never been researched on physical fitness tests and training interventions for Paralympic badminton athletes. The purpose of this study was to examine the effects of physical fitness tests and training interventions conducted on Paralympic badminton players.
METHODS: The participants were 14 Paralympic badminton players who can be divided into wheelchair athletes and standing athletes. This study measured for these athletes including body composition measurements, muscle strength tests, and aerobic capacity tests. Bodyweight, lean body mass (LBM), and body fat percentage were measured by the method of air displacement. Isokinetic strength of the extensor and flexor muscles at the knee joints were evaluated by dynamometry for standing athletes. On the other hand, upper muscle strength which includes push power and pull power were evaluated for wheelchair athletes. To measure the aerobic capacity, they performed on each multistage running test and bike ergometer test for standing athletes or hand ergometer test for wheelchair athletes, including 3-minutes stages separated by a 1-minute rest with speed or watt were increased every stage. All the tests were conducted 4

times from September 2020 to July 2021. The data that the initial day (pre) and the last day (post) were analyzed. 12 athletes of among them took part in training inventions.
RESULTS: The results showed that standing athletes' body composition measurements, muscle strength, and aerobic capacity for standing athletes were not significant compared pre and post. By contrast, body weight and body fat percentage were lower than in pre for wheelchair athletes. And upper muscle strength which includes push power and pull power were larger than in pre. On the other hand, aerobic capacity for wheelchair athletes were not significant compared pre and post.
CONCLUSION: This study has shown that wheelchair athletes improved data in body composition measurements and muscle strength tests, however, there was no significant difference pre and post for standing athletes. We can see the effects of the training interventions for particularly wheelchair athletes so that we discuss them in detail. Wheelchair athletes are required for not only badminton skills but also wheelchair skills and the power which are to move forward or backward. We conducted resistance training including push power and pull power focused on the upper body of wheelchair athletes. For this reason, Para badminton wheelchair athletes could improve upper body power. The main point of this study is that physical fitness tests and training interventions are effective for wheelchair athletes particularly.
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### 3-M ROPE-CLIMBING TEST: A COMPARISON BETWEEN MALE AND FEMALE RESULTS

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INTRODUCTION: Combat tasks (CT) expose soldiers to exhausting physical and physiological demands in war operations [1]. Specific training focused on simulated tasks (ST) can be considered the best way to increase physical readiness in combat [2] without exposing the troops to unnecessary risks. However, little is known about the differences in ST performance between men and women [3]. Thus, the purpose of the current study was to investigate possible sex differences in physical performance on a 3-m rope-climbing test (RCT).
METHODS: Two hundred cadets from the Brazilian Air Force (167 male) performed the selected test. The test began when the participant held the rope above the 1.6 m mark and started to climb. The test ended when the cadet put the two hands above the 4.6 m mark or when he gave up without completing the ST. All volunteers were already familiar with the test. Statistical analysis of group performance was compared using the chi-square test of independence. The significance level was set at $p<0.01$.
RESULTS: Significant differences were found between males and females. Male cadets had a significantly higher pass rate in the RCT ($X^2(2) = 39{,}403$; $p<0.01$). A total of 140 participants passed the test (132 men, 8 women; 94.3% and 5.7%, respectively), and 60 cadets did not complete the test (35 men, 25 women; 58.3% and 41.7%, respectively).
CONCLUSION: The physiological specificity of women may have contributed to a significantly lower performance in the RCT, which involved upper-body power. Therefore, it could be useful to take into account these differences in performance, considering that specific physical training could be developed for each gender to improve combat readiness levels.
1. Foulis et. al. (2018) 2. Knapik et al. (2009) 3. Conkright et al. (2021)

### MEASURING FITNESS IN ARTISTIC GYMNASTS: THE UPDATED MEN'S ARTISTIC GYMNASTICS FITNESS TEST BATTERY (MAG-FTB)

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INTRODUCTION: An objective assessment of specific physical fitness is an essential part of the training process of gymnasts. The Men's Artistic Gymnastics Fitness Test Battery (MAG-FTB) has been used for over 30 years as the main tool for testing specific fitness in Bulgarian male artistic gymnasts but it needed to be updated and improved due to modern developments in gymnastics. The aim of this study was to assess the need to update certain tests from the MAG-FTB and add components for monitoring and assessment of specific fitness.
METHODS: The study included 70 male gymnasts (mean age of 9.6 ± 2.5 years) who were members of the Bulgarian Gymnastics Federation. The participants completed the MAG-FTB, which included a total of 20 fitness tests with each age group undertaking between 8 and 10 tests. The modified shuttle run test on the 12m gymnastics floor was replaced with the original 20m shuttle run test (20m SRT) in order to assess gymnasts' maximal oxygen uptake (VO2max) for the gymnasts at the age of 13 and older. The test was administered by using BeepShuttle Junior software using Leger's equations to calculate VO2max. The MAG-FTB's points system for each test was modernized with percentile scores (for up-to-date application and comparison between ages), and the total test battery score was recalculated for each age group.
RESULTS: The total MAG-FTB scores showed that 4.3% of the male gymnasts were assessed as 'excellent', 18.6% as 'very good', 15.7% as 'good', 45.7% as 'fair', and 15.7% as 'poor' results. This wide variation of the results was due to the diverse nature of the gymnasts participating in the study, including both elite and intermediate level gymnasts. The relationship between total MAG-FTB scores and gymnasts' current competitive level was found to be moderately correlated ($r = 0.50$). The results from the 20m SRT showed a mean VO2max of 47.4 ± 4.0 ml/kg/min, which was close to published VO2max values for gymnasts (around 50 ml/kg/min) in different studies in the literature. The mean percentile score of VO2max was 63.5 ± 21.8. The 20m SRT provided more valuable information for the coaches in contrast to the replaced 12m shuttle run test which was previously used in the MAG-FTB. Moreover, testing gymnasts with specialized shuttle run software was well accepted, highly convenient, and comprehensive.
CONCLUSION: The MAG-FTB provides gymnastics coaches with a functional, field-based tool to measure and assess specific physical fitness for safe and effective participation in men's gymnastics. The updated battery considered the modern developments in gymnastics, and it can be easily incorporated into any artistic gymnastics program. Annual testing with the MAG-FTB can provide important information about individual training regimens, fitness deficits, and directions for training development.

**FIT FOR DUTY: THE IMPACT OF TACTICAL GEAR / LOAD CARRIAGE ON OCCUPATIONAL PERFORMANCE AND ITS RELATIONSHIP TO FITNESS ATTRIBUTES IN ELITE POLICE OFFICERS/OPERATORS**

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INTRODUCTION: Several studies on physical fitness (PF) attributes and police performance [1-3] have reported that a steady set of attributes underlie the most frequent and critical tasks identified in police duties [3]. Given the need for officers to wear tactical gear, it is important to understand the effects this additional load can have on occupational performance [2-3]. O objective of this study was to evaluate the acute metabolic impact of wearing personal protective equipment (tactical gear) on the performance of elite police officers
METHODS: 42 police officers (Age = 39.4 ± 1.3 yrs., Height = 178 ± 0.01 cm, Body mass = 80.3 ± 1.3 kg, BMI = 26.2 ± 0.3 kg/m2, Fat mass = 15.4 ± 0.5%) performed a battery of physical fitness tests including: push-ups, shuttle test, handgrip strength (kg), throw medicine ball (3kg), countermovement jump (CMJ, cm), push-ups, T-test, standing broad jump, sit-up test, and flexibility. The participants performed the On-Duty Task (ODT) Police Physical Fitness Circuit twice. The ODT was composed of tasks: The first stage was supposed to mimic a foot pursuit, completing four laps with an obstacles sprint. The second part simulates the solving of the problem, where the participant should: (a) flip a 65-kg tire four times; (b) lift and carry a 25-kg bag for 10 m; (c) push a 65-kg sled for 10 m and pull it on his way back another 10 m; and (d) drag/carry a 48-kg dummy for 15 m. The total distance of the ODT-ST was 393 m, and the final time was recorded [3]. The first ODT trial was performed in physical training (PT) clothes, whereas the second trial was performed in tactical gear (TG). During the ODT, completion time, heart rate, blood lactate, and rating of perceived effort (RPE) were assessed. Paired sample t-tests were used to compare ODT outcomes between PT and TG conditions. Correlation and regression analyses were used to identify fitness correlates of ODT time and predictive factors of ODT time in the TG condition, respectively.
RESULTS: It was observed that Elite police have a good fitness level, and good body composition (10 to 20 % Fat mass, 82% of the sample) even in comparison with the international police panorama. The use of TG increased ODT time by 25% ($p < 0.01$), and RPE ($p<0.01$). There were strong negative correlations between almost all fitness variables and ODT time ($p<0.05$). The multiple linear regression analysis produced the following predictive equation: Performance in ODT with TG = 185.87 – (2969 * No. push-ups) + (15.777 * T-Test) - (1.732 * right handgrip strength) showing that the maximum number of repetitions of push-ups, agility test time, and the right-handgrip values explained 46.2% of the variance in ODT time
CONCLUSION: The use of tactical gear decreases Elite Police operators load carriage-based occupational performance, and this performance is related to a diverse set of fitness attributes.
1. Marins et al. (2018) 2. Lesniak et al. (2020) 3. Teixeira et al. (2019)

**EFFECT OF THE TIME OF DAY OF EXERCISE TRAINING ON THE INCREASE IN STRENGTH AND ENDURANCE: A SYSTEMATIC REVIEW WITH META-ANALYSIS**

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INTRODUCTION: Diurnal variations in physiological body functions affect physical performance, with an apparent peak in the afternoon and evening [1]. However, it is unclear if training at particular times of day may result in larger improvements in physical performance. Thus, the aims of this systematic review were to investigate: 1) if in intervention studies the time of day of training influences the magnitude of the increase in performance, and 2) whether the improvement in performance is dependent on the time of day when the performance was assessed.
METHODS: EMBASE, PubMed, Cochrane Library, and SPORTDiscus databases were searched. Eligibility criteria of the studies were: (1) comparing exercise interventions between at least two different times of day, (2) examining structured exercise interventions with an intervention duration of a minimum of two weeks and at least two exercise sessions per week, (3) conducting strength and/or endurance interventions; and (4) applying a randomized parallel group or crossover design. A modified version of the “Cochrane risk of bias tool” was used to assess methodological quality of the studies. Due to the limited number of studies examining harmonizable outcomes, a meta-analysis was only conducted for jump height and maximum strength. In all studies part of the meta-analysis, all subjects performed morning and evening performance tests, both at baseline and post-intervention. The change in performance assessed in the morning and the change in performance assessed in the evening, from baseline to post-intervention was compared between morning and evening exercise interventions. Because effect sizes were reported for only some studies, Cohens d was calculated to estimate effect sizes. Here, positive Cohens d indicate larger performance improvements with evening exercise training and negative Cohens d indicate larger performance improvements with morning exercise training.
RESULTS: From 12,783 screened articles, 22 articles were included in the systematic review of which seven were also included in the meta-analyses. The overall effect sizes (95% confidence intervals) for the improvement in jump height tested in the morning was -1.11 (-2.18 to -0.03), suggesting that exercising in the morning might be beneficial to increase jump height achieved in the morning. In contrast, evening training seemed no to be beneficial for increasing jump height tested in the evening with 0.33 (-0.12 to 0.77). For maximum strength, the results were -0.14 (-0.60 to 0.32) and 0.34 (-0.03 to 0.71), for morning and evening tests, respectively.
CONCLUSION: There is little evidence that exercising at a specific time of day is more beneficial in increasing jump height or maximum strength as compared to another time of the day per se. However, the observation that morning exercise seems to improve morning performance and evening exercise improves evening performance to a higher extend, warrants further investigation.
REFERENCE:
[1] Mirizio et al., Sci Rep, 2020.

**A SIX- MONTH TAILORED TELEPHONE AND EMAIL-BASED EXERCISE INTERVENTION INCREASED PHYSICAL FITNESS IN PHYSICALLY INACTIVE ADULT:A RANDOMIZED CONTROLLED TRIAL**

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INTRODUCTION: Tailored mobile health physical activity (PA) interventions have proven effective in enhancing PA levels in adults (1), however the effect of such interventions on objectively measured physical fitness is scarce. The purpose of this parallel group randomized

controlled trial was to assess the effect of a six-month tailored telephone and email-based exercise intervention on cardiorespiratory fitness (CRF) and musculoskeletal- and neuromotor fitness (MSMF), in apparently healthy but physically inactive adults.
METHODS: A total of 111 physically inactive adults (40-55yr) from the Agder counties, Norway volunteered for the study. The participants were randomly assigned to an intervention group (IG;n=56) or a control group (CG;n=55), using random allocation numbering, stratified by gender. The IG received tailored exercise recommendations, every two months by email or mail (print) and supporting motivational follow-ups every fortnight, alternatively by email and telephone. The CG received no follow-up during the intervention period. Outcome measures were objective measures of physical fitness (CRF and MSMF), which were assessed at baseline and post-intervention (IG:n=39, CG:n=50). All personnel involved in the intervention and both assessments were blinded for group allocation. The data was analyzed by per-protocol using the Statistical Program for Social Sciences. Results are given in median and effect size. The significance level was 0.05.
RESULTS: The IG showed larger improvements compared to the CG in maximal oxygen consumption by VO2max, in ml/kg/min (ES:0.11, p=0.002) and in l/min (ES:0.12, p=0.002), muscular endurance of the back extensors (ES:0.21, p<0.001), flexibility of the hamstrings muscles (ES:0.12, p=0.006), and explosive power (ES:0.09, p=0.022), from pre- to posttest, when adjusting for baseline scores. When fully adjusted, the IG showed significantly larger improvements in VO2max in ml/kg/min (ES:0.17, p=0.002) and l/min (ES:0.13, p=0.008), compared to the CG.
CONCLUSION: A six-month tailored telephone and email-based exercise intervention had significant positive effects on several aspects of CRF and MSMF in physically inactive adults and may be a possible effective tool in promoting physical fitness in physically inactive adults.
REFERENCES
1. Davis, A., Sweigart, R., Ellis, R. (2020). "A systematic review of tailored mHealth interventions for physical activity promotion among adults." Translational Behavioral Medicine 10(5): 1221-1232.

### MULTIDISCIPLINARY PRACTICE PATTERNS CURRENTLY USED FOR ATHLETES WITH RELATIVE ENERGY DEFICIENCY IN SPORTS (RED-S)

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INTRODUCTION: Relative Energy Deficiency in Sports (RED-S) is a condition that can develop when a person's exercise energy expenditure exceeds their energy intake. Prevention and intervention strategies for RED-S are necessary to avoid potential short and long-term consequences, such as stress fractures, osteopenia and osteoporosis. Sport health professionals are crucial for screening, treating and preventing RED-S and a multidisciplinary team approach is suggested. The purpose of this study was to examine if a multidisciplinary team approach is used for RED-S among coaches, athletic trainers, and physical therapists working with athletic populations in the U.S.
METHODS: Databases were obtained for currently practicing collegiate coaches, certified athletic trainers, and physical therapists in the U.S. A survey was developed, tested for content validity, and randomly emailed to potential participants using Qualtics. The questionnaire allowed participants to provide narrative descriptions for how they treat, prevent, and screen for RED-S and data were collapsed into themes. Participants used Likert Scales to rank the specific actions they practice when they come into contact with an athlete suspected to have RED-S.
RESULTS: Three hundred twenty-five participants (136 coaches, 85 athletic trainers 104 PTs) completed the survey. Athletic trainers and physical therapists were most likely to first discuss the condition with the athlete. Coaches were most likely to first discuss the athlete and condition with the athletic trainer. The most commonly practiced treatment strategies were nutritional education, multidisciplinary consultation, incorporating more resistance training in place of cardiovascular exercise, referral to a dietitian and sports psychologist (mental health specialist). The most common prevention strategies were employing multidisciplinary educational sessions about RED-S, pre-participation screening examinations, dietary counseling, and discussing RED-S individually with the athlete or with the athlete's physician and parents.
CONCLUSION: The survey respondents in this study indicated that they use similar multidisciplinary preventation and treatment approaches to RED-S, however the order of priority and use of referral sources may differ. Of interest in future studies is determining the specific treatment and prevention strategies dietitians and sports psychologists use for the treatment and prevention of RED-S.

## Conventional Print Poster

### CP-BM05 Biomechanics and kinematics

### FOOTSTRIKE PATTERN INFLUENCE ON FOOT-ANKLE MUSCLE STRENGTH IN ENDURANCE RUNNERS.

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INTRODUCTION: Running with minimalist footwear appears to increase the strength of the ankle plantar flexors and the volume of the intrinsic foot muscles. However, authors also reported minimalist footwear induces a shift from rearfoot strike to non-rearfoot strike. Thereby, it remains unclear whether the strength gain in the foot-ankle muscle was induced by minimalist footwear or a forefoot striking pattern. The aim of this study was to assess the influence of footstrike pattern in foot-ankle muscle strength in endurance runners.
METHODS: Seventy-two volunteers filled out a questionnaire relative to their running level and training. The minimalist index of the two most frequently worn footwear during the previous six months was assessed. Maximal voluntary isometric contraction (MVIC) of six different foot-ankle muscles were assessed using a fix hand-held dynamometer. The footstrike pattern was determined with high-speed camera during a self-paced run on a treadmill. Each runner was categorized as either rearfoot or non-rearfoot strikers.
RESULTS: Data was collected amongst 36 runners with rearfoot strike and 36 with non-rearfoot strike. The results showed that non-rearfoot strikers had higher maximal voluntary isometric strength (MVIS) for ankle plantar flexors ($p = 0.015$), ankle dorsiflexors ($p = 0.01$), hallux flexors ($p = 0.04$) and toes flexors ($p = 0.0031$). No correlation was found between minimalist index and MVIS of foot-ankle muscles.
CONCLUSION: The footstrike pattern appears to have a larger influence on foot-ankle muscle strength than the type of footwear worn. However, an interventional study is needed to verify this observation.

**CORRELATION BETWEEN VARIABLES DEFINING THE FOOT-STRIKE PATTERN DURING RUNNING**

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INTRODUCTION: Currently, almost 11% of adults run regularly (1). Foot-strike pattern (FP) is one of the most heavily debated topics in the running population. There is a large volume of published studies focusing on the FP and running injuries; FP and running economy; FP in running preschool children etc. [2-4]. Foot-strike patterns are differentiated according to which part of the foot initially contacts the running surface first [5]. There are three types of FP - rearfoot, midfoot and forefoot. Various variables appear in the previous studies on the basis of how the authors define FP - vertical ground reaction force, foot-strike index, foot angle and ankle angle [3-5]. Foot-strike index is difficult to use on a treadmill because the movement of the belt can affect the accuracy of the center of pressure. Foot angle and ankle angle are kinematic measures that only indirectly indicate initial contact (IC). However, they are just useful in studies in which we do not have the ability of measuring ground reaction forces. If we want to compare the results of different studies that use different FP variables, we need to know if these variables are related. The aim of this study is to test whether different variables associated with FPs in the literature are correlated with each other (foot-strike index and foot angle).
METHODS: A total of 421 participants (166 females, 255 males) aged 30-50 years, from the database of the Healthy Aging in Industrial Environment-Program 4, were included in this study. Participants consisted of 327 recreational runners and 94 non-runners (mean age = 40.3±5.6 yrs, mass = 76.0±13.3 kg, height = 1.76±0.9 m and body fat = 28.2±6.2 %. All participants underwent kinematic and kinetic analysis of overground running at their self-selected speed (6). Foot-strike index and foot angle at sagittal plane at IC were determined (7). Spearman's rank correlation coefficient was used to determine the relationship between these variables.
RESULTS: The relationship between foot-strike index and foot angle at IC show a strong correlation (r=-0.81, r2=65.1%).
CONCLUSION: The main conclusion of the study is that there is a strong correlation between foot-strike index and foot angle which describes FP. Therefore, we could compare the results of different studies using different variables defining FP during running.
REFERENCES:
1) Pereira et al., PLoS One, 2021
2) Hollander et al., Med Sci Sports Exerc, 2021
3) Plesek et al., Med Sci Sports Exerc, 2021
4) Urbaczka et al., Gait Posture, 2022
5) Hamill et al., J Sport Health Sci, 2017
6) Jandacka et al., Int J Environ Res Public Health, 2020
7) Altman et al., Gait Posture, 2012

**NEUROMECHANICAL ADAPTATIONS OF FOOT FUNCTION TO CHANGES IN SURFACE DURING RUNNING**

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INTRODUCTION: We have shown previously that hopping humans exploit the adaptable mechanics of their feet to adapt to changes in surface. On an elastic surface, this resulted in participants selecting a posture at landing that allowed them to harness stored energy and reduce their active contribution to work. On a damped surface, participants activated their intrinsic foot muscles to contribute a substantial proportion of the additional positive mechanical work required to preserve motion. While hopping shares many mechanical characteristics with running, we have only been able to speculate if these observations are transferable. Here, we tested how running humans alter their foot function when interacting with a damped and an elastic surface and hypothesised that participants would harness energy stored in the elastic surface to reduce their intrinsic muscle activation and perform less work compared to when they ran across a damped surface.
METHODS: Nine participants ran across an adjustable platform in a damped and an elastic configuration. Three-dimensional kinematic and kinetic data were recorded in Qualisys alongside muscle activation from abductor hallucis (AH) and flexor digitorum brevis (FDB). Kinematic and kinetic data were processed in Visual3D (C-Motion) to calculate sagittal plane joint angles, moments and work performed at the midfoot using a multi-segment foot model. EMG data were processed in Matlab (Mathworks). Raw signals were band-pass filtered before root mean square (RMS) envelopes were computed and normalised for each participant to the peak amplitude recorded on a control surface.
RESULTS: Participants used similar ground contact times, landing posture and midfoot excursion on both surface configurations. The increase in energy returned from the platform in its elastic configuration meant that runners left the platform significantly faster than they did when it was in its damped configuration ($P = 0.04$), despite performing the same amount of work. Integrated EMG during contact revealed no change in activation of FDB ($P = 0.13$) or AH ($P = 0.22$) with surface.
CONCLUSION: Rather than reducing the work that they performed on the elastic surface, participants harnessed stored energy to increase their running speed. These results offer insight as to an energy-saving mechanism that may be exploited by the designers of footwear and other wearable devices to augment function.

**NEUROMECHANICAL ADAPTATIONS IN THE TRICEPS SURAE FOLLOWING CHRONIC EXPOSURE TO CYCLING AND TRIATHLON EXERCISE**

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INTRODUCTION: Chronic exposure to strenuous mechanical loading has been shown to alter muscle neuromechanical behaviour during locomotion (Bissas et al., 2020) and mechanical profiles such as joint moment-angle relationships (Herzog et al., 1991). These adaptations might be movement-specific, although there is a lack of empirical evidence showing whether changes to muscle-tendon mechanical profiles translate to improved neuromechanical performance during movement. Therefore, the purpose of the study was to compare muscle-tendon profiles in trained cyclists, triathletes, and untrained controls, and to quantify neuromechanical characteristics during steady state cycling.
METHODS: Twenty-nine participants (10 cyclists, nine triathletes and, 10 controls) cycled at four intensities (150, 200, 250, and 300 W). Measurements of pedal forces (Radlabor, Germany), joint kinematics (Qualisys, Sweden), muscle activity (Delsys, USA), and fascicle mechanical behaviour of the gastrocnemius medialis (Telemed, Lithuania) were measured during the final minute of each 5-min trial. In addition, muscle-tendon morphological and mechanical properties were measured in the form of B-mode ultrasound (Siemens, Germany) to

obtain muscle and tendon thickness, fascicle length, and pennation angle, as well as isometric/isokinetic dynamometry (Biodex, USA) to obtain passive ankle stiffness, moment-angle, and moment-velocity profiles.
RESULTS: Increases in pedal kinetics, ankle dorsiflexion angle, and normalised muscle activity were observed with an increase in exercise intensity (all $p < 0.001$). However, there were generally no differences in fascicle mechanical function (fascicle range, shortening velocity, pennation angle change), although some changes in muscle gearing were observed. There were also no differences between groups at any exercise intensity. There were typically no differences in isometric/isokinetic strength between groups. However, triathletes had a higher Achilles tendon thickness across multiple sites and a higher passive stiffness than the other groups ($p \leq 0.048$).
CONCLUSION: The triceps surae behave like a strut during cycling, transferring forces from proximal joints to the pedal. We showed that this behaviour is consistent across exercise intensities and between trained and untrained populations, concluding that the requirements and subsequent performance of the ankle plantarflexors at these intensities are unaffected by chronic exposure to loading. The tendon morphological and mechanical adaptations seen in triathletes appear to be specific to, or at least caused by, running but these do not lead to any neuromechanical differences during cycling.
References:
Bissas, A., Havenetidis, K., Walker, J., Hanley, B., Nicholson, G., Metaxas, T., Christoulas, K., Cronin, N. J. (2020). Scand J Med Sci Sports, 30, 1151-1162.
Herzog, W., Guimaraes, A., Anton, M., Carter-Erdman, K. (1991). Med Sci Sports Exerc, 23, 1289-1296.

### SMALL DIFFERENCES IN TURN CYCLE STRUCTURE ASSESSED THROUGH AN IMU COULD BE DECISIVE TO ENHANCE DESCENT PERFORMANCE OF ELITE ALPINE SKIERS IN DIFFERENT SLALOM COURSE SETTINGS

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INTRODUCTION: Competitive alpine skiing is a sport that occurs between 40 and 150 km/h. At that speed, there are many details that could go unnoticed by coaches, especially when the differences between skiers are fractions of a second. Small differences in turn cycle structure translates into better performance on the turn. However, the influence on performance along a ski run (linked curves) has not been investigated yet. The aim of this study was to assess the influence of turn cycle structure on the performance of elite alpine skiers using an inertial measurement unit (IMU) in different slalom (SL) course settings.
METHODS: An IMU device was attached to the lower back of skiers. Four 10-gate SL courses were set: a flat-turned (FT), a steep-turned (ST), a flat-straighter (FS) and a steep-straighter (SS). Five elite alpine skiers (21.2 ± 3.3 years, 180.2 ± 5.6 cm, 72.8 ± 6.6) completed several runs at maximum speed for each SL course. A total of 77 runs were obtained. The skiers' performance was evaluated with the total time of each run calculated through a validated Magnet-Based Timing System (M-BTS). For each run, the acceleration signal on the Y-axis (lateral axis) was used to identified two main phases within the ski turn: Initiation (INI) and steering (STE) phases. By fusing the accelerometer information with the M-BTS, that provides the position of the gates on the magnetometer signal, it was possible to divide the STE phase by the turn's gate position leading to the steering phases into (STEIN) and out (STEOUT ) of the turn. For each run, the times corresponding to the same phase were added together, so the total time was decomposed into three partial times: INI time, time of STEIN and time of STEOUT. The two steering times were added together to obtain STEIN+OUT time. Statistical analyses were performed to assess the influence of turn cycle structure (partial times) on the total descent time. Pearson's linear correlation coefficient was used to calculate correlation. A Linear Mixed Model (LMM) was implemented for each partial time, where the skier corresponded to the random factor, the total time variable was the response variable and the partial time variable was the explanatory variable.
RESULTS: Fast total times correlate with a longer INI time in FT, a shorter STEOUT time in the FT and FS and a shorter STEIN+OUT time in the FT and SS courses. The LMM used for the analysis revealed that in the FT-course for each second increase in the INI time, the total time is reduced by 0.45 s, and for every one-second increase in the STEOUT and STEIN+OUT times, the total time increases by 0.48 s and 0.31 s, respectively.
CONCLUSION: Regardless of the SL set up, similar characteristics were observed in turn cycle structure for the fastest runs. To enhance descent performance, the skier should lengthen the INI time and shorten the STEOUT and STEIN+OUT time. Future studies could use an IMU to detect turn phases and analyze them using the other built-in sensors.

### THE EFFECT OF EXPERIMENTAL MUSCLE PAIN ON SELF-PACED CYCLING EXERCISE PERFORMANCE

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INTRODUCTION: Elevated muscle pain has previously been shown to reduce time to task failure exercise performance (1,2). However, the effect of increased muscle pain on self-paced exercise performance is currently unknown. Therefore, the purpose of this study was to experimentally induce muscle pain and investigate cycling time-trial performance.
METHODS: Eight healthy participants completed three experimental visits after a familiarisation session. After baseline measures of maximal voluntary force, voluntary activation, potentiated twitch force, corticospinal excitability and corticospinal inhibition, participants either received no injection (CTRL), a bilateral isotonic saline injection (1 mL, 0.9% NaCl; ISO) or a bilateral hypertonic saline injection (5.85% NaCl) into the vastus lateralis to cause quadriceps muscle pain (HYP). Participants then completed a 5-minute cycling time-trial whilst recording pain intensity on a visual analogue scale (VAS) and performed measures of neuromuscular fatigue and corticospinal excitability and inhibition 30 s post-exercise.
RESULTS: Time-trial performance in HYP (3.12 ± 0.38 km) was not different from CTRL (3.21 ± 0.24 km) or ISO (3.20 ± 0.26 km; $P = 0.171$). Pain intensity was similar between CTRL (average VAS = 45/100) and ISO (average VAS = 46/100; all $P > 0.05$) but was greater in HYP (average VAS = 63/100) compared to CTRL and ISO from 30 s to 150 s (all $P < 0.05$). There was a significant correlation between the mean pain intensity within minute 1 in HYP and the change in mean power between HYP and ISO ($r = 0.717$; $P = 0.045$). There was no change in the decline in maximum voluntary force (-27%; $P = 0.413$), and potentiated doublet amplitude (-29%; $P = 0.560$) across conditions whereas voluntary activation remained unchanged from baseline ($P = 0.071$). No differences in corticospinal excitability or inhibition were seen over time or between conditions (all $P > 0.05$).
CONCLUSION: Elevated muscle pain within the vastus lateralis may only impair short duration, self-paced cycling performance when the pain intensity from the hypertonic saline and exercise-induced pain reaches 'very strong'. Increased pain did not result in any neurophysio-

logical changes to exercise. Therefore, pain appears to have divergent neurophysiological and performance effects on open versus closed loop exercise.

References
1.) Norbury et al. (2022). Eur. J. Appl. Physiol, 122(1), 113-126.
2.) Canestri et al. (2021). Psychophysiology, 58(6), e13810.

**KINETIC ENERGY OF THE TRUNK, A KEY PARAMETER TO EXPLAIN PERFORMANCE IN SPRINT RUNNING ACCELERATION?**

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INTRODUCTION: Sprint performance is determined by the ability of the sprinter to generate high velocity (V0), high power (Pmax) and forces (F0) at the centre of mass (CoM) (1). To improve these parameters, it has been showed that kinetic energy (KE) of the trunk and the leg plays a central role during the starting phase and first step (2). However, the contribution of the trunk to the rest of the acceleration phase remains unknown. This study aimed to measure the contribution of each body segment to the production of total body kinetic energy during a 40-m sprint.
METHODS: Nine recreational sprinters performed two 40-m sprints wearing a MVN Biomech suit (Xsens). Kinematic data recorded were used to calculate total body KE, and the KE of each segment from the velocity of the CoM of the segments. The KE of each segment was then expressed as a percentage of the total body KE. We divided the sprint into 3 phases according to the methodology of Samozino et al. (3) to compute the force-velocity relationship: 1-start to maximal power (Pmax), 2-Pmax to maximal velocity (Vmax), and 3-Vmax to the end of the 40m.
RESULTS: Total body KE increased from the start to the end of the 40-m sprint (from 331.3 ± 68.4 J in phase 1 to 2378.8 ± 233.0 J in phase 3 $p \leq 0.001$). The contribution of the head-trunk increased (from 39.5 ± 2.4% to 46.3 ± 1.1% $p \leq 0.05$). Contribution of the upper and lower limbs decreased over the 3 phases (respectively from 15.7 ± 2.5% to 10.6 ± 0.6% and from 44.8 ± 2.1% to 43.1 ± 1.5%; $p \leq 0.05$).
CONCLUSION: This study revealed the important contribution of the trunk to forward propulsion throughout the entire acceleration phase. When typical continuous KE of lower limb and head-trunk limb is plotted expressed as a percentage of the total energy, the KE of he lower limb and the trunk limb are in opposite phase, and suggested that trunk and legs make an opening and a closing movement during the sprint. This closing-opening movement is particularly important with a great amplitude during the first steps of the sprint. This suggested that this "closing-opening" movement is a mechanism allowing to produce a great KE energy variation and to produce higher Pmax during the phase 1.

**EFFECTS OF WEARING NIKE DRAGONFLY TRACK SPIKES ON 3000M RACE PERFORMANCE AND STRIDE LENGTH: A PILOT STUDY.**

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INTRODUCTION: Recently, several records have been broken in different athletic championships. The success has been partially attributed to including carbon or plastic fiber plates and other advanced materials in racing shoes (1). There is evidence that the novel racing shoes designed with carbon/plastic fiber plate have improved running economy (2,3) and performance (1,4) during long distance road races. However, research regarding track spikes is scarce. Therefore, this pilot study aimed to compare the effect of wearing Nike Dragonfly versus conventional track spikes on a 3000-m race performance in trained runners.
METHODS: Eight male trained middle- and long-distance runners, volunteered to participate in this experimental and ecological investigation (age: 31.88 ± 10.05 yrs; body mass: 64.88 ± 7.95 kg; height: 1.77 ± 0.04 m; running experience: 11.50 ± 5.98 yrs). In a randomized and counterbalanced design, all participants were tested in two simulated 3000-m competitions, separated by one week, using Nike Dragonfly (ND) versus their conventional track spikes (CS). The ND track spikes were provided to the participants for familiarization 2 weeks before starting the experiment.
During the testing days, participants performed a 40-min standardized warm-up, and then, they performed a simulated 3000-m competition on a conventional track wearing either the ND or CS. In addition, six marks were placed from 5 m to the finish line, separated by 1-m between them. A camera was placed 10-m apart to film this section at 240 frames/second for a posterior step analysis with Kinovea v.0.9.5 to measure the stride length (centimeters) and total time of the race (seconds). Paired t-tests were performed to compare the mean stride length and total time of the race between the ND and CS. Statistical significance was set at $p<0.05$.
RESULTS: There were significant differences for the total time ($p=0.012$) and stride length ($p=0.006$) between the ND and CS conditions during 3000-m competition. Performance was improved with the ND (548.14 ± 26.59 s) compared to CS (565.46 ± 33.24 s). In addition, the ND condition increased stride length in both right (ND = 161.75 ± 9.71 cm; CS = 160.34 ± 8.46 cm; $p=0.02$) and left leg (ND = 162.25 ± 8.78 cm; CS = 159.63 ± 9.05 cm; $p=0.001$).
CONCLUSION: According to the results of this pilot study, the ND, whose design includes a plastic fiber plate in the midsole, improve 3000-m performance and increase stride length compared to conventional track spikes. Similar to the racing road shoes, these new track spikes could be responsible, almost in part, for actual general improvement in the middle- and long-distance races in track.
REFERENCES:
1) Bermon et al. (2021)
2) Hunter et al. (2019)
3) Whiting et al. (2021)
4) Rodrigo-Carranza et al. (2021)
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### THE FOOTSTEPS OF A NEIGHBORING RUNNER AFFECT THE STEP FREQUENCY OF THE MAIN RUNNER

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INTRODUCTION: We sometimes coordinate our movements with those of others unconsciously. Such an interpersonal synchronization can occur in daily situations as well as in athletic situations. While it has been reported that interpersonal synchrony may occur during running competitions, it has not been clarified what kind of information is exchanged between runners to produce interpersonal synchrony during running. In this study, we investigated the possibility that auditory information (footsteps) is involved as a factor in the occurrence of interpersonal synchronization between long distance runners. In particular, we hypothesized that the tempo of neighboring runner (NR)s footsteps would entrain the step frequency (SF) of the main runner (SF would be closer to the tempo of the footsteps), and we aimed to clarify the effect of footsteps of a NR on the SF of the main runner.
METHODS: Ten healthy male trained distance runners participated in this experiment, in which the main runner (participant) and NR (examiner) ran with the same running speed on two adjacent treadmills separated by a thin wall. The participants were not told the true purpose of the experiment, but were told that the experiment was to measure their heart rate (HR) while running side by side. NR performed three trials of changing the footstep tempo by 5 bpm (beat per minute) faster (+5bpmFS), 5 bpm slower (-5bpmFS), or no footsteps (NF). Participants' SF were measured while running. In addition, HR and rate of perceived exertion (RPE) were measured as indices of physiological and psychological load that indirectly indicate effects on performance.
RESULTS: One-way ANOVA was performed for each measurement. While there was no main effect of running condition on neither the SF, nor the HE, nor the RPE, a significant main effect was found on the SD of SF ($p<.05$). As a result of multiple comparison, the +5bpmFS had an increase in the SD of SF compared to that of NF ($p<.01$).
CONCLUSION: Despite the faster or slower footstep tempo of a NR, there was no difference in the SF of the main runner relative to the NF. Thus, it was unclear whether the footsteps of NR produced entrainment of the running SF. However, the SD of SF increased under conditions of faster footstep tempo, suggesting that the footsteps of a NR may exert some disturbance on the SF of the main runner. The results of this study suggest that auditory information can influence the SF of long distance runners and that the footsteps of NR to them act as one of the interpersonal factors that affect performance.

## Conventional Print Poster

### CP-PN09 Gender issues / maturity / energy expenditure

### NORMALIZATION TO FAT-FREE MASS STRENGTHENS THE RELATIONSHIP BETWEEN HEMOGLOBIN MASS AND AEROBIC FITNESS AND REDUCES SEX-BASED DIFFERENCES IN INDIVIDUALS MATCHED FOR FITNESS

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INTRODUCTION: As body mass (BM) and body composition impact the interpretation of maximal oxygen uptake (VO2max) as a marker of fitness, particularly across sexes, VO2max must be appropriately normalized to accurately represent fitness status, and the same is likely true for hematological data. Females are typically reported to have lower absolute hemoglobin mass (Hbmass), blood volume (BV), plasma volume (PV), and red blood cell volume (RBCV) compared to males. Despite known differences in body composition between sexes, the convention is to normalize VO2max and hematological data to BM—rather than fat-free mass (FFM)—which may not be sufficient to investigate sex-based differences.
METHODS: Hematological data and ramp incremental cycle ergometer test data from 38 (21 male; 17 female) healthy young (mean [SD]; 29 [6] years) volunteers of heterogenous training status were analyzed. Hbmass and intravascular volumes (BV, RBCV, PV) were determined by the CO-rebreathing technique. Body composition was measured using dual-energy x-ray absorptiometry. Sex differences were analyzed by comparing relative values derived using two normalization methods between males and females (i.e., BM and FFM). Linear regressions were performed between absolute and relative (normalized to BM and FFM) values.
RESULTS: Males and females were matched for FFM-normalized VO2max (females 62 [12] and males 64 [12] mL/kg FFM/min; $p=0.68$). Absolute Hbmass, BV, RBCV, and PV were significantly higher in males than females (mean differences 36%, 23%, 35%, and 15%, respectively, all $p < 0.05$). [Hb] and hematocrit were higher in males (16.1 [1.1] g/dL and 48.6 [3.6] %) compared to females (14.1 [1.1] g/dL and 43.0 [2.2] %) ($p<0.001$ for both). Hbmass (13.5 [2.6] vs. 10.4 [1.4] g/kg) and BV (91 [16] vs. 80 [11] mL/kg) were significantly higher in males than females when normalized to BM ($p<0.001$ and $p=0.026$), but Hbmass (15.1 [1.6] vs. 14.2 [1.4] g/kg) and BV (103 [11] vs. 110 [11] mL/kg) were not significantly different between sexes when normalized to FFM ($p=0.054$ and $p=0.065$, respectively). PV was similar for males (51 [9] mL/kg) and females (49 [7] mL/kg) when normalized to BM ($p=0.54$), but higher in females (67 [7] mL/kg) than males (57 [7] mL/kg) when normalized to FFM ($p<0.001$). Absolute Hbmass showed a significant correlation with absolute VO2max ($r=0.82$, $p<0.001$). Normalization of both variables to BM resulted in a weaker, non-significant correlation ($r=0.19$, $p=0.26$), whereas normalization to FFM restored a significant correlation ($r=0.63$, $p<0.001$).
CONCLUSION: Differences between sexes were greatly reduced when data were normalized to FFM, suggesting that the difference in body composition contributes substantially to sex-based differences. Furthermore, Hbmass explained ~40% of the variation in fitness when Hbmass and VO2max were normalized to FFM but only ~4% when normalized to BM. Normalization to FFM seems to be the better strategy for investigating sex-based differences.

### ZUMBA DANCE ENHANCES FUNCTIONAL PERFORMANCES IN MIDDLE-AGED WOMEN

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INTRODUCTION: Due to aging and menopause, functional problems and disability are burdens for middle-aged women. There is a need to identify strategies that target middle-aged women to have a global impact on such issues, which is potentially important to delay functional problems later in life. Strategies to promote physical activity at this stage of life can potentially prevent the risk of falls and enhance their

quality of life (King, 2012). Zumba has become one of the most popular high-impact physical activities. Scientific data in healthy women showed that Zumba has various positive effects on functional performances in terms of body composition, postural balance, aerobic fitness and physical fitness, as well as on psychological well-being (A. A. Delextrat et al., 2016). While the good feasibility in terms of adherence, and the reduction of sports barriers related to Zumba training, to the best of our knowledge, no data about this training modality effects on functional performances in middle-aged women was available. Therefore, the objective was to examine the effect of 12 weeks of a Zumba training program on functional performances in middle-aged women.
METHODS: 38 healthy inactive women aged between 50 and 60 were randomly allocated to a control group and a Zumba group. Functional performances were measured in two test sessions before and after the intervention period, using 10m Walk test for walking speed, Timed Up and Go test for functional mobility and 30-Second Chair Stand test for lower body strength.
RESULTS: The Zumba training programs showed a significant functional performances improvement ($p<.05$) in terms of mobility, gait speed and lower body strength while, as expected, the control group showed no significant changes in the post-intervention session compared to the pre-intervention session.
CONCLUSION: Our major results showed that Zumba training improved functional performances in terms of mobility, gait speed and lower body strength in our middle-aged women. In accordance, previous studies reported that this training modality improved functional performances (i.e. static and dynamic balance and lower body strength performances in young women (Donath et al., 2014) and even in patients with Parkinson's disease (A. Delextrat et al., 2016). These improvements could be due to the nature of the exercises involved in our Zumba training program. These exercises are based on turning, twisting, stepping and jumping elements that may lead to a higher muscle activity (Donath et al., 2014). In conclusion, 12-week Zumba training was sufficient to improve functional performances in terms of mobility, gait speed and lower body strength in middle-aged women. Thus, it could be recommended as an effective way to promote health in middle-aged women

**ARE PHYSICAL CHARACTERISTICS DIFFERENT BETWEEN WOMENS INTERNATIONAL XV AND SEVEN RUGBY?**

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INTRODUCTION: Seven rugby and rugby union are team sports characterized by their specific physical requirements. Even if the practice is rugby, it will be useful to identify specific physical profile in order to guide athletes towards a position that will allow them to best use their qualities. Description of performance levels in international womens rugby is very recent and comparison of physical profile between rugby union position and rugby seven has not been done. This study aims to describe anthropometric and physical characteristics of French woman international rugby union and rugby seven players and to determine if there are specific profiles to each position.
METHODS: Anthropometric and physical performances of French rugby union and seven women players were monitored at least two times per years by the French Rugby Federation. Positions, height, weight, body fat, maximal aerobic speed, 10m time, counter movement jump test, maximal bench press and rowing repetition performances between 2009 and 2020 were analyzed using a principal component analysis over 2009 to 2020. A total sample of five hundred and ninety-seven female French international rugby players was used and only the best performance per year of each player were analyzed.
RESULTS: Three clusters were detected by the database PCA analysis. In the first cluster, forwards were the most represented (84,9%, $p<0.01$) and were characterized by a higher weight, body fat, height and 10m time and a lower aerobic fitness ($p<0.01$). The backwards are the most represented in the second cluster (92,9% ,$p<0.01$) and were characterized by a higher aerobic fitness and lower 10m time, body fat, height and weight ($p<0.05$). The third cluster was composed by the seven rugby players (97,8%, $p<0.05$) and were characterized they have higher aerobic fitness and age, and a lower 10m time, weight and body fat ($p<0.05$).
CONCLUSION: The use of the variables in the study therefore partly explains the specificities of the position and of rugby practice. The PCA can be a decision support tool for the choice of an orientation towards rugby union or sevens rugby as well as for the position.

**MUSCLE QUALITY AND ITS ASSOCIATION WITH DISEASE-RELATED OUTCOMES IN WOMEN WITH SYSTEMIC LUPUS ERYTHEMATOSUS**

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INTRODUCTION: Systemic lupus erythematosus (SLE) is an autoimmune multisystemic disease that may involve irreversible damage in any systems and organs which limits the activities of daily living and the quality of life. Patients with SLE are specially at risk for developing sarcopenia due to pro-inflammatory state and the decreases in muscle mass by inactivity and pain. Muscle quality is recognized as a prognostic factor of functional inability and mortality in obese people and elderly population. Detecting risk factors of functional inability based on muscle quality in SLE population is of clinical interest. The aim of the present study was to assess muscle quality and its association with the disease-related outcomes in women with SLE.
METHODS: This cross-sectional study included 75 women with SLE. Specific muscle power was created by the division of sit to stand power [W] (based on the 30-s chair stand test) and muscle mass [kg]. Specific muscle strength was created by handgrip strength [kg] divided by muscle mass [kg]. Muscle quality index was categorized following the criteria provided by Barbat-Artigas. Due to the lack of cut-off values for this population, tertiles were computed for each of the variables (specific strength and specific power, respectively) that creates the muscle quality index. The disease activity (SLEDAI), systemic damage index (SDI), and disease duration were assessed. Correlation analysis and linear regression models considering age and corticosteroid intake were used to assess the association between muscle quality-related parameters and disease-related outcomes.
RESULTS: Our results showed that 40% of women with SLE presented poor muscle quality index, 12% low and 48% normal. Pearson's correlation coefficients showed significant associations of specific muscle power with SDI ($r=-0.30$) and disease duration ($r=-0.45$). There was no association of specific muscle strength with disease-related outcome.
In the regression model, specific muscle power was significantly associated with disease duration ($\beta=-0.251$, $p=0.041$). Specific muscle strength was not significantly associated with any disease outcome in any analysis.
CONCLUSION: 40% of women with SLE presented a poor muscle quality index. Specific muscle power is significantly associated with degree of tissue damage and disease duration independently of age. Future research should assess the relationship of circulating biomarkers

related to muscle quality as inflammatory biomarkers are usually altered in women with SLE (i.e., C-reactive protein or inter- leukin-6). Furthermore, cut-off values appropriate for women with SLE are also needed due to the peculiarities of the disease.

### ULTRASOUND IMAGING BASED METHODS TO ASSESS BIOLOGICAL MATURITY DURING ADOLESCENCE AND POSSIBLE APPLICATION IN YOUTH SPORT: A SCOPING REVIEW

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INTRODUCTION: Bone age (BA) is an indicator that estimates the biological maturity (BM) of an individual. Particularly during adolescence, individuals show heterogeneous growth rates. Evidence suggests that differences in BM should be considered in talent identification (TID) and development (TD). Various assessment methods using X-ray of the left hand and wrist are considered the gold standard for estimating BM. The use of ultrasound (US) may be advantageous in various fields of application, however validity and reliability of US imaging procedures are under debate. Therefore, the aims of this scoping review are 1) to summarize the different methods for estimating BM by US imaging in adolescents, 2) to get an overview of the level of validity and reliability of the methods and 3) to discuss the practicability of these assessments in the field of youth sport.
METHODS: The first search was conducted using the keywords “ultrasonography”, “bone age” and “youth” in two electronic databases (PubMed, Mendeley). Articles published up until the 31st December 2021 were included. The inclusion criteria stipulated that participants fell within the age range of 8 to 23 years and were free of bone disease and/or fracture. In order to sort and furthermore analyze the extracted material, a data charting form was developed. An additional classification was developed based on the comparative techniques (device) and assessment methods (e.g. staging system, atlas) used, as well as the examined body regions. The articles were divided into two groups depending on whether the US assessment was compared to another validated assessment (validity group) or whether the US assessment itself was tested for its reliability (reliability group).
RESULTS: The VG included 15 studies, 7 of which also measured inter and/or intrarater reliability, while 15 studies were included in the RG. The research areas were pediatrics (43.3%), forensic medicine (40%), orthodontics (10%) and sports (6.7%). 8 body regions were investigated. Hand and wrist were most commonly investigated during both the comparative and the US assessments. The US assessment method was normally based on the estimation of a bone maturity stage than a decimal bone age (78.6 % in the VG, 100% in the RG). In both groups, 80% of the US assessments were evaluated as acceptable and 20% as not acceptable. In the VG, either the agreement was too low compared to the gold standard, or the staging system could not be transferred to US. In this same group however, inter and intrarater tests were all reliable. In the RG, either the staging system was not precise enough, or there was no significant difference between estimated stages and growth velocity.
CONCLUSION: None of the ultrasound assessments investigated can be referred to as the gold standard yet, as further validation studies are required. Despite low costs, portability and absence of ionization, the extension to non-expert examinators must be tested to facilitate the application for TID and TD in the field.

### EFFECTS OF A PHYSICAL ACTIVITY INTERVENTION FOR OSTEOPOROSIS PREVENTION ON BONE BIOMARKERS

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INTRODUCTION: Physical exercise is considered an effective means to stimulate bone osteogenesis in premenopausal women. The use of bone mineral density (BMD) measurements using dual-energy X-ray absorptiometry (DEXA) to monitor exercise response is limited, since BMD changes need several months to be detectable. Besides, conducting DEXA scans frequently can be costly, and radiation exposure can add up. An earlier and inexpensive evaluation of the bone metabolic response to physical exercise would be useful. Bone turnover markers (BTMs) have been validated against the gold standard bone histomorphometry and become widely used to assess bone response to treatment because of their low cost and easy accessibility. The International Osteoporosis Foundation (IOF) and European Calcified Tissue Society (ECTS) Working Group recommended the use of C-terminal telopeptide of type I collagen (CTX) and N-propeptide of type I collagen (P1NP) as the reference markers for bone resorption and bone formation, respectively, for the fracture risk prediction and monitoring of osteoporosis treatment.
The aim of the current study was to assess the effect of a non-supervised physical activity intervention on BTMs, specifically P1NP and CTX.
METHODS: A randomized controlled trial was conducted over the course of twelve weeks. Forty-two sedentary premenopausal women (41 ± 5 years; 66 ± 18 Kg; 165 ± 7 cm) were randomly assigned to an experimental group (EG; N=24) and a control group (CG; N=18). The EG was instructed to complete 60 jumps per day, and at least 10000 steps per day at a minimum pace of 150 steps/min. The CG continued with their usual everyday activities. Compliance with the intervention was monitored using a wearable accelerometer. P1NP and CTX were measured pre and post intervention. Between-groups differences were assessed by analysis of covariance (ANCOVA) with baseline values as covariate.
RESULTS: Statistically significant between-group differences in favor of intervention were found for P1NP (F=5.578; p=0.023; Partial eta squared= 0.125) and CTX (F=4.373; p=0.023; Partial eta squared= 0.101).
CONCLUSION: The physical activity program carried out in this randomized controlled trial resulted in a significant reduction in P1NP and CTX. Since a decrease in P1PN and CTX is associated with an increase of BMD and a lower fracture risk, these BTMs could be employed as an early indicator of exercise efficacy and could therefore be useful in monitoring interventions to prevent osteoporosis.
REFERENCES:
Szulc, P. (2018). Bone turnover: Biology and assessment tools. Best Practice & Research Clinical Endocrinology & Metabolism, 32(5), 725-738.
Eastell, R., Pigott, T., Gossiel, F., Naylor, K. E., Walsh, J. S., & Peel, N. F. A. (2018). Bone turnover markers: are they clinically useful? European Journal of Endocrinology, 178(1), R19-R31. doi: 10.1530/eje-17-0585

**COMPARISON OF EFFECT OF KINECT-BASED MIXED REALITY AND UNSUPERVISED FIREFIGHTER FITNESS PROGRAM ON HEALTH-RELATED PHYSICAL FITNESS IN YOUNG ADULTS**

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INTRODUCTION: The development of informative communication technologies and virtual, augmented, and mixed reality (VR/AR/MR) techniques play an increasingly important role in health [1]. One of those devices is a Kinect-based mixed reality device (KMR) which can detect 25 joints of the users by Kinect and create a mixed reality environment by interacting with the users while producing exercises with feedbacks [2]. This seems to be beneficial to Korean Firefighters (KFFs) who have relatively low levels of fitness. But they have limitations in attending exercise by their occupational characteristics [3, 4, 5]. These problems can induce low performance, high risk of injuries [6]. So, we aim to evaluate the effect of a moderate level of fitness program for KFFs (KFFP-m) and to compare the effect between KMR and unsupervised individual training for 8wks.
METHODS: A total of 36 males were recruited. The screening was held on the same day as the pre-test. Seven were dropped and 27 males were randomly assigned into 3 groups, KMR group (KG; n=9), unsupervised individual group (UG; n=9), or a control group (CG; n=9). For the pre/post-test, skeletal muscle mass, body fat %, maximal oxygen consumption ($VO_2$max), grip strength, 2-min push-up, knee 60º of peak torque, and 180º of total work by the knee were measured. After the pre-test, KG and UG conducted KFFP-m for 3days/wk for 8wks. CG received health recommendation handbooks. All groups received calls every 2wks and were randomly asked to send a diet list for 3days per 4wks. A time (pre vs. post) x group (KG vs. UG vs. CG) factorial ANOVA with repeated measures was performed to determine differences between treatments. Significant main effects were followed up by Bonferroni post hoc test ($p<.05$).
RESULTS: All participants were normally distributed, and there was no significant difference in the baseline and nutrition intakes between groups. Body fat % was significantly increased, skeletal muscle mass significantly decreased in CG, and there was no significant difference between groups. $VO_2$max, 2-min push-up, and 180º of knee extension were significantly increased in both KG and UG. Sixty-degree knee flexion was significantly enhanced in UG and 180º of knee flexion in KG. $VO_2$max (KG>CG, UG>CG), 60º of knee extension (KG>CG), flexion (KG>UG, KG>CG), 180º of knee extension (KG>CG), and flexion (KG>CG) showed a significant difference between groups.
CONCLUSION: The novel finding of this study was that KG showed significantly greater results in 60º of knee flexion compared to UG and $VO_2$max, 60º of knee extension, 180º of knee extension, and flexion significantly enhanced in KG compared to CG. However, UG showed significant enhancement in $VO_2$max only compared to CG. In conclusion, KFFP-m was effective in health-related fitness in both ways, and KMR was more efficient in providing exercises than unsupervised individual training.
1. Fu Y et al. (2022) 2. Ahn S et al. (2022) 3. Oh C. (2015) 4. No K et al. (2020) 5. NFPA 1582. (2018) 6. Poplin G S. (2014)

**THE ENERGY REQUIREMENTS OF PARALYMPIC CHAMPIONS.**

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INTRODUCTION: To optimize nutritional counseling for Paralympic athletes, advanced insight into their energy demands is required. In the current study we conducted a comprehensive assessment of energy expenditure along with energy intake (EI) and body composition in a large group of Paralympic athletes, including many Paralympic champions.
METHODS: In this ongoing cross-sectional study, 39 Dutch and Norwegian Paralympic athletes with various disabilities, competing in Para cycling (PC; n=9; M/F 6/3), wheelchair tennis (WCT; n=10; M/F 5/5), wheelchair basketball (WCB; n=13; M/F 0/13) and cross-country skiing (XCS; n=7; M/F 4/3) participated. Total daily energy expenditure (TDEE) was assessed by the golden standard doubly labeled water method over a 14-day period, resting metabolic rate (RMR) by ventilated hood indirect calorimetry, EI by three unannounced 24h-dietary recalls, body composition by dual energy x-ray absorptiometry and exercise training duration by a training log. The physical activity level (PAL) was calculated as TDEE/RMR and the physical activity energy expenditure (PAEE) as TDEE - RMR - the thermic effect of food (0.1EI). Energy availability (EA) was calculated as (EI- PAEE)/fat free mass (FFM). Data are reported as means±SD. Differences between sports were conducted by one-way ANOVA with Bonferroni correction and correlations by a Pearson correlation test.
RESULTS: The mean RMR of 1482±257 kcal/day correlated well with FFM (48.8±9.3 kg; $r=0.76$; $p<0.001$). The mean TDEE was 2948±740 kcal/day, with PC (3691±826 kcal/day), and WCT (3082±381 kcal/day) showing substantially higher TDEE compared with WCB (2301±347 kcal/day; $p<0.05$), whereas TDEE in XCS (2903±541 kcal/day) was not significantly different compared with other sports. The mean PAL values of PC (2.15±0.4) and XCS (2.17±0.19) were significantly higher compared to WCB (1.71±0.18; $p<0.05$), but not compared with WCT (2.03±0.29; $p=0.08$). Furthermore, the PAL values (1.98±0.33) correlated well with exercise training duration (1.83±0.64 h/day; $r=0.51$; $p=0.006$). When considering athletes' EI (2397±961 kcal/day), 67% of the athletes were classified as low EA according to the threshold of 30 kcal/kg FFM, although this high prevalence might have been inflated by underreporting of EI.
CONCLUSION: Paralympic athletes experience high daily energy demands, with many athletes exceeding a PAL value of 2.0. Much of the variation in energy expenditure between sports and individuals can be explained by differences in fat free mass and exercise training load. The substantial energy demands of Paralympic athletes underline the need to prevent low energy availability in this population.

## Conventional Print Poster

### CP-MH11 Back / Electrostimulation

**PREDICTING NONCONTACT LOWER LIMB INJURY USING LUMBAR MORPHOLOGY IN PROFESSIONAL AUSTRALIAN FOOTBALL AND RUGBY LEAGUE PLAYERS**

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INTRODUCTION: Non-contact lower limb injuries are common within the Australian Football League (AFL) and National Rugby League (NRL). Smaller (<8.5 cm2) lumbar multifidus at the fifth vertebra (LM L5) and larger (>8.2 cm2) quadratus lumborum (QL) cross-sectional area (CSA) have been associated with increased non-contact lower limb injury risk in AFL players. These associations have not been ex-

plored in an NRL cohort. This study will attempt to replicate previous research findings by confirming that muscle morphology is associated with non-contact lower limb injury.
METHODS: AFL (n = 87) and NRL (n = 151) players underwent LM L2-L5 and QL CSA ultrasound measures during preseason. Each club's medical staff reported all non-contact lower limb injuries sustained in the subsequent regular season. LM and QL CSA, age, body mass index and non-contact lower limb injuries were analysed using multivariable logistic regression.
RESULTS: Seventy-two players sustained a non-contact lower limb injury in the 2020 regular season (AFL = 21, NRL = 51). The multivariable logistic regression (OR: 1.36, 95%CI: 1.02-1.85, p = 0.038) identified AFL players with larger QL CSA at increased risk of sustaining a non-contact lower limb injury during the regular season but no relationship was found for LM CSA and non-contact lower limb injuries in the AFL (OR: 1.01, 95%CI: 0.36-2.78, p = 0.591) or NRL (OR: 0.63, 95%CI: 0.29-1.33, p = 0.149).
CONCLUSION: AFL players who sustained regular season non-contact lower limb injuries had larger QL CSAs in pre-season tests. no significant associations between either LM L5 CSA or LM L5 to QL ratio and regular season non-contact lower limb injuries were found.

## DOSE-RESPONSE RELATIONSHIP AND EFFECT MODIFICATION IN NON-SPECIFIC LOW BACK PAIN: SECONDARY INDIVIDUAL PATIENT DATA RE-ANALYSIS ON 1,483 STABILISATION EXERCISE PARTICIPANTS

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INTRODUCTION: Exercise therapy for low back pain results in low to moderate group effects and displays large inter-individual heterogeneity. This heterogeneity may be explained by a dose-response relationship and further effect modifiers. In the present study, we derived a dose-response relationship under consideration of further effect modifiers in stabilisation exercises on low back pain.
METHODS: In this planned project-wide secondary analysis within the MiSpEx Network, 1,483 participants with low back pain (57% females, mean age 40.9 years (standard deviation 14 years)) performed stabilisation exercises with either an additional behavioural module or an add-on stretching task or an attendant perturbative motor task (3 weeks supervised, 9 weeks self-administered). Patients reported pain intensity, disability and disability days at baseline, 3 weeks, 12 weeks and 6 months post-randomisation. All exercise characteristics and potential effect modifiers (sociodemographic factors, anxiety, depression, perceived social support and pain medication) were prospectively monitored. Linear mixed models for all pain and disability outcomes with each exercise intervention type (random), dose (duration (random) and frequency (fixed)) and covariate (effect modifiers (fixed)) were calculated.
RESULTS: Longer durations of the intervention led to larger symptom reductions. Higher exercise frequencies were associated with a decrease in pain intensity: to train once more per week led to a mean decrease of 0.93 points in pain intensity (estimate = -0.93 [95 % confidence interval = -1.54 to -0.32]). Disability days were also impacted (-0.07 [-0.14 to 0.00]), disability was not (-0.09 [-0.67 to 0.48]). The type of exercise had an impact on the symptoms; the stabilisation and perturbation exercise was superior to the other exercises. The dose-response relationships were found to be robust when the additional effect modifiers were considered. The odds for a clinically important treatment effect in pain intensity decreased at 3 weeks (frequencies above 2.5 times per week led to an odds ratio = 0.71 [0.618 to 0.813]) and increased at 12 weeks (1.13 [1.006 to 1.270], > 1.5*week-1) with higher mean exercise frequencies.
CONCLUSION: Using longer intervention durations, adding perturbation components to stabilisation exercise and utilising higher frequencies (up to a certain point) led to more beneficial responses for symptom reduction in patients with low back pain. Developing strategies to maintain an exercise frequency of at least two times per week, including the self-administered intervention periods, may be relevant in exercise therapies to treat low back pain. A stabilisation exercise frequency of three to five times per week with a duration of 20 to 30 minutes was found to be the most effective. Certain patients with an endurance-related response to pain may have to reduce their training frequency, whereas others must be engaged fully.

## EVALUATION OF THREE BACK-SUPPORT EXOSKELETONS DURING A REPETITIVE LIFTING TASK: INFLUENCE OF DESIGN ON CARDIORESPIRATORY PARAMETERS

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INTRODUCTION: Low back pain remains an important issue for workers in many companies. New technologies, such as back-support exoskeletons, have been designed to prevent these musculoskeletal disorders (1). These systems provide force assistance in order to reduce the physical workload of the task performed by workers. Previous studies have shown that back-support exoskeletons could reduce lumbar muscles activity, more or less pronounced depending in particular on the exoskeleton design. Despite the possible benefits on local muscle stress, the effects in terms of overall physical workload have been little studied (2). Thereby, the objective of this laboratory study was to assess the cardiorespiratory consequences associated with the use of different back-support exoskeletons, with special attention to their design.
METHODS: 14 women and 13 men performed a 5-min repetitive manual lifting task, with a 10-kg load, involving a full flexion/extension of the trunk in the sagittal plane. Four exoskeleton conditions were studied: with a passive exoskeleton (PASSIVE), with two active exoskeletons (ACTIVE_1 and ACTIVE _2), as well as without exoskeleton (FREE). Metabolic and cardiac costs induced by the task were analyzed using a general linear model with exoskeletons and sex as main effects ($p<0.05$).
RESULTS: The use of each exoskeleton (PASSIVE, ACTIVE_1 and ACTIVE _2) significantly reduced the metabolic cost as compared to FREE. In addition, ACTIVE_1 showed a significant larger decrease (-28%) than PASSIVE (-7%) and ACTIVE_2 (-13%). Compared to FREE, the cardiac cost was only reduced for ACTIVE_1 (-24%). The metabolic cost did not significantly differ between men (11.6 ± 2.7 ml.min-1.kg-1) and women (10.6 ± 2.0 ml.min-1.kg-1), while women presented a significantly higher cardiac cost (61.7 ± 10.6 bpm) than men (49 ± 12.7 bpm). No interaction effect between exoskeleton and sex has been reported.
CONCLUSION: Occupational back-support exoskeletons appear to reduce the overall physical workload associated to a repetitive manual lifting task. The different exoskeleton designs, such as the technology used (passive vs. active) or the level of anthropomorphism (related to the number of joints of the device), could explain the different effect levels among the exoskeletons. The lack of interaction between exoskeleton and sex leads to the conclusion that these assistive devices provide benefits on the overall physical workload for both men and women.
References
1) Theurel & Desbrosses, IISE Trans Occup Ergon Hum Factors, 2019
2) Kermavnar et al., Ergonomics, 2021

**MARKED IMPROVEMENT OF MULTIFIDUS MUSCLE QUALITY AFTER A REHABILITATION PROGRAMME BASED ON HEAVY LOADED ISOLATED LUMBAR EXTENSION RESISTANCE EXERCISE (ILEX) IN PATIENTS WITH SPECIFIC SPINAL DISORDERS**

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INTRODUCTION: A loss of lean muscle mass and local fat infiltration in the paraspinal extensor muscle (intrinsic part/ m. multifidus) are common observations in patients with chronic related spinal disorders and in age related degeneration (Hodges & Danneels, 2019, Dahlqvist et al., 2017). Despite of promising clinical results of ILEX-based exercise intervention, there is little information on the morphological effects of this specific treatment (Steele et al., 2015, Golonka et al., 2021).
METHODS: This pilot case series represents five male patients (mean age 51,8, range 36-70) with disc herniations/protrusions, spondylarthritis and radiculopathies who underwent an ILEX-based exercise intervention consisting of 25 exercise sessions (ES) with 18 ES 2x/week and seven additional ES 1x/week. Range of Motion (ROM) was limited in order to protect passive structures. Before and after the treatment MRI was taken and analysed muscle cross sectional area (CSA, in cm2), lean muscle mass (LM, in cm2) and fat fraction (FF, in %) of m. multifidi for both sides (r/l) in three lumbar spinal segments L3, L4 and L5.
RESULTS: MRIpost showed an increase in CSA and LM and a reduction of FF compared to MRIpre for all patients at all examined segments. The following results represent mean values for both sides for all patients in L3-L5: (CSApre/CSApost/ΔCSA) in L3 (7.4/8.2/+9.5%); in L4 (10.5/11.2/+7.1%); in L5 (11.2/12/+6.7%); (LMpre/LMpost/ΔLM) in L3 (6.1/6.9/+13.1%); in L4 (8.1/9/+12.2%); in L5 (8.7/10/+14.4%); (FFpre/FFpost/ΔFF) in L3 (17.8/15.3/-14%); L4 (22.2/18.5/-16.7%); in L5 (22/16.1/-26.7%).
CONCLUSION: Heavy loaded ILEX leads to a marked improvement in the morphology of m. multifidus and is therefore a suitable treatment option for patients with specific spinal disorders. Furthermore, it can be potentially used for delaying age-related muscle atrophy and for maintaining spinal health. To the best of our knowledge, this is one of the first studies comparing quality of m. multifidus pre and post exercise intervention through MRI measurements. Further studies with more probands are being designed at the moment.
Reference
Dahlqvist, J. R., Vissing, C. R., Hedermann, G., Thomsen, C., & Vissing, J. (2017). Fat Re-placement of Paraspinal Muscles with Aging in Healthy Adults. Medicine and Science in Sports and Exercise, 49(3), 595–601.
Golonka, W., Raschka, C., Harandi, V. M., Domokos, B., Alfredson, H., Alfen, F. M. & Spang, C. (2021). Isolated lumbar extension resistance exercise in limited range of motion for patients with lumbar radiculopathy and disk herniation - Clinical outcome and influencing factors. J Clin Med., 10(11), 2430.
Hodges, P. W. & Danneels, L. (2019). Changes in structure and function of the back muscles in low back pain: Different time points, observations, and mechanisms. J Orthop Sports Phys Ther., 49(6), 464-476.
Steele, J., Bruce-Low, S., Smith, D. (2015) A review of the clinical value of isolated lumbar extension resistance training for chronic low back pain. PM R., 7(2), 169-87.

**PEAK HEAD ACCELERATIONS IN ELITE RUGBY UNION PLAYERS DURING MATCH-PLAY COLLISIONS: A PRELIMINARY STUDY COMPARING MALES AND FEMALES USING INSTRUMENTED MOUTHGUARDS**

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INTRODUCTION: The collision-dominant nature of rugby union exposes players to head acceleration events (HAEs), which are a potential risk factor for the development of brain injuries, such as concussion. Instrumented mouthguards enable direct measurement of the magnitude of these HAEs during training and competition. The differences in physical demands of the game, and physical characteristics of males and females, suggests that they might experience different magnitudes of head accelerations owing to a collision; however, this has not been investigated among elite rugby players. The aims of this preliminary study were to compare the magnitude of peak linear and angular head accelerations i) experienced by male vs. female players and ii) during head vs. body impacts.
METHODS: Using the PROTECHT instrumented mouthguard system (Sports & Wellbeing Analytics, UK), a total of 822 HAEs were recorded across 100 male (27 ± 4 years, 103 ± 14 kg, 1.86 ± 0.10 m, 659 HAEs) and 37 female (26 ± 4 years, 73 ± 22 kg, 1.68 ± 0.107 m, 163 HAEs) rugby union players from match collisions during the English Premiership, United Rugby Championship and Premier 15s 2021/2022 and 2022/2023 seasons. All HAEs were video-identified and classified into direct head or body impacts according to the anatomical location of initial impact on the player being monitored. Linear and angular acceleration signals were filtered using a zero-phase lag 4th order Butterworth filter, with a low-pass cut-off frequency of 160 Hz. Linear acceleration signals were transformed to the head centre of mass. Peak linear (PLA) and angular acceleration (PAA) values were defined as the resultant signal maxima. Data were log-transformed and grand-mean centred prior to performing multi-level linear models, comparing the magnitude of PLA and PAA, with player as a random factor and sex (male/female) and impact location (head/body) as fixed factors. Significance was set at $P < 0.05$ and significant fixed effects were followed up with Bonferroni post-hoc tests.
RESULTS: There were no differences in PLA nor PAA ($P > 0.05$) between males (24.0 ± 16.8 g, 1703 ± 1948 rad/s^2, n = 659 [80%]) and females (PLA; 22.2 ± 14.7 g, PAA; 1719 ± 1365 rad/s^2, n = 163 [20%]). Both PLA and PAA were significantly greater ($P < 0.001$) in HAEs resulting from impacts imparted to the head (PLA; 33.7 ± 23.6 g, PAA; 2304 ± 2384 rad/s^2, n = 141 [20%]) vs. body (PLA; 20.9 ± 12.0 g, PAA; 1494 ± 1358 rad/s^2, n = 581 [80%]). There were no interaction effects to indicate differences between male and females at the two anatomical locations.
CONCLUSION: This preliminary analysis, comparing males and females, demonstrated no differences in the peak linear and angular head acceleration magnitudes during match HAEs, despite the physical differences typically observed between sexes. The higher magnitudes during direct head impacts compared to body impacts warrants further investigation into the contextual factors surrounding a direct head impact to better understand the potential causes.

**THE IMPACT OF SPINE MOBILIZATION EXERCISES ON MOBILITY AND PAIN IN THE CERVICAL SPINE IN OFFICE WORKERS**

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INTRODUCTION: Musculoskeletal disorders (MSDs) are a common health problem for office workers who suffer from back pain in particular. Occupational health promotion programs that include exercise can help reduce sickness absenteeism by reaching large target groups

and being easily accessible. The aim of the study was to test the effect of a home-based exercise program to reduce back pain and increase work comfort among office workers.
METHODS: 133 office workers were qualified for the exercise program (women, n=98, 25-62 years old and men, n =35, 26-63 years). The inclusion criterion was the presence of mild pain in the cervical spine, with varying frequency, for more than 3 months, good general health and no contraindications to exercise. The subjects performed a set of exercises for 8 weeks (minimum 3 times a week). The exercise program focused on relaxing, mobilizing and gently strengthening the body parts most exposed to overload in office work. Before and after the start of the exercise program, the range of cervical movement between the designated anatomical points (flexion, extension, lateral flexion, rotation) was measured and a questionnaire survey was carried out (own survey).
RESULTS: After the 8-week exercise program, participants reported subjective improvement in fitness, reduced pain levels, increased body awareness and physical activity. The analysis of the results of the range of motion of the cervical spine showed no statistically significant differences. Employees report lack of time and household responsibilities as the main reasons for not taking up physical activity in their free time. However, they show great interest in educational programs organized in the workplace.
CONCLUSION: Health promotion programs can contribute to increasing knowledge about the importance of physical activity in the fight against ailments related to the type of work performed. Preventive programs based on physical activity, organized regularly in the workplace, can be an excellent element in the prevention of diseases of the musculoskeletal disorders.

### BIOMECHANICAL EFFECTS OF USING PASSIVE AND ROBOTIC BACK-SUPPORT EXOSKELETONS DURING A LIFTING TASK

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INTRODUCTION: Previous studies have shown that both passive and active back-support exoskeletons could be an effective countermeasure to prevent low back pain by reducing the stress on the lower back muscles (1). However, the possible interaction effect between exoskeleton and sex on lower back muscle activity (2,3) and lumbar kinematics (4) remains unclear. The purpose of this study was to evaluate the effects of back-support exoskeletons and sex on these biomechanical parameters.
METHODS: Fifteen men (25±5 years, 1.80±0.04 m, 75.5±7.9 kg) and fourteen women (24±6 years, 1.66±0.06 m, 63.6±13.3 kg) performed a standardized manual lifting task in the sagittal plane with the stoop technique. They handled a 15kg-box at an imposed rhythm of 15 cycles.min-1. Three exoskeleton conditions were tested: without assistance (FREE), with a passive exoskeleton (P-EXO; BackX, SuitX, USA; 4.5 kg; set at the highest assistance possible), and with an active exoskeleton (A-EXO; Cray X, German Bionic, Germany; 11 kg; set at 72N.m assistance). The level of muscle activity (percentage of a maximal voluntary contraction) was calculated from electromyographic recordings of erector spinae (ES) and rectus abdominis (RA) muscles. Back curvature was evaluated thanks to inertial measurement units in order to provide lumbar and thoracic range of motion during trunk flexion (LF and TF, respectively). An analyse of variance was conducted to determine the influence of exoskeletons (repeated measures) and sex on the different variables ($p<0.05$).
RESULTS: There was a main exoskeleton effect on ES muscles activity ($p<0.001$). Mean ES activity with A-EXO (76.3±20.8%) was significantly lower ($p<0.001$) than both P-EXO (90.0±23.3%) and during FREE (93.3±23.9%). However, no sex nor interaction effect was found on ES muscles activity. Mean RA muscles activity (3.5±3.7%) was kept at the same very low level whatever the exoskeletons or the sex conditions, and no interaction effect was reported.
Mean LF and TF range of motion values (24.7±19.3° and 42.2±34.6°, respectively) were not significantly influenced by exoskeletons or sex and no interaction effect has been observed.
CONCLUSION: Occupational back-support exoskeletons reduce trunk extensors activity during a lifting task, while keeping at the same level the neuromuscular activity of the trunk flexors. This reduction was however only significant for the active Cray X exoskeleton. It is worth noticing that this benefit was true for both men and women. Moreover, the use of these exoskeleton designs did not affect spine kinematics. Together with the reduction of back muscle activity, this might speak in favour of reduced low back disorders with the use of the Cray X exoskeleton.
REFERENCES:
1) Theurel & Desbrosses, IISE Trans Occup Ergon Hum Factors, 2019
2) Alemi et al., Hum Factors, 2020
3) Schwartz et al., Int J Environ Res Public Health, 2021
4) Ulrey & Fathallah, J Biomech, 2013

### EFFECTS OF ELECTROMYOSTIMULATION ON PERFORMANCE PARAMETERS IN TRAINED ATHLETES: A SYSTEMATIC REVIEW AND NETWORK META-ANALYSIS

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INTRODUCTION: Exercise training with electromyostimulation (EMS) evolved to an increasingly popular complementary training approach to improve muscular strength and muscle mass in various populations [1,2]. As trained athletes are confronted with limited margin of performance gains, such training approaches might provide further adaptive potential. However, available evidence on training recommendations for trained athletes in terms of application and stimulation are still lacking. Therefore, this systematic review with a network meta-analysis assessed the occurrence and magnitude of EMS training effects on performance and its surrogates in trained athletes using direct and indirect comparison computing a meta-analytical network.
METHODS: The research was conducted using the electronic online databases PubMed, Web of Science, Cochrane and SPORTDiscus for studies with the following inclusion criteria: (a) controlled trials, (b) EMS trials with at least one exercise and/or control group, (c) strength and/or jump and/or sprint and/or aerobic capacity parameter as outcome (d) sportive/trained subjects. Standardized mean differences (SMD) with 95% confidence interval (CI) and random effects models were calculated. Interventions were ranked using the P-score and relative pairwise effects were presented via the SMD and 95% CI. Study quality was rated using the PEDro scale.
RESULTS: Thirty-six studies with 1.092 participants were selected and 4 distinct networks (strength, jump, sprint, aerobic capacity) were built. The highest effects for pairwise comparisons against the reference control “active control” were found for the combination of resistance training with superimposed EMS and additional jump training (outcome strength: 4.43 SMD [2.15; 6.70 CI]; outcome jump: 3.14 SMD [1.80;4.49 CI]), jump training with superimposed whole-body electromyostimulation (WB-EMS) (outcome sprint: 1.65 SMD [0.67; 2.63 CI] and high intensity bodyweight resistance training with superimposed WB-EMS (outcome aerobic capacity: 0.83 SMD [-0.49; 2.16 CI]. Other variations of EMS applications or training combinations resulted in merely trivial to moderate, occasionally even negative effects.

CONCLUSION: Our findings indicate that the choice and the combination of EMS training with other training methods has notable impact on the magnitude of the effects and should therefore be carefully considered in trained athletes. Superimposed EMS with relatively low volume, high intensity and outcome-specific movement pattern appeared to most promising and beneficial EMS training approach in trained athletes.
[1] Kemmler et al. (2021). Efficacy of Whole-Body Electromyostimulation on Body Composition and Muscle Strength in Non-athletic Adults. A Systematic Review and Meta-Analysis. Front. Physiol., 12, 451.
[2] Filipovic et al. (2012). Electromyostimulation—A systematic review of the effects of different electromyostimulation methods on selected strength parameters in trained and elite athletes. J Strength Con Res, 26(9), 2600–2614.

**IMMERSIVE VIRTUAL REALITY MAY CHANGE SENSORY WEIGHTING DURING UPRIGHT STANDING**

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INTRODUCTION: Immersive virtual reality (VR) has emerged over the last decade as a promising clinical and scientific tool [1]. For example, VR allows to design specific visual stimuli that can be used to challenge postural control [2], and thereby to induce specific adaptations within the postural control system. The aim of this study was to assess whether repetitive VR induced changes in postural control in healthy young adults.
METHODS: Fifty-nine participants [mean (SD); 31(13) yrs] stood upright during 6 bouts of 90-s within a VR environment simulating forward and backward displacements (VR practice). Before and after VR practice, the path length of the center of pressure (CoP-path) was recorded for 60-s while participants stood upright on a force platform, with eyes open (EO) and closed (EC). In addition, participants performed two 60-s VR trials during which a forward (one trial) or backward (one trial) displacement was simulated for 15-s. During these trials, the CoP-path and mean CoP position (CoPmean) were measured by 15-s epochs (0-15s: no simulated displacement; 15-30s: simulated displacement; 30-45s and 45-60s: no simulated displacement). A control group (n=8) performed the same experiment without the VR practice.
RESULTS: Although the CoP-path with EO did not change after VR practice ($p=0.87$), the CoP-path with EC and the EO/EC ratio decreased significantly (mean (SD); -3.14(15.5)% and -3.18(16.9)%, respectively; $p<0.05$]. During VR trials, the CoP-path decreased for the 15-29s and 30-45s epoch for forward [median(interquartile); 15-29s: -22(48)mm; 30-45s: -5(38)mm, $p<0.05$] and backward simulated displacement [15-29s: -36(43)mm; 30-45s: -11(32)mm, $p<0.05$]. No statistical change was observed for the control group.
CONCLUSION: In agreement with a previous study, the results indicate that one VR session decreased postural response to simulated displacement [1]. Furthermore, the decrease in CoP-path during EC trials and the decrease in the EC/EO ratio suggest a sensory re-weighting, likely increasing the contribution of proprioceptive information to control posture [3]. Overall, this study indicates that VR can be a relevant tool to improve postural control.
REFERENCES
1. Slobounov et al. (2013). Neurosciences letters 547: 6-9.
2. Fransson et al. (2019). Scientific reports 9.1: 1-10.
3. Henry and Baudry (2019). Journal of Neurophysiology 122(2): 525-538.

## Conventional Print Poster

### CP-AP07 Women health

**THE FENDURA PROJECT: DOES MENSTRUAL CYCLE PHASE INFLUENCE RECOVERY MEASURES IN ENDURANCE ATHLETES? A PILOT STUDY.**

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INTRODUCTION: Recovery is crucial for inducing training adaptation and minimizes the likelihood of non-functional overreaching and injuries (1). The hormonal fluctuations during the menstrual cycle (MC) are likely to exert an effect on women's exercise physiology, as well as on perceived feelings, and could therefore result in variations in commonly used markers of recovery. However, the influence of the MC on subjective recovery measures, subjective sleep quality and resting heart rate (HR) in highly trained athletes has not been investigated. The purpose of the present study was to investigate how MC phases influence resting HR, subjective sleep quality, as well as physical and mental readiness to train among endurance athletes.
METHODS: This study was part of the Female Endurance Athlete (FENDURA) project led by the UiT The Arctic University of Norway (Tromsø).Fifteen naturally menstruating, highly trained (14±4 hours/week) endurance athletes (24±7 years old) recorded daily data representative of recovery, training sessions as well as MC-related side effects for 2±1 MCs. Resting HR was assessed using night-recording watches or a standardized procedure upon awakening; subjective self-report measures of sleep quality, physical and mental readiness to train were assessed with a visual analogue scale (1-10). Four MC phases were determined using the calendar-based counting method and the urinary ovulation prediction test and identified based on the current methodological guidelines for studies in sport and exercise science with women as participants (2): early follicular phase (EFP), late follicular phase (LFP), ovulatory phase (OP) and mid-luteal phase (MLP). Data were analyzed using mixed-effects modelling, with MC phase, MC-related perceived side effects and ovulatory/anovulatory cycles (for resting HR only) as fixed effects, recovery variables as outcome, and participant cluster as random effect.
RESULTS: Resting HR was significantly higher in ovulatory compared to anovulatory cycles ($p=0.020$), without a significant change between MC phases. MC phase had a significant influence on the subjective recovery measures: subjective sleep quality was decreased in the OP ($p=0.006$) and MLP ($p=0.006$), physical and mental readiness to train were lower in the MLP ($p=0.030$; $p<0.001$) compared to the EFP. Increased MC-related perceived side effects were associated with a reduced mental readiness to train ($p=0.024$).
CONCLUSION: We found decreased subjective recovery in the MLP which suggests that there could be a diminished recovery capacity in this MC phase. However, the reduced mental readiness to train associated with higher MC-related perceived side effects implies a higher perception of MC symptoms in the MLP. Altogether, these findings indicate that the MC should be accounted for when monitoring recovery, as MC phase, including MC-related side effects, and menstrual disturbances can influence recovery.

1. Meeusen et al. (2013). Med Sci Sports Exerc. 45(1):186-205.
2. Elliott-Sale et al. (2021). Sports Med. 51(5):843-861.

### VIGOROUS - NOT MODERATE - PHYSICAL ACTIVITY IS ASSOCIATED TO REDUCED CARDIAC ADIPOSE TISSUE IN WOMEN WITH OBESITY

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INTRODUCTION: Obesity is a known risk factor for cardiovascular disease, diabetes, and hypertension, and other diseases, and it is characterized by excess adipose tissue. Under normal conditions, fat accumulates in deposits adjacent to the myocardium and within the pericardium. The cardiac adipose tissue (CAT) protects the heart under normal physiological conditions by secreting numerous molecules; nevertheless, increased excess CAT has been identified as a risk factor for cardiovascular disease and other medical complications1. Observational research on whole-body adiposity has uncovered a negative link between physical activity (PA), fat mass and fat dispersion. The same way poor levels of physical fitness (PFit) have consistently been linked to an increased risk of mortality and cardiovascular disease. However, the relationship between PA, PFit and CAT volumes is unknown. Therefore, the goal of this study was to analyze the associations between CAT, PA, and PFit in a group of obese, but otherwise healthy, women.
METHODS: A total of 26 women with obesity (age: 23.41± 5.78 years-old) participated in this cross-sectional study. Physical activity was measured using accelerometry (Actigraph GT3X), cardiorespiratory fitness was measured breath by breath using the Bruce protocol, muscular strength was evaluated through a one maximum repetition test, and body composition was determined using dual-energy X-ray absorptiometry and anthropometric measurements. The CAT was quantified using magnetic resonance imaging (3.0T MRI). Associations were examined by Pearson's and Spearman correlation analyses.
RESULTS: Analysis showed negative associations of CAT with vigorous physical activity (VPA) levels ($r_S$ = - 0.41, p = 0.037), and positive associations with waist circumference ($r_S$ = - 0.58, p = 0.002) and visceral adipose tissue ($r_S$ = - 0.60, p = 0.001). All PA levels showed positive associations with and upper-body lean mass [Low Physical Activity (LPA): $r_S$ = 0.52, p = 0.007; Moderate Physical Activity (MPA): $r_S$ = 0.53, p = 0.005; VPA: $r_S$ = 0.40, p = 0.044]. Negative associations between PA levels, and %BF and lower body fat mass (FMlegs) were also described (%BF: LPA$r_S$ = - 0.65, p < 0.001; MPA$r_S$ = - 0.62, p = 0.001; VPA$r_S$ = - 0.41, p = 0.037; FMlegs: LPA$r_S$ = - 0.49, p = 0.011; MPA$r_S$ = - 0.42, p = 0.034; VPA$r_S$ = - 0.43, p = 0.027).
CONCLUSION: All types of PA showed a positive influence on whole-body and lower body fat in women with obesity, whereas only VPA had a significant impact on CAT volume. Previous studies utilizing exercise as a tool to reduce CAT showed that only those with sufficient intensity and frequency were capable of inducing CAT loss2. Therefore, VPA could be key for the prevention of gains and reduction of cardiac fat deposits. Nevertheless, more research is required to support our findings, and to uncover the most optimal forms of vigorous exercise that would aid in CAT reduction and prevent gains long term.
1 Iacobellis et al., 2015. Nat Rev Endo.
2 Launbo et al. 2021. Ob Rev.

### THE EFFECT OF ORAL CONTRACEPTIVE USE ON THE PRO- AND ANTI-INFLAMMATORY CYTOKINE BALANCE AFTER ACUTE STRENGTH EXERCISE

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INTRODUCTION: Previous research has shown that a controlled release of cytokines is essential for morphological muscle adaptations in response to strength training. An acute release of pro-inflammatory cytokines to initiate muscle repair is followed by anti-inflammatory cytokines to avoid an excessive inflammation[1]. However, hormonal fluctuations in women, either due to the menstrual cycle or contraceptive use, may impact inflammatory processes[2]. Especially oestrogen is discussed to attenuate pro-inflammatory responses[3]. Therefore, we aimed to compare changes in key-players of pro- (IL-1β) and anti-inflammatory (IL-1ra) cytokines after acute strength exercise between naturally menstruating women and women using oral contraceptives.
METHODS: Twentyone women (age: 23±3 yrs, weekly strength training: 4.4±1.7 h) were separated into two groups: 1) a naturally menstruating group without hormone use (MC, n=13) and 2) a contraceptive group (OC, n=8) regularly using a monophasic combined pill (>9 months). Testing consisted of a one repetition maximum test (1RM) and a strength training session in the deep squat (4x10 repetitions at 70% 1RM). Venous blood sampling for the assessment of IL-1β and IL-1ra and explosive strength testing to assess mean propulsive velocity (MPV) were performed before (t0), directly after (t1) and 24 h after (t2) strength exercise. All testing was performed in the follicular phase (MC) or the pill free interval (OC).
RESULTS: MPV showed no effect for time ($F_{[2,38]}$=2.77, p=.076, $\eta^2$=.127) or interaction ($F_{[2,38]}$=1.54, p=.227, $\eta^2$=.075). For IL-1ra an effect for time was found in the OC group only ($F_{[2,14]}$=5.25, p=.02, $\eta^2$=.429), with concentrations increasing from t0 to t1 (+51.1±59.4%, p=.197) and decreasing from t1 to t2 (-38.6±17.4%, p=.013). There was no interaction effect ($F_{[2,38]}$=1.30, p=.283, $\eta^2$=.064). For IL-1β no effect for time ($F_{[2,38]}$=.03, p=.975, $\eta^2$=.001) or interaction ($F_{[2,38]}$=.06, p=.944, $\eta^2$=.003) was found. Additionally, an association between the changes in MPV and IL-1β was found from t0 to t1 across both groups (r=-.447, p=.048).
CONCLUSION: While the strength exercise did not statistically cause reductions in strength performance, larger losses in MPV were associated with greater increases in the pro-inflammatory cytokine IL-1β. Furthermore, compared to the follicular phase, the pill-free interval of oral contraceptives seems to produce a greater response to strength exercise in the anti-inflammatory cytokine IL-1ra. This could potentially impact the pro-inflammatory effects of IL-1, such as stem cell activation and muscle regeneration[4]. However, the effect on the overall pro-/anti-inflammatory cytokine balance remains to be determined and further cytokines should be investigated.
[1]D. J. Freidenreich et al. , Exerc. Immunol. Rev. 2012, 18, 8.
[2]E. A. Lynch et al., J. Immunol. 1994, 153, 300.
[3]J. J. Puder et al., J. Clin. Endocrinol. Metab. 2001, 86, 2403.
[4]C. Chaweewannakorn et al., Am. J. Physiol. - Regul. Integr. Comp. Physiol. 2018, 315, R90

**URINARY STEROID VARIATIONS IN ACTIVE WOMEN USING AN ORAL CONTRACEPTIVE PILL**

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INTRODUCTION: The Athlete Biological Passport (ABP) longitudinally monitors steroidal variations that could be indicative of doping. This study investigated the potential influence of the oral contraceptive pill (OCP) cycle on the steroidal biomarkers of the ABP in physically active women taking OCPs.
METHODS: Urine and serum samples were collected weekly from 15 physically active women taking OCPs during two consecutive cycles. Urinary steroid values (testosterone (T), androsterone (A), etiocholanolone (Etio), 5a-androstane-3a, 17b-diol (5aAdiol), 5b-androstane-3a,17b-diol (5bAdiol) and epitestosterone (E)) were determined by gas chromatography coupled to tandem mass spectrometry (GC-MS/MS) according to the World Anti-Doping Agency (WADA) guidelines and entered into the Anti-Doping Administration and Management System (ADAMS) computing longitudinal profiles.
RESULTS: The values of the T/E ratio could not be determined in 61% of the samples (n=73) since the urinary concentrations of T and/or E were below the limits of quantification (LOQ, 1 ng/ml). Consequently, only the A/Etio and 5aAdiol/5bAdiol ratios were considered for statistical analyses. The longitudinal monitoring of the steroidal passport in ADAMS did not elicit any atypical passport finding (ATPF) at a 99.9% specificity level. In contrast, when data was pooled in function of weeks following the bleeding (W1, W2, W3 and W4) A, Etio and 5bAdiol yielded significant differences (W1=1083 vs. W2=1584 ng/mL [p<0.05]; W2=2183 vs. W3=1531 ng/mL [p<0.05]; W1=78.1 vs. W2 53.0 ng/mL [p<0.05]; respectively). A significant increase in A/Etio was observed at W3 (0.96 +/- 0.39; p<0.05) and W4 (0.93 +/- 0.30; p<0.05) compared to the preceding 2 weeks (W1, 0.79 +/- 0.34; W2, 0.79 +/- 0.30). In serum, values for progesterone (1.1 +/- 0.4 nmol/L) and estrogen (53.8 +/- 39.4 pmol/L) were in accordance with previously published ranges in woman using OCPs. Spikes occurred during the placebo phase of the OCP cycle (i.e. W1) with LH higher (3.2 +/- 2.2 IU/L) compared to W3 (1.8 +/- 2.7; p<0.001), and W4 (0.9 +/- 1.4; p<0.001). FSH was also higher in W1 (6.4 +/- 3.1 IU/L) compared to W2 [4.1 +/- 2.7; p<0.001], W3 [2.1 +/- 2.4; p<0.001] and W4 [1.2 +/- 1.8; p<0.001]).
CONCLUSION: Urinary steroidal hormones varied in active women using OCPs with significant differences between successive weeks after bleeding. However, the analyses of variations using individual ABP profiles reflect that actual variations were limited within the narrow individual limits of the longitudinal model. Our results therefore support the relevance of the Bayesian approach of the ABP that focuses on individual variations rather than population means. As expected T/E ratios could not be determined (i.e. with T and/or E undetectable) in a majority of the women considering the low androgenic hormonal levels. The latter is however supportive of the steroidal ABP module aimed at detecting abnormal increases due to exogenous steroids intake.

**ASSOCIATION OF MATERNAL PHYSICAL FITNESS, GESTATIONAL WEIGHT GAIN AND PRE-PREGNANCY AND POSTPARTUM BODY MASS INDEX WITH THE DESCENDANT'S BODY COMPOSITION AT 4 YEARS OLD: THE GESTAFITOS PROJECT**

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INTRODUCTION: Physical fitness (PF) and body composition are considered important markers of health throughout the life course. Regarding pregnancy, both outcomes could influence early programming and have an influence on the body composition of the descendants. The purpose of this study was to investigate the association between maternal PF at the 16th gestational week (g.w.), pre-pregnancy body mass index (BMI), gestational weight gain and postpartum BMI with the body composition of the offspring at 4 years old.
METHODS: Sixty-seven pregnant women (33.2±4.1 years) and their descendants were included for the present analyses. Cardiorespiratory fitness, muscular strength, flexibility and overall PF was measured at the 16th g.w. Pre-pregnancy body mass index, differences in body weight from the 16th g.w. until the 34th g.w. and BMI 6 weeks-postpartum were registered. Body weight, height, lean mass and fat mass percentage of the offspring were measured at 4 years of age.
RESULTS: After adjusting for potential confounders, a greater maternal flexibility at the 16th g.w. was associated with lower body fat in the children (β=-0.272, p=0.027). A higher pre-pregnancy BMI and a higher postpartum BMI were associated with greater body fat in the children (β=0.263, p=0.048 and β=0.276, p=0.031, respectively). No other statistical differences were observed (all p>0.05).
CONCLUSION: Higher flexibility during pregnancy and BMI before pregnancy and at the postpartum period were associated with lower body fat in the offspring at 4 years of age. Further studies are needed to explore the potential mechanism behind the association found between maternal flexibility and lower body fat in the descendants.

**THE EFFECTS OF MENSTRUAL CYCLE PHASE ON ELITE ATHLETE PERFORMANCE: A LONGITUDINAL AND PROSPECTIVE STUDY**

ALICE, M.

*INSEP*

INTRODUCTION: In elite athletes, training individualization is widely recommended to optimize competitive performance. Previous studies have evidenced the impact of hormonal fluctuations on different performance parameters among female athletes, but the parameters themselves, the magnitude and the direction of the effects are inconclusive. While consideration of menstrual cycle phases as a parameter in training individualization strategies is necessary, systematic evidence identifying such impacts in elite athletes should be evaluated. Additional longitudinal and prospective studies to systematically monitor on-field performance parameters are urgently required to enable recommendations and training individualization in female elite athletes.
METHODS: The EMPOWER project proposed a longitudinal and prospective study coupled with robust statistical methods to establish and validate causal links, quantify impacts, and make reliable recommendations that can guide evidence-based future training individualizations. The follow-up started with 12 rowers and para-rowers, 16 cyclists, 1 fencer, 6 artistic gymnasts, 23 football players, 5 biathletes, 5 skiers and 4 cross-country skiers. During the follow-up, athletes were asked to fill in a short questionnaire every morning notably with information related to sleep, mood, training performance and feelings. On a regular basis, in each phase of the cycle, athletes had to take a saliva sample to accurately quantify five hormones (testosterone, estrogen and progesterone) as well as a sport-specific performance test for rowers and skiers. Every day their trainings were monitored using different connected devices (watches, power meters…) or questionnaires to quantify the training load of athletes.

RESULTS: Before starting the protocol, we assess the necessity of such a monitoring on athlete and their need to an individualized training. First results revealed that each athlete reacts differently to issues related to their gender, and high-level athlete reacts differently from less-trained athletes. In particular, the symptoms related to menstrual cycles are different from those who practice less sport. Athletes are very sensitive to these issues, and this may explain the high level of compliance with the questionnaire (more than 85% of assiduity depending on the sport). Among the population of athletes monitored, we observed divergent hormonal profile. Each female athlete is different from another and does not respond similarly to training throughout the menstrual cycle. There is a variety of athlete responses to physical tests.
CONCLUSION: As highlighted in the divergent literature, responses to menstrual issues regarding performance is widely heterogeneous from one athlete to another. These findings emphasize the need for researchers and support staff to undertake menstrual cycle profiling and monitoring and continue to develop awareness, openness, knowledge and understanding of menstrual cycle.

**ASSESSMENT OF ABDOMINAL MUSCLE THICKNESS IN POSTPARTUM WOMEN WITH AND WITHOUT EXERCISE DURING PREGNANCY**

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INTRODUCTION: Pregnancy and childbirth can affect abdominal muscles morphologically and functionally. Previous studies have reported morphological changes and dysfunction in the abdominal muscles of postpartum women, with concerns that they may be a risk factor for persistent postpartum back pain. Such problems for postpartum women may pose difficulty in returning to daily life and sporting activities. Approaches to maintaining the condition of abdominal muscles during pregnancy for comfortable postnatal activity are necessary, and exercise can play an important role. Therefore, we focused on postpartum abdominal muscle thickness as a morphological indicator of the muscles. Thus, this study aimed to compare the thickness of abdominal muscles postpartum with and without exercise during pregnancy.
METHODS: This study enrolled 34 women within 6 months of postpartum. The thickness of the abdominal muscles was measured in the rectus abdominis, external oblique, internal oblique, and transversus abdominis muscle (TrA) using ultrasound imaging. Participants were classified into two groups: one group performing exercise during pregnancy (EX group) and another without exercise during pregnancy (no-EX group). The abdominal muscle thickness in both groups was compared using an unpaired two-tailed t-test or the Mann-Whitney U test. The statistical significance was set at $p<0.05$.
RESULTS: The EX and no-EX groups comprised 9 and 25 women, respectively. The TrA muscle thickness was significantly thicker ($p=0.014$) in the EX group (2.9 ± 0.7 mm) than that in the no-EX group (2.2 ± 0.6 mm). No significant differences were observed in the thickness of the remaining three abdominal muscles.
CONCLUSION: This study showed differences in the postpartum TrA muscle thickness with and without exercise during pregnancy. TrA has been reported to be an important muscle for spinal and pelvic stability. In addition, most biomechanical studies indicate that TrA is the most important abdominal muscle involved in back pain. The results of this study suggested that exercise during pregnancy might help maintain postpartum abdominal muscle thickness. Although further research is needed, exercise during pregnancy might lead to more comfortable postnatal daily physical and sports activities, which could contribute to improved quality of life in postpartum women.

**EVALUATION OF A CO-DESIGNED ADAPTED PHYSICAL ACTIVITY INTERVENTION FOR PREGNANT WOMEN: PRELIMINARY RESULTS FROM THE WELL-DONE!STUDY**

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INTRODUCTION: Nowadays, the importance of practicing physical activity (PA) during pregnancy is widely known and recommended thanks also to several guidelines. Nonetheless, fewer than 15% of pregnant women reach these recommendations. Given the above, the implementation of adapted physical activity (APA) intervention emerges among the possible strategies that allow pregnant women to perform the right dose of PA. Childbirth preparation classes (CPCs), offered by the national healthcare system, can represent an ideal setting for the promotion of PA during pregnancy and the implementation of APA programs. The aim of this study was to co-design an intervention of APA tailored for pregnant women to be included in the CPCs and to evaluate the feasibility and efficacy in terms of PA levels and physical performance.
METHODS: Pregnant women have been recruited at the University Hospital of Bologna (Italy) and assigned to two different groups: the experimental group (EG) and the control group (CG). EG attended 1hour/week session of APA during the usual CPCs for a 6 weeks period. While the CG received a one hour lesson regarding PA recommendation during pregnancy. Physical activity levels were assessed through the Pregnancy Physical Activity Questionnaire (PPAQ) at baseline (T0) and follow-up (T1). Variations in physical performance were assessed by Sit-to-Stand test and 6-Minute Walking Test. Data analysis was conducted using STATA software.
RESULTS: A sample of 50 pregnant women aged between 29-46 (mean age=35.44 ± 3.99) were involved in the study. The total activity score (-0.72 ± 34.30 MET-h/wk in the experimental versus -10.18 ± 40.72 MET-h/wk in the control) showed that PA levels decreased in both groups. Sedentary activity score was more reduced in the EG compared to the CG, without statistically significant differences (-10.20 ± 24.12 MET-h/wk in the EG versus -4.59 ± 24.99 MET-h/wk in the CG). Light and moderate activity scores increased in the EG, while were slightly reduced in the CG. As far as concerned physical performance, the EG showed a greater increase both in the number of repetitions and in the total distance, without statistically significant differences in comparison to the CG.
CONCLUSION: Preliminary results suggest that, albeit without being statistically significant, we observed a positive trend in the EG. Specifically, this group showed a reduced sedentary time, an improved moderate activity and physical performance. It is notably that sedentary activity also decreased in the control group, although to a lesser extent than in the EG. This data underlines that even a purely informative intervention, such as the one the control group was subjected to, can be effective in sensitizing women to reduce their sedentary lifestyle.

**EFFECTS OF A TRAINING INTERVENTION TAILORED TO THE MENSTRUAL CYCLE ON ENDURANCE PERFORMANCE AND RECOVERY AND STRESS BALANCE IN FEMALE RECREATIONAL RUNNERS – A RANDOMIZED-CONTROLLED PILOT STUDY**

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INTRODUCTION: Polarized training is well known to stimulate training effects and improve performance in recreational runners [1]. On the other hand, the menstrual cycle (MC) may affect performance in eumenorrheic women [2,3]. Adaptions of a traditional training program on the MC phases may impact training response in female runners. Therefore, this study aimed to assess the effect of the adaption of the polarized training adapted to the MC phases on performance development and recovery-stress balance.
METHODS: Sixteen eumenorrheic, moderately-trained female runners (age: 24±2.8 years; height: 169±8cm; weight: 62±8 kg; maximal oxygen uptake: 43±5 mL/min/kg) took part in an 8-week running training intervention consisting of three weekly training sessions. The participants were randomly assigned to a control and an intervention group. The control group followed a training program based on polarized training [1] consisting of two 4-week mesocycles. The mesocycles included three weeks of progressive training load and one week with a reduced load. The intervention group followed the same training content, but the single training sessions were adapted to their MC with a higher training load within the follicular phase, medium training load within the luteal phase, and regeneration during the menstrual phase. A baseline and post-assessment were used to analyze anthropometrics (weight, height, waist circumference, body composition), cardiovascular (blood pressure, heart rate variability), and performance changes (CMJ (OptoGait, MicroGait, Italy), ventilatory thresholds, VO2peak (running graded exercise test; treadmill: Quasar, h/p/cosmos, Germany; respiratory gas analyzer: MetaMax 3B, Cortex, Germany). The heart rate training stress score (hrTSS) and subjective Intensity (BORG-RPE) were collected to determine training loads for each training session. Further, the short version of the Recovery-Stress-Questionnaire was used at the baseline assessment, after four weeks of training, at the end of the training period.
RESULTS: Data is currently collected and analyzed. The following parameters will be compared between the intervention and control group and presented at the conference: Anthropometrics, cardiovascular and performance parameters, and information about subjective and objective training loads.
CONCLUSION: The novel findings of this pilot study could enhance our knowledge about the influence of adapting polarized training programs to the MC phases in female recreational runners, and could provide knowledge for further studies.
1. Munoz et al. (2014) 2. McNulsty et al. (2020) 3. Oosthuyse & Bosch (2010)

**CAN LIFELONG PARTICIPATION IN TEAM SPORTS MAINTAIN MECHANICAL MUSCLE FUNCTION IN WOMEN?**

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INTRODUCTION: Age-related impairments in mechanical muscle function are typically manifested as decreases in maximal muscle strength, power and rate of force development (RFD). Participation in team sports such as football and team handball has previously proven effective in maintaining or even improving muscle strength and functionality. The aim of this cross-sectional study was to compare elderly lifelong trained team sport players with age-matched untrained controls, young team sport players and young untrained controls.
METHODS: A total of 129 women were recruited for the study and divided into four groups as follows: elderly trained (ET) (n=35), aged 63.9±0.7 yrs (mean±SD), with regular participation in team handball training for 43.3±2.0 yrs; elderly controls (EC) (n=35), aged 66.1±0.6 yrs, with no regular participation in exercise for 14.7±3.2 yrs; young trained (YT) (n=29), aged 22.5±0.6 yrs, with regular participation in elite football training for 14.9±0.6 yrs; young controls (YC) (n=30), aged 24.9±0.4 yrs, with no regular participation in exercise for 4.8±0.9 yrs prior to this study. Following standardized warm-up, maximal voluntary isometric contraction (MVIC) strength along with early (0-50 ms) and late (0-200 ms) phase RFD of the knee extensor and knee flexor was measured in the dominant leg. In addition, handgrip strength of the dominant hand and performance in a 30-s sit-to-stand (STS) test was measured.
RESULTS: Despite a 41-yr difference in average age, there was no difference in knee extensor MVIC strength between ET (165.5±29.2 Nm) and YC (184.6±39.1 Nm) ($p=0.14$). Early and late phase RFD for the knee extensor were not different ($p>0.05$) between ET and YC (562.2±428.6 and 563.1±225.4 Nm/s) or between ET (371.0±342.4 and 424.6±226.1 Nm/s) and EC (283.3±276.4 and 339.8±177.4 Nm/s). Knee flexor MVIC strength did not differ ($p=0.06$) between ET (71.5±16.4 Nm) and YC (83.2±17.5 Nm). There were no difference in early phase RFD of the knee flexor between ET (160.0±138.8 Nm/s) and YC (227.6±148.0 Nm/s) ($p=0.16$) or between ET and EC (129.0±92.5 Nm/s) ($p=0.75$). Late phase RFD for the knee flexor showed no difference between ET (178.1±93.5 Nm/s) and EC (143.4±61.5 Nm/s) ($p=0.31$). The handgrip strength was not different between ET (32.2±6.4 kg) and YC (30.4±6.1 kg) ($p=0.53$) or between ET and YT (35.4±4.9 kg) ($p=0.10$), but results showed a significant difference between ET and EC (26.6±5.1 kg) ($p<0.00$). In the sit-to-stand test, there was no difference between ET (22.5±4.7 STS) and YC (24.0±5.4 STS) ($p=0.60$). For all other comparisons, ET was superior ($p<0.05$) compared to EC, and YT was superior ($p<0.05$) compared to all three groups.
CONCLUSION: This study indicates that lifelong participation in team sports is effective in reducing the age-dependent impairment in mechanical muscle function (MVIC and handgrip strength) and functionality (STS), as elderly lifelong trained women showed comparable values to young untrained controls despite an 41-yr age-difference.

**LONGITUDINAL COMPOSITIONAL ANALYSIS OF 24-HOURS ACTIVITY BEHAVIORS COMPOSITION DURING PREGNANCY: A NOVEL APPROACH FROM THE PREGNACTIVE PROJECT.**

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*UNIVERSITY PABLO DE OLAVIDE*

INTRODUCTION: During the course of pregnancy it has been described a reduction of physical activity levels (Barone Gibbs et al., 2021). Despite the different potential effects of moderate-to-vigorous physical activity (Davenport et al., 2018) or sedentary behavior (Fazzi et al., 2017)) on health, it is essential to know what activity behavior is selected by pregnant women when reducing the time spent in physical activity. This study aimed to properly analyze the longitudinal changes in the components of the 24-h day by using the compositional data analysis approach (Chastin et al., 2015).
METHODS: Eighty one pregnant women were longitudinally evaluated from midpregnancy to later pregnancy. The 24-h activity behaviors: sedentary time, sleep, light intensity physical activity, and moderate to vigorous intensity physical activity were objectively assessed by multi-sensor monitors. Statistical analysis included the Hotelling T2 test which was used to test if the perturbation between mid-pregnancy

and later pregnancy compositions indicated a significant change, and the compositional regression test which was developed for test the explanatory factors of the perturbation coordinates.
RESULTS: The Hottelling T2 test indicated that the compositional change between the mid-pregnancy and later pregnancy was statistically significant (F-stat= 6.4, p = 0.001). The relative contributions of light intensity and moderate-to-vigorous intensity physical activity, and sleep to the 24-h activity behavior composition decreased over time while increased sedentary time (≈3.1%). Compositional regressions developed for the perturbation coordinates indicated that MVPA increases when occupational status was maintained along pregnancy and when pregnant woman has higher educational level.
CONCLUSION: These findings reinforce the need to promote an active lifestyle during pregnancy to, at least, maintain physical activity levels and limit sedentary time along the course the pregnancy. The fact that higher educational level predisposes to increase physical activity levels suggest the importance of guarantee the access of pregnant women to the knowledge about the benefits and limited risk of physical activity during pregnancy .
References:
Barone Gibbs, B., Jones, M. A., Jakicic, J. M., Jeyabalan, A., Whitaker, K. M., & Catov, J. M. (2021). Objectively Measured Sedentary Behavior and Physical Activity Across 3 Trimesters of Pregnancy: The Monitoring Movement and Health Study. Journal of Physical Activity & Health, 18(3), 254–261. https://doi.org/10.1123/jpah.2020-0398
Chastin, S. F. M., Palarea-Albaladejo, J., Dontje, M. L., & Skelton, D. A. (2015). Combined Effects of Time Spent in Physical Activity, Sedentary Behaviors and Sleep on Obesity and Cardio-Metabolic Health Markers: A Novel Compositional Data Analysis Approach. PLoS ONE, 10(10), e0139984. https://doi.org/10.1371/journal.pone.0139984
Davenport, M. H., McCurdy, A. P., Mottola, M. F., Skow, R. J., Meah, V. L., Poitras, V. J., Jaramillo Garcia, A., Gray, C. E., B.

# Friday, September 2, 2022

## 08:00 - 09:15

### Invited symposia

### IS-PN08 Muscle structure and function in health, ageing, and pathological scenarios: new advances of an old tale

#### SARCOMEROGENESIS AND MUSCLE PLASTICITY: THE "OLD STORY

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Muscles undergo continuous turnover and adaptation in response to daily functional requirements. This represents a fundamental capacity for our survival, as, across different species, muscles have considerably evolved to make motion possible and to remarkably perform a variety of tasks. The modulations of sarcomere length and addition are thought to be two of the main mechanisms by which muscle plasticity is displayed in living organisms. The current and main accepted hypothesis is that muscle adaptations to loading and unloading are predominantly mediated by the addition or subtraction of muscle fundamental units, the sarcomeres, either placed in-parallel or in-series. For these reasons, sarcomerogenesis has been studied since the 1960s to clarify the mechanisms responsible for muscle plasticity. Interestingly, serial sarcomerogenesis phenomenon has been studied mostly in animal models, within different species, and across different muscles with distinct architecture and biomechanical functions, using different conditions and intervention durations. It follows that the literature presents contradictory findings regarding muscle adaptations to loading and disuse, and this can limit the current practice of orthopaedic decision making, of rehabilitation strategies, or simply our understanding of optimal exercise prescription, as sarcomere adaptations strongly influence muscle contractility and force generation. The present lecture aims to provide a critical discussion on sarcomerogenesis literature up to now, discussing the main accepted results and current limitations. Starting from Goldspink's work of the 70's and 80's, the main objective will be to present novel insights into muscle plasticity which have been recently introduced by the acquisition in vivo of images of human sarcomeres by microendoscopy technique1,2. The lecture will then present very recently published data on sarcomerogenesis in humans investigated by three-dimensional ultrasound and microendoscopy after 3 weeks of an eccentric exercise protocol3, discussing the possible strategies of muscle remodeling to specific mechanical stimuli. Not only the topic is of broad interest for sport scientists, kinesiologists, biomechanics professionals and researchers, physiologists, but it will also lay the ground for the other two talks, which will cover the relation between structure and function in health, ageing, and pathological settings.

References:
1 Sanchez, G. N. et al. Neuron 88, 1109–1120 (2015)
2 Lichtwark, G. A. et al. J. Appl. Physiol. 125, 1812–1820 (2018)
3 Pincheira, P. A. et al. J. Sport Heal. Sci. (2021)

#### LONGITUDINAL MUSCLE REMODELLING ON MECHANICAL FUNCTION

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Our group is interested in the effects of chronic changes to muscle fascicle length on mechanical function. Here we use two models to explore this relationship: aging which results in a loss of sarcomeres in series, and downhill running which results in an increase of sarcomeres in series.

Aging muscles undergo structural remodelling, whereby fascicle lengths become shorter in old as compared with young. Thus, the fascicles and sarcomeres of muscles in older adults may experience greater relative length changes for a given displacement, resulting in increased passive tension as compared with young. In a young (≈9 months ≈20 human years) and old cohort (~32 months; ≈75-80 human years) of rats we compared the medial gastrocnemius to determine differences in fascicle length, serial sarcomere numbers and sarcomere length, and record passive tension from short to long muscle lengths. The MG was surgically isolated, and passive force was recorded. The animals were sacrificed and the hind limb was fixed in formalin at the muscle length corresponding to optimal force. The muscles were then dissected into 4 lengthwise sections medial and lateral of the centre and sarcomere length measurements were obtained. From these experiments we showed the age-associated reduction in muscle fascicle length is primarily owing to fewer sarcomeres arranged in series, without a significant difference in sarcomere length. Additionally, passive force was greater in muscles from the old rats as compared with young at long muscle lengths. It was expected that shorter fascicles and fewer serial sarcomeres in muscles from old experienced greater relative length changes for a given displacement however this was not the case.

Increased serial sarcomere number (SSN) has been observed in rats via downhill running training, however, little is known about the influence on dynamic contractile function. Therefore, we employed 4 weeks of downhill running training in rats, then assessed soleus SSN and work loop performance in vitro to characterize dynamic performance. Thirty-one Sprague-Dawley rats were assigned to control (n=18) or training (n=13). Following sacrifice, the soleus was dissected and tied to a force transducer and length controller, then the optimal muscle length (LO) was determined. Muscles then performed work loops (active shortening followed by passive lengthening) about LO at various cycle frequencies. Next, muscles were fixed in formalin at LO for 1 week, then digested in nitric acid. Fascicle lengths and sarcomere lengths were measured and used to calculate SSN. From these experiments we show training-induced longitudinal muscle growth can improve dynamic performance.

Taken together it seems that longitudinal muscle remodeling whether it be a loss or gain of serial sarcomeres can alter passive and dynamic mechanical function.

The talk is of interest of movement scientists, as it covers fundamental knowledge of how muscles adapt to maintain optimal function.

### MULTI-SCALE MEASURES OF MUSCLE ARCHITECTURE IN THE BICEPS BRACHII: LOSS OF SERIAL SARCOMERES ACCOMPANIES CHRONIC HEMIPARETIC STROKE

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*NORTHWESTERN UNIVERSITY*

INTRODUCTION: Human muscle structure and function is plastic. However, few studies quantify muscle structural adaptation in vivo as needed to compute optimal fascicle length and physiological cross-sectional area (PCSA). By integrating 3 imaging methods (second harmonic generation endoscopy, extended field-of-view ultrasound, MRI), my lab quantified structure at the sarcomere, fascicle, and whole muscle scales in living humans [1]. We establish confidence in the ability to quantify these data and demonstrate that current approaches can detect structural adaptation in human muscle.
METHODS: Optimal fascicle length and PCSA were calculated from sarcomere lengths, fascicle lengths, and muscle volume measured in biceps brachii of both arms of 11 subjects (7 with chronic hemiparetic stroke; 2 female/5 male, 60 ± 9 yrs, Fugl-Meyer 26±9, 13±10 yrs post-stroke; 4 age-range matched participants without stroke; 2 female/2 male, 62±6 yrs). All length data were collected in the same posture, under passive conditions. We used sarcomere images from these participants and two additional unimpaired participants (1 female 28 yrs/1 male 29 yrs) to quantify experimental uncertainty associated with these novel data. Our methods are described in the literature [1, 2].
Results: Interlimb difference in volume for the stroke participants (med: 42.67 cm3, IQR: 23.54 cm3) was significantly larger than for those without stroke (med: 0.48 cm3, IQR: 7.65 cm3), indicating substantial loss of muscle (32.7%) in the paretic limb. Biceps fascicle lengths were shorter in the paretic limb; interlimb differences in stroke were significantly larger than without stroke. Interlimb differences in sarcomere length were comparable between groups. When computed from the fascicle and sarcomere length data, optimal fascicle length for the paretic biceps (i.e., the number of sarcomeres in series) was 20.0% shorter than the contralateral, nonparetic limb. When computed from muscle volume and optimal fascicle length, PCSA (a correlate of maximum isometric force) was significantly smaller in the paretic biceps. Normalized interlimb differences in PCSA (15.6%) were smaller than volume. The magnitude of the uncertainty for in vivo sarcomere length was ~0.25µm. When propagated, this uncertainty yields uncertainty in optimal fascicle length and PCSA of ~7–8%.
Conclusions: A loss in muscle volume (area×length) is often considered synonymous with a loss of PCSA. Our data show that loss of muscle volume can involve loss of sarcomeres in series, which has different functional implications. The uncertainty in sarcomere length and its propagation through calculation of the most functionally meaningful muscle architecture parameters, suggests measuring sarcomere length and studying muscle adaptation in vivo is practical and of interest for movement scientists, orthopaedic researchers and clinicians.
References:
1. Adkins, AN et al. PNAS 2020.
2. Adkins, AN et al. Front Physiol (accepted).

## Invited symposia

### IS-BM03 Wearable accelerometry-based technology to assess functional activities in older populations: from the laboratory to the free-living environment

#### A BODY-FIXED SENSOR-BASED ANALYSIS OF STAIR CLIMBING CAPACITY IN LABORATORY SETTINGS

VAN ROIE, E.

*KU LEUVEN*

Reduced lower-limb muscle power has been proposed as an important predictor of age-related deterioration in functional capacity. Clinically feasible measurements of lower-limb power are crucial to enable frequent assessments and to detect early changes, so that exercise interventions can be initiated in time. This session demonstrates the use of sensor-based trunk kinematics to estimate the vertical power produced during stair ascent in older adults. Different stair models (3 step – 6 step – 12 step) will be compared. Reliability of the measurement, the relationship with leg-extensor power and the age-related changes will be discussed.

#### THIGH-WORN ACCELEROMETRY TO DETECT AND QUANTIFY FREE-LIVING SIT-TO-STAND TRANSITIONS

LÖPPÖNEN, A.

*UNIVERSITY OF JYVÄSKYLÄ*

Sit-to-stand (STS) transitions are one of the most common activities of daily life and good STS performance is an important factor in maintaining functional independence. Usually, STS assessments is based on laboratory measurements, such as the five-times STS test. However, laboratory measured capacity should not be equated to functioning in free-living environment when measuring older adults without mobility limitations. This session demonstrates the use of thigh-worn accelerometers to detect and quantify sit-to-stand (STS) transitions in free living environment. The relationship between sit-to-stand performance in free-living environment and laboratory-based lower-extremity capacity will be examined.

#### CAPACITY IN THE LAB VERSUS DAILY LIFE PERFORMANCE: THE STRENGTH OF ASSESSING BOTH

RANTALAINEN, T.

*UNIVERSITY OF JYVÄSKYLÄ*

There is a clear distinction between a person's ability to perform a skill in the laboratory ("capacity") and his/her ability to perform that same skill in a natural environment ("daily performance"). This is particularly the case in individuals without mobility limitations. Individuals with a high strength reserve, i.e. much higher than the minimum strength required for a certain functional task, do not need to use their full capacity in free-living environments. However, this does not mean that free-living data cannot give important insights in the functioning of an individual. In this session, Dr. Rantalainen will discuss how to analyze free-living data by zooming in on 'best' performance in daily

life (“capability”). In addition, he will discuss how to use the complementary information of laboratory and free-living data to identify individuals at risk for functional decline.

## Invited symposia

### IS-MH07 Exercise as medicine in obesity-related breast cancer prevention and survivorship: From muscle to adipose tissue

#### EXERCISE AS MEDICINE IN BREAST CANCER PREVENTION. THE ROLE OF MYOKINES IN THE MUSCLE-ADIPOSE TISSUE-IMMUNE SYSTEM COMMUNICATION NETWORK

PÉREZ LÓPEZ, A.

*UNIVERSITY OF ALCALÁ*

During menopause, adipose tissue became the primary source of estrogens and androgens, altering glucose and lipid metabolism and increasing visceral fat mass accumulation. When these metabolic changes are accompanied by physical inactivity, the risk of obesity and the development of comorbidities, such as breast cancer, increased due to an augmented inflammatory state caused by adipocytes and immune cells release of pro-inflammatory cytokines (e.g., IL-6, IL-13 or IL-15) into the circulation to promote damaged tissue reparation and toxic agent neutralization. However, the chronic presence in the circulation of these pro-inflammatory cytokines contributes to an inflammatory spiral that damages several tissues’ metabolism and elevates the risk of non-communicable diseases. Exercise training can restore some of the metabolic disturbances experimented during menopause by regulating sex hormones production and promoting anti-inflammatory effects. Nevertheless, the mechanisms by which exercise facilitates muscle-adipose tissue-immune system crosstalk communication resulting in fat mass and breast cancer risk reduction are not entirely understood.
Myokines are among the main candidates to enable muscle-adipose tissue crosstalk communication. The acute release of some of these myokines (e.g., IL-6, IL-13, IL-15, IL-15Rα and FGF21) stimulates fatty acid oxidation in skeletal muscle and liver, lipolysis in skeletal muscle, a reduction in lipid accumulation in adipose tissue and improve glucose uptake and oxidation in skeletal muscle, liver and adipose tissue. These effects allow establishing a muscle-adipose tissue-immune system by which exercise can attenuate inflammatory state, restore sex hormones production and reduce fat mass accumulation.
Therefore, this presentation will aim to discuss the role of myokines in muscle-adipose tissue-immune system communication network, particularly in postmenopausal women with obesity at high risk of breast cancer.
RELEVANCE
Breast cancer is one of the most commonly diagnosed cancers in women worldwide. Obesity and physical inactivity are associated with postmenopausal breast cancer risk since inflammation and fat mass increase. Therefore, lifestyle interventions are required in women to facilitate the metabolic changes experimented during menopause to prevent or at least minimize breast cancer occurrence. We have used exercise as medicine to improve health outcomes and markers of breast cancer risk in postmenopausal women focused on elucidating the role of myokines and sex hormones in the muscle-adipose tissue-immune system communication network.
TARGET AUDIENCE
This presentation could be relevant to medical, nutrition and exercise practitioners interested in non-pharmacological strategies to prevent breast cancer or other chronic non-communicable diseases in postmenopausal women, from the basic science behind the inter-tissue communication to the practical application of exercise intervention.

#### EXERCISE AS MEDICINE DURING BREAST CANCER TREATMENT: HIGH INTENSITY INTERVAL TRAINING (HITT) AS A TIME-EFFICIENT APPROACH

GONZALO-ENCABO, P.1,2, KYUWAN, L.3, CHRISTOPHER, C.1,2, NORMANN, A.1,4, YUNKER, A.1,5, NORRIS, M.1, WANG, E.6, DIELI-CONWRIGHT, C.1,2

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While breast cancer is the most diagnosed cancer in women worldwide, cancer treatments have permitted an average 5-year survival rate for women with non-metastatic invasive breast cancer of 90%. Treatment strategies may include surgery, radiotherapy, and systemic therapy (e.g., endocrine therapy or chemotherapy). However, breast cancer and its treatments have multiple detrimental side effects, including physical, physiological, and psychosocial deficits. For example, for women diagnosed with early and advanced-stage breast cancer, the most commonly used treatment is anthracycline-based chemotherapy, which is associated with cardiotoxicity, and thus increases the risk of cardiovascular diseases. Other common side effects include weight gain, cancer-related fatigue, osteoporosis, muscle weakness, sarcopenia, declines in physical function, impaired quality of life, depression and anxiety, treatment-related cognitive impairments, and weight gain. Given the burden of pharmacological treatments experienced by cancer patients, it is important to explore non-pharmacological strategies that could counteract treatment side effects. In this regard, exercise is a low-cost, non-pharmacological strategy to promote clinical and health outcomes during breast cancer treatments. Particularly, high-intensity interval training (HIIT) is a time-efficient exercise type that combines exercise bursts with recovery periods. HIIT has shown beneficial effects in other clinical populations, whereas clinical oncology exercise research using HIIT remains largely unexplored. The purpose of this presentation will be to discuss the impact of breast cancer treatments on health-related outcomes such as cardiovascular and cognitive health, and the use of exercise (particularly HIIT) to improve health outcomes in breast cancer patients undergoing chemotherapy from previous and ongoing exercise oncology clinical trials.
RELEVANCE
Given the burden of breast cancer worldwide, it is important to understand how exercise can improve clinical and health outcomes during breast cancer treatment, with the ultimate goal of reducing comorbidities and mortality. In this regard, we have used exercise as medicine in our laboratory to improve health outcomes during breast cancer treatments, particularly prescribing a supervised and periodized HIIT intervention considering cancer-related side effects.
TARGET AUDIENCE

The content of this presentation is relevant to clinicians and for the sports science community, particularly for those who work with clinical populations living with chronic diseases. Transferring research into practice, our main goal with this presentation is that clinicians, researchers and trainers understand that exercise is medicine during breast cancer treatment.

### EXERCISE AS MEDICINE AMONG BREAST CANCER SURVIVORS: THE TRANSLATION OF SPORTS SCIENCE INTO CHRONIC DISEASE TO IMPROVE HEALTH OUTCOMES

DIELI-CONWRIGHT, C.

*DANA-FARBER CANCER INSTITUTE*

Individuals diagnosed with cancer experience a milieu of adverse treatment-related side effects that persist for many years negatively altering the risk of comorbid diseases and quality of life. Specifically, metabolic dysregulation (MetD), defined here as metabolic syndrome (MSY), insulin resistance (IR), and visceral adiposity (VA), and sarcopenia are long-term complications of curative treatment for many cancers including breast, prostate, and testicular. MetD in breast cancer survivors (BCS) is a serious concern during cancer survivorship that if treated may improve survivorship and further prevent cancer recurrence. MetD, due to heightened adipose and systemic inflammation, and increased cell proliferation, may influence one's risk for cancer recurrence and mortality. BCS represent a distinctive group who endure many treatment-associated alterations in lifestyle habits including weight gain, skeletal muscle loss, reduced physical activity levels, and worsening metabolic profiles leading to MetD. Exercise may be an effective intervention for attenuating MetD and sarcopenia, thereby reducing risk for additional associated chronic diseases. Since lifestyle factors such as exercise and dietary intake affect the risk of developing MetD, it is important, possibly preferable, to target lifestyle factors to prevent/manage MetD in BCS, particularly due to the fact that cancer survivors have undergone the physiologic burden of other cancer-related pharmacologic treatments with varying side effects. The purpose of this presentation will be to discuss the impact of MetD and sarcopenia on cancer-related outcomes and the utilization of exercise to target said health measures in BCS from previous and ongoing exercise oncology clinical trials.
RELEVANCE
Cancer affects millions of patients and caregivers worldwide that results in declining health outcomes at an earlier age and progress more rapidly when compared to age-matched adults and children without cancer. Thus the application of exercise to improve various health outcomes has the ability to improve survivorship and quality of life. Importantly, our research laboratory uses an exercise as medicine approach to deliver exercise in a highly prescriptive manner thus increasing the potential efficacy of the interventions we employ. Said interventions utilize basic principles of exercise and sports science yet with rigorous considerations based on cancer-related treatment side effects.
TARGET AUDIENCE
Based on the clinical implications of this presentation, this content is relevant to medical and exercise practitioners, particularly those who encounter individuals with chronic diseases. In addition, our research utilizes exercise prescription principles, such as the principle of overload, thus our exercise interventions are pertinent to clinicians and fitness professionals alike.

## Invited symposia

### IS-AP08 Overcoming challenges of COVID-19 for sport and exercise scientists: harnessing remote technology to measure sport and exercise outcomes

### MOVING SPORT SCIENCE FROM THE LABORATORY TO HOME: VIRTUAL ENVIRONMENTS AND SPORT PERFORMANCE

EDWARDS, A.

*CANTERBURY CHRIST CHURCH UNIVERSITY*

With COVID-19 restrictions placed on sport and exercise scientists to continue testing in laboratories and maintain a social distance, conducting testing in the laboratory is problematic. As an alternative, sport and exercise scientists can adopt virtual training environments to examine and manipulate sport performance from a remote setting. Virtual environments refer to a computer reality that aims to induce a sense of being mentally and physically present in another place, and in the last five years, prevalence of use has increased exponentially. A range of virtual environment software is available to athletes where they can interact with the environment to stimulate "real world" training and competition. This technology is highly useful for athletes wanting to compete and train at a time when social restrictions may prevent these from taking place. In fact, such technology has made it possible to augment and improve the performance of athletes, which is an invaluable tool that can be accessed from home.
An inherent advantage with virtual environment is that researchers can conduct a study from home without the need to supervise participants. One popular virtual environment software, with over 2.5 million users in over 190 countries, is Zwift, whereby cyclists ride their bikes on a stationary trainer that provides measures of power, speed, cadence, and heart rate. This software could be used as an alternative for sport and exercise scientists being in the laboratory and provides opportunities to examine and manipulate various forms of outcome measures related to, for example, physiology, biomechanics, and psychology.
In this session, the speaker will provide an overview of virtual environment software that sport and exercise scientists can use to obtain valuable outcome measures. This will be followed by empirical data related to the reproducibility of performance using virtual environment software (i.e., Zwift) and the outcomes of a nutritional intervention using the software. Implications about the advantages and disadvantages will be discussed, alongside how sport and exercise scientists can maximise their use of remote technology to help them continue their scientific endeavours.

### THE ROLE OF AVATARS TO HELP IMPROVE SPORT PERFORMANCE AND EXAMINE COMPETITIVE BEHAVIOUR

HETTINGA, F.

*NORTHUMBRIA UNIVERSITY*

Social distance restrictions have reduced the occurrence of sporting competitive events worldwide and impeded sport scientists examining in-person competition and training. Competition between athletes is central to sport, which has shown to influence performance via a

myriad of factors related to behavioural, psychological, and physiological mechanisms. Athletes need to determine how and when to invest their limited energy resources to optimise their pace and self-regulate their pace depending on the physiological and biomechanical capacity and environmental factors, such as the presence and behaviour of another athlete. Excellence in many sports involves mastering of tactical competitive elements, and athlete motivation for training and competition is hugely influenced by other exercisers and/or competitors.
Remote technology can be used to help identify the interaction of competition on an athlete's performance or offer competitive training scenario's and motivation without F2F contact. One method is via the use of avatars, which can be a graphical representation of an athlete's own performance or that of another athlete. A body of research has shown that avatars can influence emotional and psychological responses, which in turn influences that athlete's performance. This research has shown that avatars can influence self-regulatory processes, which affects beliefs, motivations and perceptions of energy and fatigue.
In this session, the use of remote technology to replicate competitive sport environments will be discussed and how they can help understand more about the myriad of factors that impact competitive sport performance.

**EXERGAMING AS A TOOL TO PROMOTE PHYSICAL ACTIVITY AT HOME**

LAMOTH, C.

*UNIVERSITY OF GRONINGE*

Physical inactivity is associated with cardiovascular disease, type II diabetes and obesity, which in turn can increase the risk of premature mortality. In the context of COVID-19, maintaining and increasing physical activity is challenging with gyms and fitness centres being closed, and exercise events, such as parkrun, being cancelled. Similarly, while evidence suggests people have more time to be physical activity due to working from home, the impact of social restriction measures has negatively affected mental health outcomes, such as stress and depression, which can further negatively affect physical activity levels. In short, the restrictions associated with COVID-19 has significantly affected people's physical activity behaviour.
In the past two decades, a growing body of evidence has examined the use of interactive gaming (i.e., exergaming) to help increase physical activity and thus improve a person's health and wellbeing. Exergaming offers an immersive experience that simulates an active gaming experience to function as a form of physical activity by using videogames and devices to convert a person's body movements into an avatars movements on their TV screen. Exergames are relatively easy to use, with instructions being available to help guide the user through the game without the need of supervision. As such, exergames offer an easy, remote, and engaging platform in which to examine and measure physical activity outcomes remotely.
In the present session, the use of exergaming to benefit physical activity outcomes will be discussed. Algorithms for adaptive games and feedback to the user at different time scales to enhance exercise outcomes will be discussed as well as an overview of the evidence that exergaming can increase physical activity. This in turn will be followed by a critique of how unsupervised exergaming can be used to improve physical activity that is feasible and practical.

## Oral presentations

### OP-PN32 Energy expenditure and metabolism

**LOWER BASAL METABOLISM IS ASSOCIATED WITH ELEVATED CIRCULATING LEVEL OF INTERLEUKIN-6 IN TYPE 2 DIABETES MELLITUS: THE APETEX/EDUGUTION STUDY**

CASALS, C., CORRAL-PÉREZ, J., REBOLLO-RAMOS, M., MARÍN-GALINDO, A., MONTES-DE-OCA-GARCÍA, A., RAMÍREZ-JIMÉNEZ, M., OPAZO-DÍAZ, E., CALDERON-DOMINGUEZ, M., PONCE-GONZÁLEZ, J.G.

*UNIVERSITY OF CADIZ*

INTRODUCTION: The elevated circulating level of interleukin-6 (IL6) has been identified as an independent predictor of type 2 diabetes mellitus (T2DM). Thus, IL6 is considered to be involved in the development insulin resistance and β-cell dysfunction as a pro-inflammatory marker. Nevertheless, IL6 is a multifunctional cytokine and an increasing number of evidence have suggested that it has an anti-inflammatory role and could improve glucose metabolism. Therefore, the aim of this study was to analyse the relationship between IL6 and relevant health parameters, including glycosylated haemoglobin (A1c), body composition, basal metabolism, fat oxidation capacity and cardiorespiratory fitness in patients with obesity and T2DM.
METHODS: This pilot study of the APETEX/EDUGUTION project included a first batch of 15 patients (6 females) with a body mass index over 30 kg/m2 and diagnosis of T2DM. All participants were non-smokers and non-insulin-dependent patients. Blood samples were collected from the antecubital vein to measure IL6 and A1c. Body composition was estimated by bioimpedance. Basal metabolism was registered through indirect calorimetry with the subject lying in supine position during 30 min; then, FatMax (the intensity of maximal fat oxidation capacity) was calculated with an incremental test consisted in 3-min steps of 15W at 60-80 rpm on a cyclo-ergometer until RER reached 1, followed by a 1-min incremental test until exhaustion to estimate VO2max. Also, body composition was estimated by using bioimpedance. All measurements were performed in the morning and in fasting conditions (8-10 h). Additionally, 7 days before measurements, diet was registered by the weighting method.
RESULTS: Linear regression models with the stepwise method showed that the elevated levels of IL6 were associated with lower basal metabolism in T2DM (β=-0.61, R2=0.37, p=0.015); the rest of variables were excluded. Moreover, by including A1c as dependent variable, it was showed an association with basal metabolism and FatMax (R2=0.55, p=0.009).
CONCLUSION: Lower basal metabolism is associated with elevated IL6 circulating levels in patients with obesity and T2DM. As basal metabolism is the largest component (60–75%) of daily energy expenditure for most individuals, its relevance with body mass management is highlighted. Also, as it was expected, a poorer diabetes control, estimated with A1c%, leads to a worse FatMax that can be considered a relevant marker of metabolic flexibility. It was presented without a significant effect of the VO2max, although it must take into account that this population (obese patients with T2DM) has a lower cardiorespiratory fitness compared with healthy subjects. A higher sample will be studied in this project which consists in a randomized clinical trial with exercise interventions and nutritional counselling, leading to a

better understanding of IL6 signalling mechanisms and its relation with T2DM. GRANTS: PID2019-110063RA-I00, PID2020-120034RA-I00, and LI19/21IN-CO09.

### ACUTE EFFECT OF CONCENTRIC AND ECCENTRIC CYCLING EXERCISE ON SUBSTRATE OXIDATION AMONG OBESE MALE

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INTRODUCTION: Greater fat utilisation has been previously shown during eccentric compared to concentric cycling at the same workload among healthy men (Penailillo et al. 2014). Among obese individuals, there are evidence of an impaired lipid oxidation during exercise as the result of reduced mitochondrial content (Kim et al. 2000), lower oxidative-enzyme capacity (Simoneau et al. 1999) as well as reduced insulin concentration (Thyfault et al. 2004). Based on this evidence, this study aims to explore the acute effect eccentric cycling exercise among obese male.
METHODS: Eleven overweight men (35 ± 3 years; 35.8 ± 3.7 %Body Fat) performed a concentric (CON) and two eccentric (ECC1, ECC2) intermittent cycling exercise bouts for 45 min. The intensity of exercise for CON and ECC1 and was set at 60% of CON maximal power output (POmax), while the intensity for ECC2 was set at 120% CON POmax. Prior to exercise testing, each participant was provided with three familiarisation sessions.
During exercise, Fat and carbohydrate utilisation during exercise were estimated from the RER measured by the metabolic cart (ParvoMedics, Sandy, USA). Substrate oxidation was estimated using the stoichiometric equations assuming a non-protein respiratory quotient (Jeukendrup and Wallis, 2005). In each trial, participants provided venous blood samples at the start and the completion of the exercise. Blood samples were analyzed for triacylglycerols (TG), total cholesterol (TC), low-density lipoprotein (LDL), and high-density lipoprotein (HDL).
RESULTS: There was no significant difference in fat utilization during exercise between CON to both ECC1 and ECC2 trials (139.8kJ ± 150.7 vs. 152.3kJ ± 57.3 and 254.3kJ ± 118.6, respectively; P>0.05). There was a significantly higher CHO utilization during the CON exercise when compared with both ECC1 and ECC2, respectively (1690.8kJ ± 473.5 vs. 476.9kJ ± 161.95 and 729.2kJ ± 118.6, respectively; P<0.05). There was no significant (P>0.05) difference in the percent change in TG, TC, LDL and HDL from the start to the end within the CON and ECC1, and ECC2.
CONCLUSION: This study observed that a single bout of eccentric cycling did not show a favorable fat utilization as compared to concentric cycling among obese men. Reduced mitochondrial content and lower oxidative-enzyme capacity have been previously shown to limit lipid oxidation during exercise among obese individuals (Arad et al. 2020).

### COMPARISON OF METABOLIC PARAMETERS AND, PERIPHERAL AND CENTRAL OXYGENATION, BETWEEN HEALTHY AND TYPE 2 DIABETIC WOMEN.

ÁVILA, L., PONCE-GONZÁLEZ, J.G., MONTESDEOCA, A., CORRAL-PÉREZ, J., OPAZO, E., MARÍN-GALINDO, A., RAMIREZ-JIMENEZ, M., ORELLANA PECINO, I., REBOLLO-RAMOS, M.

*UNIVERSITY OF CÁDIZ*

(co-authors)González Mariscal, A., Pérez-Bey, A., Casals, C., Velázquez-Díaz, D.
INTRODUCTION: Cardiorespiratory fitness (CRF) and fat oxidation (FO) are lower in sedentary women with diabetes compared to their healthy counterparts (1), however, the differences in other metabolic parameters, as resting FO, is unclear. A previous study suggests that peripheral oxygenation may be impaired in the lower extremities in T2D (2), although, few studies have analysed the differences of peripheral and central between healthy women and women with T2D. The aim of this study was to analyse the differences of CRF, FO and peripheral and central oxygenation between healthy and women with T2D.
METHODS: 17 women (33.8±14.9 years; 6 with T2D) were included in this study. Resting FO were registered through indirect calorimetry. Then, an incremental exercise protocol on a cycle ergometer with two phases was performed. The first phase aimed to determine maximal FO and consisted of 3-min steps of 15/30W (depending on the weight of the individual) maintaining a pedalling cadence of 60-80 rpm. This phase was stopped when RER≥1. The second phase to detect the VO2max. Near Infrared Spectroscopy (NIRS) at rest and during the incremental test was used. One NIRS sensor was placed on the non-dominant frontoparietal area for estimation of central oxygenation, while another sensor for estimation of peripheral oxygenation was placed on the vastus lateralis. Student t-test was applied to analyse the differences between groups.
RESULTS: CRF was higher in healthy women compared to diabetics (p<0.001). Women with T2D showed higher resting FO than healthy women (p=<0.002), however, these significant differences were not observed with maximal FO. Regarding resting peripheral oxygenation, there were significant differences between healthy and women with T2D, being higher in healthy individuals (P=0.002), however, women with T2D showed higher peripheral oxygenation at light, submaximal and maximal exercise intensity than healthy women (all p<0.005). There were no significant differences regarding central oxygenation.
CONCLUSION: Women with T2D showed a higher FO at rest compared to healthy women. Moreover, women with T2D achieved higher peripheral oxygenation level during light, submaximal and maximal exercise intensity than healthy women, although, healthy women showed a higher peripheral oxygenation at rest. These findings suggest that women with T2D had higher peripheral oxygenation than healthy women during exercise.
Grants: 1) PID2019-110063RA-I00. 2) PID2020-120034RA-I00. 3) LI19/21IN-CO09.
References:
1. Cancino Ramírez J, Soto Sánchez J, Zbinden Foncea H, et al. Cardiorespiratory fitness and fat oxidation during exercise as protective factors for insulin resistance in sedentary women with overweight or obesity. Nutr Hosp. 2018 Mar 1;35(2):312-317.
2. Gildea, Norita, Joel Rocha, Adam McDermott, et al. 2019. “Influence of Type 2 Diabetes on Muscle Deoxygenation during Ramp Incremental Cycle Exercise.” Resp Phy and Neuro 269.

**INVESTIGATING THE ROLE OF TESTOSTERONE IN SKELETAL MUSCLE ADAPTATION IN PRE-MENOPAUSAL FEMALES**

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INTRODUCTION: Testosterone is the major male sex hormone and promotes virilising traits. Testosterone is also present in females, albeit at concentrations 10-fold lower than in males. Testosterone positively regulates skeletal muscle mass and function in males via binding to its receptor, the androgen receptor, and increasing muscle protein synthesis. However, evidence is emerging that, when at physiological levels, total testosterone may not be related to muscle mass nor strength in pre-menopausal females. This study aims to establish whether testosterone concentrations are predictive of the muscular adaptations that occur in response to 12 weeks of resistance training in pre-menopausal females.
METHODS: Twenty non-resistance trained, pre-menopausal females (age 23.4 years ± 4.6) underwent 12 weeks of resistance training designed to maximally increase muscle size and strength. Thigh muscle cross sectional area, measured via peripheral quantitative computed tomography, and muscle strength, measured via leg press 1RM, were assessed before and after the training program. Sex hormone levels were assessed via ELISA. Muscle biopsies were collected before and after the training program. The muscle transcriptome was sequenced using RNASeq and the protein levels of the total and phosphorylated forms of the androgen receptor as well as common markers of muscle protein synthesis and degradation were analysed via western blot.
RESULTS: The average testosterone concentration of participants at baseline was 1.99 ± 0.53 nmol/L and did not fluctuate with training. Lower limb strength and thigh muscle cross sectional area increased by 28.5 and 7.3%, respectively. Total testosterone was not significantly correlated to muscle strength or size at baseline, or with the changes that occurred with training. Similarly, testosterone levels were not related to androgen receptor protein content or the relative expression of total or phosphorylated markers of protein synthesis.
CONCLUSION: Twelve weeks of resistance training increased muscle size and strength in pre-menopausal females. Total testosterone levels were however not related to increases in muscle size or function, nor to downstream markers of protein synthesis. This suggests that total testosterone plays a minor role in the regulation of muscle growth and function in pre-menopausal females.

**VALIDATION OF THE APPLE WATCH AND FITBIT FOR ASSESSING ENERGY EXPENDITURE DURING WHEELCHAIR PROPULSION IN ABLE-BODIED PARTICIPANTS AND WHEELCHAIR USERS**

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INTRODUCTION: Wheelchair users (WU) have a higher risk of obesity compared to able bodied (AB) individuals, mainly due to a lower daily energy expenditure (EE) . Closely monitoring EE and physical activity can serve as a tool for matching daily EE with energy intake, and thereby prevent or counteract obesity. The Apple watch is currently the only commercially available, wrist-worn watch with specific setup and EE estimation algorithms for wheelchair users. However, the accuracy of EE estimations from the Apple watch compared to other commercially available watches without a wheelchair-specific setup has not yet been established. Therefore, the purpose of this study was to investigate if the Apple watch and Fitbit accurately estimate EE during wheelchair propulsion.
METHODS: Data of 20 AB participants are currently included (age: 33 ± 11 years, height: 176 ± 10 cm, body mass: 75 ± 11 kg), while data from 20 manual WCU are still being collected. Criterion data for EE was measured with an ergospirometer (Vyntus CPX) during three 4-min stages of treadmill wheelchair propulsion at a 2.5% incline (women:2,3,4, men:3,4,5 km/h). Simultaneously, participants wore the Apple watch (set to wheelchair propulsion at walking pace) and Fitbit (set to treadmill running) on the non-dominant wrist. Placement of the devices (i.e., closeness to the wrist) was counterbalanced. Bland-Altman plots with mean differences (MD) between the average EE (kJ/min) recorded by the criterion device compared to either the Apple watch or Fitbit including lower and upper limits of agreement (LoA) were used to establish absolute agreement. Intraclass correlation coefficients (ICCA,1) were used to establish relative agreement.
RESULTS: The Apple watch underestimated EE with larger LoAs at higher intensities, with MDs [lower, upper LoAs] of: Stage 1 (-3.5 [-8.7,1.6]), stage 2 (-6.3 [-12.7,0.1]) and stage 3 (-10.1 [-1.4, -18.7]).The Fitbit overestimated EE for all three stages: Stage 1 (11.7 [3.5, 19.8]), stage 2 (12.5 [3.8, 21.1]) and stage 3 (12.9 [1.9,23.8]). Furthermore, ICCs were low to moderate during all stages for the Apple watch (0.47,0.27, 0.19) and the Fitbit (0.26, 0.5, 0.72).
CONCLUSION: Based on current preliminary findings, our result suggested that both the Apple watch and Fitbit were not accurate enough for estimating EE during wheelchair propulsion in AB people. Additional data on WCU still needs to be investigated before any definite conclusions can be drawn for the EE estimation of Apple watch and Fitbit.

## Oral presentations

### OP-AP14 Monitoring in soccer

**POSITIONAL DIFFERENCES IN ABSOLUTE VS. RELATIVE TRAINING LOADS IN ELITE ACADEMY SOCCER PLAYERS.**

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INTRODUCTION: The quantification of relative training loads (RTL) is useful to assess how much players are exposed to competitive demands during training [1,2]. However, this alternative method to absolute training loads (ATL) quantification has only been scarcely used. Most studies have mainly expressed the RTL without considering the position of the players. This study therefore aimed to evaluate ATL and RTL and compare positions over the full in-season in an elite soccer academy.
METHODS: Twenty-four elite academy soccer players were categorized in five positions (CD: central defender; FB: full back; CM: central midfielder; WM: wide midfielder; FW: forward) and monitored using global positioning system (GPS). Only the weeks that fulfilled the following criteria were considered: (i) the team played only one match during the week, (ii) with a minimum of 6 days between the matches, (iii) players should complete all training sessions of the considered week, and (iv) should play the whole match. Firstly, ATL were calculated using day-by-day (according to their distance from match day [MD]) mean values from the considered weeks. Then, RTL were calculated using ATL expressed as a fraction of mean values of all the competitive matches of the considered weeks. GPS-derived data included

total (TD), moderate (MSD; [15-20[ km·h-1), high (HSD; [20-25] km·h-1), and sprint distance (SPRa; > 25 km·h-1), the total number of accelerations (ACC; > 3 m·s-2) and decelerations (DEC; < -3 m·s-2). One-way ANOVA were performed to evaluate differences between positions, followed-up by Bonferroni post-hoc procedures. Cohen's d effect size were calculated. Significance was set at p<0.05.
RESULTS: Absolute TD was greater for WM than CD (p=0.003; d=1.268) on MD-3, while relative TD did not demonstrate significant difference. Absolute MSD did not highlight difference across positions, while relative MSD showed that CD performed greater distances than CM, WM, and FW over the entire microcycle (p=0.045; d=1.248). Additionally, FB also performed a greater relative MSD than WM, on MD-4, MD-3, and MD-2 (p=0.001; d=1.107). On MD-4 and MD-3, WM demonstrated greater absolute ACC and DEC values than CD (ACC: p=0.047; d=1.057; and DEC: p=0.007; d=1.149) and CM (ACC: p=0.039; d=1.167; and DEC: p=0.011; d=1.423), while relative ACC and DEC did not differentiate positions.
CONCLUSION: Our results therefore highlight the need to quantify RTL over ATL. Quantifying RTL adds context to training loads by taking into account the competitive demands, and result in markedly different conclusions.
1. Guerrero-Calderón B, Fradua L, Morcillo JA, Castillo-Rodríguez A. Analysis of the Competitive Weekly Microcycle in Elite Soccer: Comparison of Workload Behavior in Absolute and Relative Terms. J Strength Cond Res. 2022;
2. Baptista I, Johansen D, Figueiredo P. Positional Differences in Peak- and Accumulated- Training Load Relative to Match Load in Elite Football. Sports. 2019;

## WITHIN PLAYER MONITORING OF WELLNESS, SLEEP AND READINESS TO PLAY AND THE EFFECT OF TRAINING LOAD IN ELITE FOOTBALL

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INTRODUCTION: Frequent matches and training sessions in elite football result in high training loads and constrained time for recovery. Careful planning of training loads, using valid and reliable tools, may assist to reduce injury risk and increase physical performance [1]. Monitoring individual training load, perception of wellness and sleep may be useful tools for tracking training load and the response to training and matches, and therefore improve training preparations. An important question is therefore how training load is related to wellness, sleep and readiness to play. Therefore, the aim of this study was to assess how wellness, sleep, readiness to play vary in the days pre- and post-match over two consecutive seasons within one elite football team.
METHODS: Thirty-one players (age 25.5±5.1 yr) from an elite Norwegian football team participated in the study over two consecutive seasons. Sixteen players participated in both seasons, while the remainder participated in either season. Each player reported daily their individual session rating of perceived exertion training load (sRPE-TL), wellness questionnaire [2], hours of sleep and readiness to play via a mobile-app. The data was pooled into days (-3 to +3 relative to match day [MD]) and analyzed using a linear mixed effects model, adjusting for training load, training load x day interaction, season trend and random effects for player and week.
RESULTS: Large day-to-day differences of sRPE-TL (ES: 1.1-2.5; p<0.01), hours of sleep (ES: 0.5-1.1; p<0.01), readiness to play (ES: 0.7-2.4; p<0.01) and wellness (ES: 0.3-1.5; p<0.01-0.03), with the exception of MD-1, were observed in the periods of MD-3 to MD+3 days relative to the matches in season 1. In season 2, these equivalent day-to-day differences were very similar for sRPE-TL (ES: 0.7-2.5; p<0.01), hours of sleep (ES: 0.4-1.1; p<0.01-0.02), readiness to play (ES: 0.7-2.7; p<0.01-0.05) and wellness (ES: 0.4-1.6; p<0.01), with the exception of MD-1.
CONCLUSION: The study shows that sRPE-TL, wellness, hours of sleep and readiness to play are sensitive to day-to-day differences in the days before and after the match, and are consistent over two seasons in this cohort. Hence, these variables are practical to include in a player monitoring regime. Furthermore, training load had an effect on wellness and readiness to play the day after the match, but not on the other days, highlighting the impact of the match.
1. Bourdon et al, (2017); 2. McLean et al. (2010);

## ANALYSIS OF THE PHYSICAL DEMANDS AND LOAD REQUIRED IN TRAINING AND MATCHES IN YOUNG U10 AND U12 SOCCER PLAYERS

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INTRODUCTION: The Global Positioning System (GPS) is widely used in professional football and in the adult population, providing external load data that allows coaches to analyze physical demands according to the different playing positions in matches and to program training loads (1-2). However, there is a paucity of knowledge of the external load in training and matches for young players. Therefore, the aim of the present study was to analyze the performance variables and physical demands of U10 and U12 football players according to playing position, pre-match, and match training (MD-4, MD-2 and MD).
METHODS: Twenty-one U10 (age= 10.2 years) and U12 (age= 12.3 years) amateur players were analysed using the GPS WIMU PROTM 15Hz, with a total of 504 observations in a period of 3 months of 8-a-side football training and matches. The variables of total distance, distance in high intensity and sprint, maximum speed, time interval between accelerations, maximum speed acceleration, maximum acceleration, acceleration distance and number of high-intensity accelerations were analysed in absolute and relative values with respect to competitive match play.
RESULTS: The most notable differences in the U10s showed that midfielders in matches covered higher distance and higher intensity acceleration than in training (p<0.05; ES: 0.72 to 1.57) and at a with respect to defenders and forwards (p<0.05; ES: 1.05 to 2.00). In the U12s the midfielders in matches covered a higher distance and at a higher intensity than in training (p<0.05; ES: 1.05 to 2.39). The relative results compared to to match day in the U10 category, showed midfielders had a significantly lower percentage of total distance than defenders and forwards (p<0.05; ES: 0.76 to 0.83).
CONCLUSION: The present study indicates that the physical demands of young footballers in training and competition are influenced by the playing position and the age category. The playing position influences the physical performance in such a way that the U10 and U12 midfielders cover longer distances and perform a higher number of high-intensity actions in training and matches than the defenders and forwards. With regard to the importance of the category, the U12 players present fewer differences in physical demands between positions and trainings and matches due to their greater experience and age. The physical demands of the players in training are higher than in matches due to the rules of the game itself because the training is longer than a match and based on a learning and development approach, contrary to the loads of training in adult players, which are based on reaching the match day in the best shape.

1. Mallo et al. (2015); 2. Castellano et al. (2014)

**ACUTE FUELLING AND REFUELLING PRACTICES OF MALE ACADEMY SOCCER PLAYERS: IMPLICATIONS FOR PHYSICAL DEVELOPMENT AND PERFORMANCE**

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INTRODUCTION: The energy expenditure of male adolescent soccer players [1] from the English Premier League (EPL) is comparable to (or greater) than adult players [2]. Given the requirement to promote growth and maturation in this population, there is a necessity for players to consume sufficient energy and macronutrient intake (EI) in the hours before and after training. "Under-fuelling" at this time is likely to reduce training performance and may increase the risk of injury to bone and tendinous structures. Accordingly, the aim of this study was to quantify the EI of male adolescent soccer players in the four hours pre- and post-training.
METHODS: During a 3-day data collection period, youth soccer players from an EPL academy (n = 48; U12, U13, U14, U15/16, U18, U23, all n = 8) self-reported their EI in the four hours pre- and post-training via the remote food photography method. Pitch-based loading was quantified using GPS technology during three (U12, U13, U14) and four (U15/16, U18 and U23) training sessions over the assessment period.
RESULTS: Total distance was greatest in the U15/16 (6162 ± 1165 m) squad, more than the U18 (5099 ± 1160 m) and U23 (4878 ± 1171 m) squads (both P<0.05). Distance covered by the U12 squad (6057 ± 1494 m) was greater than the U23 squad (P<0.05). No differences were found between the U13 (5931 ± 646 m) and U14 (5715 ± 1978 m) squads compared to all other squads. EI was consumed in closer proximity to the start of training in the U15/16 squad (- 40 ± 28 mins) compared to the U12 (- 91 ± 77 mins), U13 (- 99 ± 63 mins), U14 (- 104 ± 56 mins), U18 (- 114 ± 71 mins) and U23 (- 99 ± 52 mins) squads (P<0.05). There was no difference between the timing of EI between groups post training, (U12: + 56 ± 39 mins; U13: + 50 ± 34 mins; U14: + 39 ± 27 mins; U15/16: + 53 ± 25; U18: ± 54 ± 91 mins; U23: + 70 ± 84 mins). CHO intake pre-training was greater in U12 (1.4 ± 0.9 g.kg-1; all P<0.05) and U13 (1.5 ± 1.0 g.kg-1; all P<0.05) squads compared to U14 (0.8 ± 0.5 g.kg-1), U15/16 (1.0 ± 1.1g.kg-1) and U23 (0.7 ± 0.4 g.kg-1) squads. CHO intake in the U18 group (1.2 ± 0.1 g.kg-1) was not different from any other squad. Post-training relative CHO intake was greater in the U12 (1.5 ± 0.9 g.kg-1; all P<0.05) and U13 (1.6 ± 0.8 g.kg-1; all P<0.05) compared to U14 (0.8 ± 0.4 g.kg-1) and U23 (0.9 ± 0.4 g.kg-1) squads. CHO intake in the U14 squad was less than U15/16 (1.3 ± 0.6 g.kg-1) and U18 (1.6 ± 0.6 g.kg-1) squads (all P<0.05). CHO intake was lower in the U23 (0.9 ± 0.4 g.kg-1) compared with the U18 squad (P<0.05).
CONCLUSION: When compared with current recommendations to promote high CHO availability before and after exercise, data demonstrate that the present cohort of players under-consume CHO. Given the requirement to promote physical development alongside training intensity in an adolescent population, careful consideration should be given to the "acute" fuelling and re-fuelling practices for elite youth soccer players.
1. Hannon et al., 2021 2. Anderson et al., 2017

**VISUAL SCAN PATTERNS OF FOOTBALL ASSISTANT REFEREES WHEN JUDGING OFFSIDE.**

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INTRODUCTION: Decision-making in sports is mediated by perceptual-cognitive mechanisms. Visual scan patterns have been studied in multiple contexts to analyze observers perceptual abilities. However, the structure of these patterns has not been extensively studied in athletes. This work aimed to analyze the visual search strategies and decision-making processes of a group of football assistant referees.
METHODS: Ten national-level (9.0 ± 4.3 years of experience) and ten regional-level (8.6 ± 5.3 years of experience) football assistant referees (AR) were recruited for the study. Participants watched twelve task-specific video clips where the relative position of the attackers had to be perceived (i.e. onside/offside position) while wearing eye-tracker glasses. Four areas of interest (AOI) were established: attacker with the ball, attacker receiving the ball, defenders, and intermediate space. A visual fixation was defined if the gaze remained at the same AOI for a minimum time of 100 ms. Differences between groups were analyzed for dependent variables: response accuracy, stationary gaze entropy (SGE), and gaze transition entropy (GTE). Finally, the Kendall agreement coefficient (W) was calculated for one trial to analyze if participants tend to visit AOI in the same order.
RESULTS: No statistical difference was found between national- and regional-level ARs in response accuracy (58.5 ± 15.3% vs 60.9 ± 9.0%, p=0.673), SGE (92.3 ± 6.3% vs 92.8 ± 6.1%, p=0.859), and GTE (64.3 ± 16.4% vs 62.5 ± 19.0%, p=0.824). Concordance coefficient showed absence of agreement in national-level AR (W = 0.04; p>0.05). However, concordance coefficient showed agreement in the order of fixation locations in regional-level participants (W = 0.59; p<0.05).
CONCLUSION: AR in both groups showed a high gaze dispersion and transition rate between AOI, which highlights the relevance of the available stimuli when refereeing offside situations. However, regional-level AR presented a more predictable ordering when visiting AOI. On the other hand, national-level AR showed no systematic ordering when visiting AOI. These results suggest that each participant within the national-level AR group has developed a particular strategy when exploring the environment during offside judgments. However, these differences did not have an impact on the response accuracy, as both groups showed similar values. Further research should explore the timing of visual fixations that occurs between AOIs and the importance of the last fixation, also known as quiet eye.

# Oral presentations

## OP-PN33 Thermoregulation II

### SEASONAL HEAT ACCLIMATISATION IN HEALTHY ADULTS: A SYSTEMATIC REVIEW

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INTRODUCTION: Physiological heat adaptations can be induced following various protocols that use either artificially controlled or naturally occurring environments. During the summer months in seasonal climates, adequate exposure to outdoor environmental heat stress should lead to transient seasonal heat acclimatisation.
Objectives: To assess the available literature and characterise seasonal heat acclimatisation during the summer months and identify key factors that influence the magnitude of adaptation.
METHODS: Eligibility criteria: English language, full-text articles that assessed seasonal heat acclimatisation on the same sample of healthy adults a minimum of three months apart.
Data sources: Studies were identified using first- and second-order search terms in the databases MEDLINE, SPORTDiscus, CINAHL Plus with Full Text, Scopus, and Cochrane, with the last search taking place on 15th July 2021.
Risk of bias: Studies were independently assessed by two authors for the risk of bias using a modified version of the McMaster critical review form.
Data extraction: Data for the following outcome variables were extracted: participant age, sex, body mass, height, body fat percentage, maximal oxygen uptake, time spent exercising outdoors (i.e. intensity, duration, environmental conditions), heat response test (i.e. protocol, the time between tests), core temperature, skin temperature, heart rate, whole-body sweat loss, whole-body and local sweat rate, sweat sodium concentration, skin blood flow and plasma volume changes.
RESULTS: Twenty-nine studies were included in this systematic review, including 561 participants across eight countries with a mean summer daytime wet-bulb globe temperature (WBGT) of 24.9°C (range: 19.5 to 29.8°C). Two studies reported a reduction in resting core temperature (0.16°C, $P<0.05$), 11 reported an increased sweat rate (range: 0.03 to 0.53 L/h, $P<0.05$), two observed a reduced heart rate during a heat response test (range: 3 to 8 beats/min, $P<0.05$), and six noted a reduced sweat sodium concentration (range: -22 to -59%, $P<0.05$) following summer. The adaptations were associated with a mean summer WBGT of 25.2°C (range: 19.6 to 28.7°C).
CONCLUSION: Limitations: The available studies primarily focussed on healthy male adults and demonstrated large differences in the reporting of factors that influence the development of seasonal heat acclimatisation, namely, exposure time and duration, exercise task and environmental conditions).
Conclusions: Seasonal heat acclimatisation is induced across various climates in healthy adults. The magnitude of adaptation is dependent on a combination of environmental and physical activity characteristics. Providing environmental conditions are conducive to adaptation, the duration and intensity of outdoor physical activity, along with the timing of exposures, can influence seasonal heat acclimatisation. Future research should ensure the documentation of these factors to allow for a better charactersation of seasonal heat acclimatisation.

### HEAT ACCLIMATION/ACCLIMATIZATION AND ASSOCIATED NUTRITION PRACTICES: A SURVEY TO DETERMINE PRACTITIONER AND ELITE ATHLETE KNOWLEDGE AND USE (SHOULD WE BE CONCERNED?).

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INTRODUCTION: Heat acclimation/acclimatization (HA) is the principal and most effective intervention to protect athletes from heat-mediated performance decrements and provide some protection against heat illnesses when exercise is performed in thermally challenging environments. That said, relatively little is known regarding how centuries worth of data in these regards, penetrates the knowledge and practice of elite athletes and practitioners. With the ever-increasing globalization of sport on a consistently warming planet, elite sport, including mega events, are increasingly held in such thermally challenging environments (e.g., Tokyo 2020ne). Thus, practitioners and their athletes alongside policy makers have a responsibility to prepare their athletes appropriately and educate their members, respectively. Additionally, the events themselves require diligent infrastructural and logistical preparation to deliver evidence-informed performance-facing support and potentially life-saving medical services. Therefore, the purpose was to survey elite athletes and practitioners to identify: (i) knowledge and application of heat acclimation/acclimatization (HA) interventions; (ii) barriers to HA application; and (iii) nutritional practices supporting HA.
METHODS: Practitioners (99) and elite athletes (55) completed an online survey. Pearson's Chi-square [ES; Phi] and logistic regression determined relationships. Differences between ROLE (athletes vs. practitioners) and CLIMATE (hot vs. temperate) were determined by Mann Whitney-U tests [effect size (ES; r)].
RESULTS: Practitioners were more likely to report measuring athletes' core temperature (Tc) [training: practitioners 40% (athletes 15%); $p=0.001$, Odds Ratio (OR) = 4.0, 95% Confidence Interval (CI) 2 to 9%; competition: practitioners 25% (athletes 9%); $p=0.020$, OR=3.4, 95% CI 1 to 10%]. Practitioners [55% (15% athletes)] were more likely to perceive rectal as the gold standard Tc measurement-site ($p=0.013$, phi=0.49, medium ES). Temperate [57% (22% hot)] CLIMATE dwellers ranked active heat acclimatization effectiveness higher ($p<0.001$, r=0.30, medium ES). Practitioners commonly identified athlete's preference (48%), accessibility and cost (both 47%) as barriers to HA. Increasing carbohydrate (CHO) intake when training in the heat was more likely recommended by practitioners (49%) than adopted by athletes (26%; $p=0.006$, 95% CI 0.1 to 1%). Practitioners [56% (28% athletes)] were more likely to plan athletes' daily fluid strategies, adopting a pre-planned approach ($p=0.001$, 95% CI 0.1 to 1%).
CONCLUSION: Practitioners and to a greater extent athlete's lacked self-reported key HA knowledge (e.g. Tc assessment/monitoring methods) yet demonstrated comparatively more appropriate nutritional practices (e.g. hydration). Concerningly, reported data included biologi-

cally implausible values and assertions, emphasizing the need for palatable educational resources from policy makers and/or stakeholders for their members.

**IMPACT OF ACUTE AND PROLONGED COOLING ON SKELETAL MUSCLE FORCE IN YOUNG MALES**

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INTRODUCTION: In athletes, exposure to cold during winter sports may impair physical performance. Severe muscle cooling appears to reduce maximal force and induces a shift towards a slower contractile profile. However, whether moderate muscle cooling and the duration of cooling affect muscle contractile profile (assessed from electrically evoked torque at low and high frequencies) and maximal voluntary force (isometric and isokinetic contractions) remains to be clarified. Therefore, the aim of this study was to investigate the impact of acute and prolonged cooling on electrically evoked torque and maximal voluntary contraction torque in young males.
METHODS: Twelve active males (27.2 ± 6.6 years old) were recruited for this study, consisting of 2 phases: acute and prolonged exposures. During each phase, participants were randomly exposed to cold water immersion (CWI, 10°C, up to the iliac crest) or passive resting (PR). Exposure to CWI was either continuous during 45min (acute CWI, A-CWI) or intermittent during a period of 300min [prolonged CWI (P-CWI) including immersions between baseline to 45min, 165 to 180min, and 255 to 270min]. Muscle (Tmu, average across 1, 2 and 3cm depth) and rectal (Trec) temperatures were assessed using thermo-sensors. Transcutaneous electrical stimulation of the quadriceps muscle was performed to determine torques at low (20 Hz: P20) and high (100 Hz: P100) frequencies, and P20/P100 ratio was calculated. Maximal voluntary isometric torque of the knee extensors (MVIC), as well as peak isokinetic torques (90°/s) of knee extensors (KE-IsoC) and flexors (KF-isoC) were determined. Neuromuscular tests were performed at baseline (BL) and 60min after BL during acute exposure, and at BL, 60, 90, 150 and 300min after BL during prolonged exposure.
RESULTS: Trec did not change after A-CWI while it was reduced (0.8 ± 0.4°C, $p<0.001$) after P-CWI compared to BL. Tmu decreased during A-CWI and P-CWI compared to BL (6.1 ± 2.2°C and 4.6 ± 1.1°C, respectively, $p<0.001$), with larger reduction of Tmu after A-CWI than P-CWI ($p<0.05$). P20 was not affected by the conditions. P100 was lower after 60min in A-CWI and P-CWI compared to PR ($p<0.05$). After the last bath (60min in A-CWI and 300min in P-CWI), P100 was nearly significantly higher in A-CWI than P-CWI ($p=0.05$). P20/P100 was higher after 60min in A-CWI and P-CWI compared to PR ($p<0.001$), but this ratio was lower in P-CWI than A-CWI after the last bath ($p<0.05$). MVIC torque remained unchanged during A-CWI and P-CWI, while KE-IsoC and KF-IsoC torques were similarly reduced after A-CWI and P-CWI compared to PR ($p<0.05$).
CONCLUSION: Moderate muscle cooling preferentially impairs maximal force production of dynamic contractions, but not isometric contractions, regardless of exposure duration. A shift towards a slower contractile profile (i.e., increased P20/P100) is more evident after A-CWI than P-CWI, which may be partially explained by a larger reduction of Tmu rather than the exposure duration or reduced Trec.

**FACTORS CONTRIBUTING TO THE CHANGE IN THERMONEUTRAL MAXIMAL OXYGEN CONSUMPTION AFTER FIXED-INTENSITY HEAT ACCLIMATION OF VARYING INTENSITY, VOLUME AND THERMAL LOAD**

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INTRODUCTION: Performing heat acclimation has been reported to improve exercise capacity and maximal oxygen consumption (VO2max) when measured in a thermoneutral environment. However, there are various ways to administer exercise training and heat acclimation programmes, including the number of days, ambient temperature or humidity and exercise intensity; however, there is limited guidance on which combination of factors maximises the training response. Likewise, it is unclear whether participants' responses to the programme explains their adaptation capacity. The aim of this study was to evaluate factors explaining variance in thermoneutral VO2max adaptation to training in a hot environment, with consideration of training programme parameters, individual biophysical variables and responses to training.
METHODS: Seventy-one participants from a range of training backgrounds, consented to perform fixed-intensity training (range: 45% - 55% VO2max) in a controlled thermal chamber (range: 30°C - 38°C; 20% - 60% relative humidity) on consecutive days (range: 5 days -15 days) for between 50-min and-90 min. The range of conditions provided variation in training and thermal stimuli. The participants were evaluated for their thermoneutral VO2max in the preceding 72-h and re-assessed between 24-h and 96-h after. The change in resting plasma volume was assessed across the training period. Participants' sweat rate, heart rate, core temperature, perceived exertion and thermal comfort were measured throughout all sessions, and the percentage change in these responses across the programme was also determined as an indication of adaptation. Partial least squares regression was used to explain variance in the percentage change in VO2max across the programme using 24 latent variables. The number of components that minimised the root mean squared error of prediction (RMSEP) and explained the greatest variance (R2) in VO2max change, based on cross-validation analysis was used in the final PLSR model. The contribution of each latent variable to the overall model was calculated by applying the Jack-knife function.
RESULTS: Sixty-three percent of the participants increased VO2max more than the typical error of the test with a mean improvement of 2.6 +/- 7.9%. The final model contained five components, explaining 75% of the variance in VO2max change. The variables significantly contributing to the overall model were: average core temperature (beta = 2.05, P = 0.022), relative change in perceived exertion (beta = 1.06, P = 0.044) and the number of days post-testing (beta = 2.84, P = 0.017).
CONCLUSION: Within the range of programme parameters evaluated, training at a fixed-intensity in artificial heat increases (63% of the time) thermoneutral VO2max, with the average core temperature, the reduction in perceived exertion across the programme and the number of days between the final training day and post-testing providing the greatest contributions.

**THE EFFECTS OF WEARING A CHANGE ROBE GARMENT AFTER COLD WATER IMMERSION ON PHYSIOLOGICAL AND PERCEPTUAL RESPONSES**

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INTRODUCTION: Open water swimming often takes place in cold water, with this exposure potentially leading to a phenomenon known as post-immersion afterdrop, where there is a continued drop in core body temperature during the rewarming phase. Recommendations for rewarming include consuming a hot drink, relocating to a warmer environment and changing into appropriate clothing. A Dryrobe® is a commercially available clothing garment primarily designed for individuals rewarming after cold water immersion, although scientific

studies have yet to test this product. The aim of the study was to investigate the effects of wearing a change robe garment after cold water immersion on physiological and perceptual responses.
METHODS: Unhabituated healthy male participants (n=15) were recruited (only data from participants who have completed all conditions n=6 is presented in this abstract). A randomised repeated-measures design was used, with participants assigned to wearing a Dryrobe®, towel, or foil space blanket. Core body temperature was measured using an ingestible telemetric pill and skin temperature using wireless iButtons. Thermal sensation (1-7 Likert) and comfort (1-4 Likert) were measured using standardised ASHRAE scales. Baseline data (10-min) was recorded before participants were immersed in cold water (14oC) for 30-min. Once participants exited the water they were then provided with either a Dryrobe®, a towel, or a foil space blanket. To simulate the conditions following open water swimming participants were then positioned in front of fans to replicate wind speed (10 mph) for 15-min. All data was collected in standardised environmental conditions (12oC, 35% RH).
RESULTS: Core body temperature had the smallest afterdrop between 0 and 15-min post immersion in the Dryrobe® condition (37.04 (0.43) vs. 36.97 (0.46)oC; -0.07 (0.19)oC) compared to the towel (-0.17 (0.27)oC) and foil space blanket (-0.11 (0.21)oC). Skin temperature increased the greatest between 0 and 15-min post immersion in the Dryrobe® condition (15.5 (0.6) vs. 18.7 (1.2)oC; 3.2 (1.0)oC) compared to the towel (1.1 (1.3)oC) and foil space blanket (2.5 (1.2)oC). After 15-min positioned in front of the fans post immersion, participants rated their thermal sensation score higher in the Dryrobe® (3.3 (0.8) AU) compared to the towel (1.5 (0.5 AU) and foil space blanket (1.5 (0.8) AU). Thermal comfort was also rated higher in the Dryrobe® (3.5 (0.5) AU) compared to the towel (1.8 (0.8 AU) and foil space blanket (2.2 (0.8) AU).
CONCLUSION: In these data, the Dryrobe® condition had the smallest afterdrop in core body temperature and the largest increase in skin temperature following cold water immersion compared to a towel and a foil space blanket. Thermal sensation and thermal comfort were also rated higher in the Dryrobe® condition. From this initial data, it appears that it would be advantageous to wear a change robe garment such as the Dryrobe® following cold water immersion, although further data is required to substantiate this.

## Oral presentations

### OP-BM06 Biomechanics and sprinting

#### SPRINT ACCELERATION FORCE-VELOCITY PROFILE DERIVED FROM GPS DATA: A MULTI-DEVICE COMPARISON STUDY

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INTRODUCTION: Global Positioning System (GPS) is a useful device to analyse high-intensity training and competition demands in many sports (Cummins et al., 2013), and may be used to derive macroscopic sprint mechanical components based on velocity data over time and Newtonian laws of motion. Indeed, a simple field method has recently been validated to compute ground reaction force and running velocity outputs during sprint acceleration from kinematic data (Samozino et al., 2016; Morin et al., 2019). The aim of the present study was to determine the accuracy and reliability of GPS to compute the force-velocity sprint profile on a 40-m linear sprint, in comparison to other field devices that had been previously used to perform this analysis.
METHODS: Eighteen participants performed 3 sprints on a 40-m outdoor track, with a 3-point start. A laser (Muscle Lab; 1000 Hz), 1080 Sprint (1080 motion; 333 Hz), Radar (Stalker Pro II; 48 Hz), timing gates (Witty Microgate; 0, 5, 10, 15, 20, 30, 40 m) and a GPS unit (Catapult Vector S7; 10 Hz) were used to record running velocity during each sprint. Force-velocity profiles for the 2 best trials were computed for the 5 devices from the method proposed by Samozino et al. Maximal velocity (Vmax), Tau, theoretical maximal velocity (V0) and horizontal component of the ground reaction force (F0) were calculated. For velocity recording devices, data retained for analysis ranged between 0.5 m.s-1 and the last velocity point of the Vmax plateau. Mean, standard error and absolute bias were computed on the main variables to compare data between the different devices and more especially between GPS and the 1080 Sprint, considered as a 'silver standard'. Coefficients of variation (CV) were calculated for each variable between the 2 best trials to assess reliability.
RESULTS: Vmax was close between 1080 Sprint (8.02±1.20 m.s-1), Laser (8.00±1.15), Radar (8.00±1.15), timing gates (8.04±1.15) and GPS (8.01±1.18). However, Tau showed larger differences between 1080 Sprint (1.22±0.12 s), Laser (1.18±0.12), Radar (1.24±0.12), timing gates (1.25±0.11) and GPS (1.29±0.16). While GPS Vmax remained close to 1080 Sprint with a standard error of -0.006±0.085 m.s-1 (CI: -0.210 ; 0.188) and an absolute bias of 0.98± 0.78%, GPS Tau was higher compared to 1080 Sprint with 0.067±0.128 s (CI: -0.184 ; 0.319) and 9.55±7.50%, respectively. The following inter-trial CVs were obtained across the five devices for Vmax and Tau, respectively: 1080 Sprint (15.0%; 9.4%), Laser (14.3%; 9.8%), Radar (14.4%; 9.4%), timing gates (14.3%; 8.9%) and GPS (14.7%; 12.2%).
CONCLUSION: Given the inter-device and inter-trial differences observed, the GPS system tested here can be considered a relevant system to compute force-velocity sprint profile using Samozino et al.'s validated approach. However, data interpretations should be context- and device-dependant. These results suggest several practical applications such as regular analysis of the sprint mechanical profile in prevention or injury management.

#### CONCURRENT VALIDITY OF AN INERTIAL MEASUREMENT SYSTEM TO DETERMINE SPRINTING CENTER OF MASS VELOCITY AND FORCE-VELOCITY-POWER PROFILES IN WELL TRAINED SPRINTERS

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INTRODUCTION: The use of inertial measurement systems (IMS) to perform on-field kinematic analysis of sports activities has gained interest over the past decade. IMS have shown good concurrent validity for whole body 3D kinematic analysis in comparison to optoelectronic systems (OS) for different activities and high-velocity sport disciplines [1, 2, 3]. A recent comparison of the force-velocity-power profiles (FVP) mechanical variables computed from the center of mass (COM) velocity-time curve using an IMS and the athlete's velocity measured with a radar [4] found good agreement between both systems for the theoretical maximal force, the theoretical maximal velocity and the associated maximal power output. However, radars measure the velocity of all moving objects within their scope, not specifically the COM velocity. Therefore, the comparison of the COM velocity between IMS and force platforms (FP) has not yet been done.

METHODS: Nineteen (15 male and 4 female) sprinters (mean ± SD: age = 23.9 ± 3.7 years; body mass = 73.9 ± 7.4 kg; height = 178.8 ± 7.0 cm) performed 5 straight-line sprints (10, 15, 20, 30 & 40 m) during which COM velocity was measured with both an IMS (MVN Biomech Link device, Xsens Technologies BV, Enschede, The Netherlands) sampling at 240 Hz and 6 FP connected in-series (1.2 x 0.6 m, KI 9067; Kistler, Wintherthu, Switzerland) sampling at 1 000 Hz and embedded within the track. Averaged step-by-step and maximal COM velocity for each sprint, as well as the FVP relationships and the associated mechanical variables already presented by Samozino et al. [5] over a reconstructed 40-m sprint were computed with both systems and compared using Pearson's correlations coefficient as well as bias and limits of agreements.
RESULTS: Mean IMS step-by-step velocities were very highly to almost perfectly correlated with those calculated from FP data ($0.897 < r < 0.983$; $p < 0.001$), and mean bias was low (between -4.87 to -0.61% for the different intervals). Correlations for FVP mechanical variables between the IMS and FPs ranged from moderate to almost perfect ($0.609 < r < 0.989$; $0.01 < p < 0.001$) with mean bias comprised between -5.43 to 0.97% for all FVP variables.
CONCLUSION: The present findings showed good to excellent concurrent validity between data from an IMS and FPs for the computation of the COM velocity-time curves and the FVP mechanical variables computed from the reconstructed 40-m sprint. Together with studies that demonstrated the validity of IMS data for the computation of 3D kinematics in various high-velocity movements, these results show that IMSs can be used to compute on-field 3D joints' and segments' kinematics as well as COM velocity-time curves and FVP either indoors or outdoors.
1) Robert-Lachaine et al. (2017)
2) Blair et al. (2018)
3) Pedro et al. (2021)
4) Slawinski et al. (2020)
5) Samozino et al. (2016)

**RELATIONSHIPS BETWEEN STARTING BLOCK PERFORMANCE AND DYNAMIC STRENGTH INDEX IN ELITE SPRINTERS**

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INTRODUCTION: In short sprinting events like 100m race, performance at the starting block (SB) phase has a critical importance to the final outcome. Among different variables mentioned as critical of SB performance, normalized average horizontal power (NAHP) was identified as the most appropriate measure of performance [1]. This indicates that the athletes ability to produce horizontal power (HP) in a short period of time is a decisive factor in this phase of race. Thus, it is of great interest for strength and conditioning coaches who work with sprinters to understand the associations between athletes SB and their lower limbs strength and power qualities.
We aim to understand the relationship between SB performance of elite male sprinters and their lower-body dynamic strength index (DSI).
METHODS: Eleven male elite sprinters, (age 23.5 ± 2.9 years; height 1.82 ± 0.04m; body mass 76.8 ± 5.9kg; 100m PB, 10.56 ± 0.27s), performed 3 maximal 10m sprints start on an indoor track, from instrumented SB (Kistler Instruments AG. Winterthur. Switzerland), sampling at 1000 Hz. Block performance was quantified trough NAHP as described by Bezodis et al. [1], where the HP was averaged over the duration of the block phase and normalized to sprinters' body mass and leg length. The best NAHP obtained over 3 trials were used for analysis. To determine DSI, all sprinters performed 3 trials of isometric mid-thigh pulls (IMTP) (isometric task) and countermovement jumps (CMJ) (dynamic task) on a homemade force platform (Shear Beam Load Cells - Flintec BK2) and connected to an A/D converter (MP100 – Biopac Systems Inc. 16 bits) with a sampling rate of 1000 Hz. Best trails were used for analysis. Vertical ground reaction peak force (PF) attained during CMJ was divided by the PF attained in the IMTP to obtain the DSI, as described by Comfort et al [2]. Pearson's correlation coefficients (r) were used to test the relationship between dependent variables. A statistical significance was set at $\alpha = 0.05$.
RESULTS: NAHP was correlated with the block velocity ($r = 0.60$; $P = 0.03$). Furthermore, a very large significant correlation was identified between the NAHP and DSI ($r = 0.85$). A very large significant correlation was also observed between NAHP and CMJ force ($r = 0.86$). No significant associations were observed between NAHP and IMTP force ($r = -0.26$; $P = 0.220$).
CONCLUSION: The main conclusion was that NAHP has strong associations with muscle power indicators, measured through CMJ and DSI. These results indicated that DSI and CMJ can be used as indicators of SB performance, in elite male sprinters. These results also highlighted the importance of high-power capacities for a successful sprint start. Thus, the sprinters' strength and power qualities regularly monitored through DSI are very important and determinant to individualize strength-training programs and optimize training stimulus for overall performance improvement.
[1] https://doi.org/10.1080/14763141.2010.538713
[2] https://doi.org/10.1123/ijspp.2017-0255

**EFFICIENCY AND KINEMATIC ANALYSIS OF INITIAL STEP PATTERNS FOR MULTIDIRECTIONAL ACCELERATION IN TEAM AND RACQUET SPORTS**

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INTRODUCTION: The ability for quick multidirectional accelerations over short distances is crucial for athletic performance in team and racquet sports (Northeast et al., 2019; Taylor et al., 2017). So far, there is only few research dedicated to the different initial step patterns usually applied by players. Therefore, the present study investigated the kinematic characteristics and efficiency of the step patterns, Jab Step (JS), Pivot Step (PS), Gravity Step (GS) and Counter Step (CS).
METHODS: Twenty-two male competitive team and racquet sport athletes (age: 22.1 ± 2.7 years; height: 185.9 ± 7.3 cm; body mass: 84.1 ± 9.9 kg) completed maximum lateral accelerations (90° to the start position) utilizing four different initial step patterns (JS, PS, GS, CS). The step patterns were trained in a familiarization session until reaching a performance plateau (2.5% deviation of three successive sprints, relative to the fastest attempt). On one experimental day for each of the four step patterns, three 5m sprints into both directions (left & right) in response to a visual stimulus were completed. Sprint times (5 m) and the translation of the center of mass (CoM) as well as joint angles of the hip, knee and ankle joints from movement initiation were obtained using three-dimensional motion analysis (Vicon). The sequence of the four step patterns was matched in a counterbalanced order. Resting time was 30s between sprints followed by a 3 min rest after three trials.
RESULTS: The 5 m sprint times of the CS were significantly faster compared to GS and PS for both directions ($p<0.01$). A detailed distance-time analysis revealed that for shorter distances (<100 cm) only the JS was faster than the GS ($p<0.01$) while no advantage for CS compared

to any other step pattern remained. Regarding the sequence in which the maximum angular velocities in the hip, knee, and ankle were reached during push off, there was a proximal-to-distal sequence for JS and CS, while the hip reached its maximum angular velocity before the knee for GS and PS.
CONCLUSION: The results reveal that the JS and the CS are superior for accelerations towards the lateral. Specifically, they indicate that the JS is more suitable for covering very short distances and the CS is superior for covering further distances. In addition, the distal-to-proximal sequence of the maximum angular velocities during push-off in the GS and the PS might indicate a lower kinematic efficiency.
[1] Northeast, J., Russell, M., Shearer, D., Cook, C. J., & Kilduff, L. P. (2019). Predictors of Linear and Multidirectional Acceleration in Elite Soccer Players. Journal of Strength and Conditioning Research, 33(2), 514–522.
[2] Taylor, J. B., Wright, A. A., Dischiavi, S. L., Townsend, M. A., & Marmon, A. R. (2017). Activity Demands During Multi-Directional Team Sports: A Systematic Review. Sports Medicine (Auckland, N.Z.), 47(12), 2533–2551.

## THE EFFECT OF HIP EXTENSION VELOCITY ON THE ASSOCIATION BETWEEN HIP EXTENSION TORQUE AND SPRINT HORIZONTAL FORCE IN ELITE ATHLETES

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INTRODUCTION: Hip extensors have a major contribution to sprint running propulsion in the early stance phase when glutes and hamstrings shorten at high velocities (1). Considering the difficulties to perform isokinetic testing of this muscle group, hip extensors are typically tested in isometric conditions, which may not reflect the role of hip extensors in sprinting. The aim of this study was to 1) develop a protocol for testing hip extensors in isometric and concentric conditions, and 2) examine the association between hip extension torque measured at different velocities and sprint horizontal force in elite athletes.
METHODS: A total of 82 elite athletes from sprint-based sports (track and field, rugby 7) participated in this two-part study. In Part 1, 13 sprinters/hurdlers performed maximal isometric (50 deg hip flexion) and concentric hip extensions on a dynamometer at four velocities (60, 120, 180, and 350 deg/s) with their dominant leg, in supine position. Contractions were performed with knee flexed to 30 deg (externally fixed), as well as without fixing the knee but asking the athletes to keep it at ~90 deg flexed position. Torque and dynamometer position, and 3-D displacements of reflective markers were recorded. A custom model was used to calculate hip angles, which was used to define relevant dynamometer positions. Differences and correlation between torque in extended and flexed knee positions were calculated. In Part 2, 69 athletes performed isometric and concentric hip extensions (60 and 350 deg/s) without fixing the knee while torque and dynamometer position were recorded. Torque in each condition was analysed over the range of motion defined in Part 1, and was related to the maximal horizontal force in sprinting as measured using a radar during 40m acceleration sprints.
RESULTS: Based on kinematic analysis, dynamometer range of motion of interest was 50 to 0 deg, over which torque was analysed in all conditions. In Part 1, hip extension torque was 29 to 42% higher in the relatively more extended knee position than in relatively more flexed knee position at all velocities ($p<0.01$). The torque measured in the two knee positions significantly correlated in all conditions ($r=0.62$ to 0.89, $p < 0.025$), with the weakest correlation at 350 deg/s. In Part 2, isometric and concentric torque at 60 deg/sec significantly correlated to horizontal force in sprinting ($r=0.53$, $p<0.01$, and $r = 0.48$, $p<0.01$, respectively), however, this association was not significant at 350 deg/s ($r=0.22$, $p=0.06$).
CONCLUSION: In isometric and at slow concentric contractions, evaluating hip extension torque in ~90 deg flexed knee position provides valuable information for elite athletes from sprint-based sports. However, at high velocity, hip extensors should be tested in a relatively extended knee position.
REFERENCES
1) Chumanov et al., Med Sci Sports Exer, 2011

## NEUROMUSCULAR AND AUTONOMIC RECOVERY AFTER A SINGLE SPRINT INTERVAL SESSION

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INTRODUCTION: Sprint Interval Training (SIT) is known to be a very effective approach for improving both the anaerobic and anaerobic pathways in very short periods of time (1). However, since high-intensity exercise creates a large accumulation of physiological stress, the time required to fully recover after a SIT session needs to be considered for practitioners and coaches aiming to optimize training prescription. Previous works have reported impaired performance and delays in recovery of up to 24 to 72h for the neuromuscular system (2) and up to 48h for the cardiac parasympathetic reactivation (3). The aim of this study was to determine whether the neuromuscular and autonomic nervous systems would be impaired 24 and 48 hours after a single session of SIT.
METHODS: 21 healthy and recreationally active subjects (8 females) performed an 8x15s all-out session on a cycle ergometer with two minutes of recovery between repetitions after a familiarization session comprising 3x15s all-out sprints the week before. Blood lactate concentration ([LA−]b) was measured 3 minutes after the last sprint. A complete neuromuscular evaluation during both isometric and dynamic conditions was performed before (PRE), 24 (POST24h) and 48h (POST48h) after the session. Knee extensor maximal voluntary contraction (MVC), voluntary activation (VA), high- and low-frequency doublets (Db100 and Db10) as well as maximal force, velocity and power during two 7s sprint on cycle ergometer at two different loads were analyzed. Additionally, participants were asked to record their heart rate the previous and the three subsequent nights to the session to assess heart rate variability (HRV).
RESULTS: [LA−]b was 13.4 ± 2.5 mM after the session. No significant impairment at POST24h and POST48h was observed for the MVC ($p = 0.24$), Db10:Db100 ratio ($p = 0.15$) nor VA ($p = 0.08$). From a dynamic standpoint, no impairment was observed at POST24h and POST48h for maximal force ($p = 0.11$), velocity ($p = 0.88$) or power ($p = 0.63$). Finally, HRV did not reveal any significant changes the nights following the SIT session (rMMSD; $p = 0.17$).
CONCLUSION: In conclusion, despite of the great physiological stress accumulation, a single session of SIT did not induce significant fatiguing effects in either the neuromuscular or on the autonomic nervous system from 24h after its completion.
Key words: sprint interval training, neuromuscular fatigue, recovery, heart rate variability
References
1. Ross A, Leveritt M. Long-Term Metabolic and Skeletal Muscle Adaptations to Short-Sprint Training: Implications for Sprint Training and Tapering. Sports Med. 2001;31(15):1063–82.

2. Skorski S, Mujika I, Bosquet L, Meeusen R, Coutts AJ, Meyer T. The Temporal Relationship Between Exercise, Recovery Processes, and Changes in Performance. Int J Sports Physiol Perform. 2019 Sep 1;14(8):1015–21.
3. Stanley J, Peake JM, Buchheit M. Cardiac parasympathetic reactivation following exercise: implications for training prescription. Sports Med. 2013 Dec;43(12):1259–77.

# Oral presentations

## OP-MH08 Injury Prevention

### ATHLETES' PROTECTION FROM CONCUSSION IN DIFFERENT OLYMPIC COMBAT SPORTS. LET'S START FROM THE RULES

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INTRODUCTION: In the past decade, sports-related concussions have drawn considerable attention from the public, the media, and sports medicine professionals. Epidemiological reports provide convincing evidence that numerous concussions occur at all levels of sport activity, but little is known about the differences in the level of protection that rules offer to the athletes in different sports, especially in those where risks are higher, as combat sports.
METHODS: A revision of the rules of the different Olympic combat sports (boxing, taekwondo, judo, wrestling, fencing and karate)was done, in order to compare the level of protection (in trms of protective equipement, level of impact allowed, umpires decisions in case of a concussion, and protective time to return to sports after a concussion) both in adults and in adolescent athletes.
RESULTS: Only two sports (boxing and taekwondo) allow concussion as a way to victory in a match, both in adults and in athletes over 16 years of age. Competition rules in karate restrain impact force in younger athletes to that which would no represent a significant energy transfer to the head of the athlete (i.e.: no displacement when receiving the hit). Protection period after a concussion ranges from 7 days in Judo to 30 days in boxing and Taekwondo, although only karate rules impose a longer period after a second concussion (3 months) and even longer after a third one (one year). Helmets are used in boxing for females and for under 18 year old boxers; they are used in taekwondo through all ages, as they are instrumented with contact sensors, as they are in fencing. Protection gloves are quite different in boxing, karate and taekwondo, both in size and weight. Rules in taekwondo and karate give extra points to hits in the head area compared to the body
CONCLUSION: In light of the obvious differences among the different combat sports, it is not possible to unify criteria regarding protective equipement, but probably a more uniform joint effort to establish protection criteria regarding time to return to sport should be set. Also, the fact that the head offers a higher score in karate and taekwondo, and that the goal of redeeming an oponent out of combat is clearly easier in boxing through head impacts than through body punches, clearly encourages using the head as target and increases the risk of concussions.

### FOAM-ROLLING AND NEUROMUSCULAR EXERCISES AS INTERVENTION TO PREVENT THE OCCURRENCE OF RUNNING-RELATED INJURIES IN RECREATIONAL RUNNING.

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INTRODUCTION: Recent years have seen an increasing interest in research on the prevention of running-related injuries (RRIs). Interventions including, but not limited to, running training programs, running shoes, and foot muscle strength with varying effectiveness have been conducted (1, 2, 3). Some factors such as improved muscular strength, proprioceptive balance, and flexibility are pointed out as possible mechanisms in an injury prevention program. Conditioning exercises such as neuromuscular control and foam rolling exercises have been suggested to improve these factors. However, the effectiveness of a program consisting of neuromuscular control and foam-rolling exercises in combination has not yet been evaluated. Therefore, the aim of this study was to compare the cumulative injury incidence proportion (CIP) of RRIs between runners who received an injury prevention program with runners who did not receive a program, over the course of 18 weeks.
METHODS: We invited 433 recreational runners (n=203 female) to participate in the study. The intervention group (n=228) performed neuromuscular control and foam-rolling exercises twice a week for 18 weeks. The control group (n=205) received no treatment. Running volume and running-related pain were reported weekly using an online questionnaire. Compliance with the intervention program was defined according to the number of sessions (low=<18, intermediate=18-31, high=32-40). Time-to-event statistics were used to calculate the CIP at 18 weeks for both groups respectively, as well as for each intervention subgroup with regard to compliance.
RESULTS: The CIP for the intervention group was 23.0% (95%CI=17.8-29.4) and 27.1% (95%CI=21.4-33.9) for the control group. The CIP for intervention subgroups were 43.2% (95%CI=32.8-55.4), 16.0% (95%CI=9.0-27.8), 4.6 (95%CI=1.5-13.6) for the low, intermediate, and high group, respectively. In total, 100 RRIs were sustained.
CONCLUSION: Although no difference between the intervention group and the control group was observed, runners with higher compliance with the intervention were less likely to sustain an RRI compared with the control group. Therefore, despite the program was not effective in reducing the occurrence of RRIs on a group level, it may be beneficial for certain types of runners or beneficial if a certain dose (e.g. at least twice a week) is implemented.
REFERENCES:
1. Fokkema, de Vos, Van Ochten, Verhaar, … & van Middelkoop. (2019). Online multifactorial prevention programme has no effect on the number of running-related injuries: a randomised controlled trial. BJSM, 53(23), 1479-1485.
2. Nielsen, Bertelsen, Ramskov, Damsted, … & Malisoux. (2020). Randomised controlled trials (RCTs) in sports injury research: authors—please report the compliance with the intervention. BJSM, 54(1), 51-57.
3. Taddei, Matias, Duarte, & Sacco. (2020). Foot core training to prevent running-related injuries: a survival analysis of a single-blind, randomized controlled trial. Am J Sports Med, 48(14), 3610-3619.

### PHYSICAL LITERACY FOR SPORT INJURY PREVENTION – BUILDING THE BASE FOR ATHLETE DEVELOPMENT

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INTRODUCTION: Participation in sport and recreation is a common mechanism for physical activity (PA) among youth. Decades of scientific literature documents participation in sport and PA resulting in positive health outcomes. Despite some literature supporting a relative decline in the number of youth participating in PA generally, studies suggest that over 80% of Canadian youth participate in at least one organized sport, annually. However, the landscape of sport participation in youth in Canada is changing. Increasingly, we note that there are two ends to the sport participation spectrum, one where athletes participate in intense amounts of PA and experience more frequent training, compared to youth at the other end who are less physically active, have low muscular strength and mastery of skills. This dichotomy paints a bleak picture for the physical literacy and overall health in youth, including the athletes that will form the base of athletic programs in the future. Further, and most importantly, literature supports an increase in the risk of sport-related injury at both ends of the spectrum.
The objective of this work was to highlight the similarities in physical literacy (PL) and sport injury prevention programming for athlete development, to develop a resource that supports the work of athlete development across sectors, and to discuss opportunities for collaboration for athlete development that includes injury prevention, across the athlete lifespan.
METHODS: Practitioners in both elite and recreational sport requested an accessible resource to support both athlete development and injury prevention. An on-line resource that provides evidence-informed injury prevention strategies using an integrated knowledge translation approach was co-created. A framework was used to guide a literature review of over 50 sport and recreational activities, across outcomes consistent with the public health approach to prevention. Key to the process of resource development was engagement with a team of stakeholders including athletes, coaches, and experts in physical literacy, injury prevention and public health.
RESULTS: The resource presents summaries of evidence on prevalence and risk factors, as well as effective interventions for sport injury that can be used across sporting activities. The resource presents both the scientific literature as well as resources that support the critical components of both physical literacy and sport injury prevention programming for youth, including neuromuscular training (NMT).
CONCLUSION: Active & Safe Central (www.activesafe.ca) is a resource that addresses an identified gap in access to evidence and resources for athlete development. The resource emphasizes the priority for both physical literacy and NMT for athlete development that includes sport injury prevention at an early age. Further, collaboration across sectors including education, elite and recreational sport, and public health is critical for a comprehensive approach to healthy athlete development.

### THE IDENTIFICATION OF PRIORITY TOPICS FOR RESEARCH AND COCHRANE REVIEWS ON INTERVENTIONS DESIGNED TO PREVENT SPORTS INJURIES: A THREE-PHASE INTERNATIONAL CONSENSUS PROJECT

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INTRODUCTION: Injury prevention is important for sustaining a physically active lifestyle, and to help maximise health and societal benefits. For the best use of research funding, time and efforts, it is important to identify research priority topics using formal mixed methods that involve researchers and end-users of research. Such approaches are rare in exercise science. In collaboration with the Cochrane Bone, Joint and Muscle Trauma Group, we conducted a three-phase project aiming to identify priority topics for Cochrane Reviews and primary research of interventions used to prevent lower and upper limb sports injuries in adults.
METHODS: After a rigorous formulation and piloting process, online surveys were completed by 357 sports participants (aged 16-84 years) from 29 countries, and by 227 people (aged 16-69 years) from 27 countries in roles that supported sports participants. Posed questions related to employed injury prevention strategies, reasons for use, potential drawbacks and future research topics. Recruitment was completed via social media outlets. For the subsequent three-round electronic Delphi study, a panel of 28 expert researchers were recruited by purposeful sampling with set criteria, e.g., publication records. In the first round, participants were asked to state in their opinion, the three most important topics for future injury prevention research. In the subsequent rounds, consensus ratings on a 1-9 GRADE scale were obtained to arrive at perceived priorities for future Cochrane Reviews. For each project phase, web-based platforms were used where opinions were collated and synthesised using formal content analysis methods.
RESULTS: Suggested topics were numerous and heterogeneous within, and between, each phase of the project. Sports participants deemed areas relating to individual (personalised) athlete approaches, nutritional interventions, and strength and conditioning interventions to be most important for future research, with 12%, 11% and 11% of total responses relevant to each respective theme. Sports support staff prioritised training load interventions (18%), strength and conditioning interventions (12%) and individual (personalised) athlete approaches (7%) to be priority topics. The response rates for Rounds 1, 2 and 3 of the eDelphi were 89%, 92% and 87%, respectively. The first round identified 74 priority topics. At the end of the final round, 85% of the participant cohort graded training load to be of critical importance (7-9 on the GRADE scale). Additionally, 65% and 60% of the participant cohort deemed neuromuscular training and psychological interventions to be of critical importance.
CONCLUSION: Common priority topics across the first two project phases related to individual athlete (personalised) approaches, nutritional interventions and strength and conditioning interventions. In the eDelphi study, training load interventions, neuromuscular training and psychological interventions were deemed to be the most important by experienced researchers.

### UNDERSTANDING HEAD IMPACT EXPOSURE IN MALE AND FEMALE AMATEUR OLYMPIC BOXERS

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INTRODUCTION: Amateur boxing is a high-intensity intermittent combat sport, which results in the accumulation of sub-concussive head impacts during competition. It has been debated in a number of combat and collisions sports that the result of repetitive head impact exposure is associated with long term neurodegeneration. There is currently a gap in understanding the relationship between head impacts and neurological function due to a lack of quantification of forces that individuals are exposed to in competition. This study aimed to characterize impact exposure and the associated injury metrics of amateur male and female international boxers during an Olympic qualifying competition via an instrumented mouthguard monitoring system.
METHODS: Thirteen amateur international Olympic boxers took part in an Olympic qualifying event (29.8±5.5 yrs, 1.79±0.03 m, 70.5±11.9 kg). Head accelerations were measured using the PROTECHT instrumented mouthguard (IMG) system (Sports & Wellbeing Analytics, UK).

Linear and angular acceleration signals were filtered using a zero-phase lag 4th order Butterworth filter, with a low-pass cut-off frequency of 160 Hz. Head impact accelerations were compared across impact events, rounds, weight class and sex. Impacts were video-verified and classified according to event (jab, hook, movement, overhand and uppercut) and location (head and body). Multi-level linear models compared peak linear acceleration (PLA) and peak rotational acceleration (PRA) head impact values across striking events (jab, hook, movement, overhand and uppercut), rounds (1-3), weight class (light, middle and heavy) and sex (male v female).
RESULTS: IMG data was collected from 15 bouts and 45 rounds. A total of 1542 head impacts were identified and video verified, with mean values of 24.0±12.3 g and 2411±1627 for PLA and PRA. No differences were observed across sex or weight for PLA and PRA values ($p > 0.05$). Significant differences ($p < 0.05$) were observed between linear acceleration for striking events jab and hooks when compared to overhands ($p < 0.05$), but no differences were observed rotationally ($p > 0.05$). Head acceleration impacts recorded in rounds and bouts were 33±16 and 94±44, but no round or bout differences were observed across sex or weight categories ($p > 0.05$).
CONCLUSION: Characterisation of impact exposure identified no differences between male or female athletes or different weight categories. The overhand attributed higher linear intensity values compared with the jab and hook. Though no significant the female cohort and lighter weight cohorts attained greater impact volumes than the male and heavier cohorts, whereas the male and heavier cohorts attained greater striking magnitudes. The results provide the first evidence of head impact exposure of amateur international Olympic boxers in competition.

## Oral presentations

### OP-PN29 Supplements III

#### LOW DIETARY ACID LOAD IS ASSOCIATED WITH LOWER CORTISOL AND LEUKOCYTE RESPONSES TO EXERCISE AFTER A 12-WEEK DIET AND TRAINING INTERVENTION

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INTRODUCTION: Physical exercise is considered a stressor that promotes an acute suppression of the immune system, which can be seen e.g., as an increased number of leukocytes. We investigated acute cortisol and leukocyte responses to endurance and strength training after a 12-week combined endurance and strength training and dietary intervention period.
METHODS: In all, 46 healthy, recreationally active men and women participated in the study and were randomly divided into low dietary acid load (L-DAL) and moderate dietary acid load (M-DAL) groups for 12 weeks. In L-DAL there were 9 men (age 32.0 ± 9.6 yr, body mass index 27.2 ± 3.1 kg/m2) and 13 women (34.3 ± 6.9 yr, 23.0 ± 3.5 kg/m2), and in M-DAL 12 men (31.3 ± 5.1 yr, 25.2 ± 2.1 kg/m2) and 12 women (32.0 ± 5.9 yr, 23.7 ± 3.5 kg/m2). L-DAL was advised to increase the consumption of fruits and vegetables (pre: 340 ± 180 g vs. post: 970 ± 560 g) and M-DAL was advised to limit their intake of fruits and vegetables (pre: 270 ± 180 g vs. post: 250 ± 210 g). The aim was that potential renal acid load (PRAL) of L-DAL was alkalogenic (pre: 7.19 ± 27.6 vs. post: -48.1 ± 34.6 mEq/d), whereas during M-DAL, PRAL was aimed to be acidogenic (pre: -30.4 ± 42.2 vs. post: 4.17 ± 17.3 mEq/d). The participants trained twice a week, and every standardized training session consisted of both endurance and strength training. Participants performed a submaximal cycling test (CT) with three 8 min workloads at 35%, 55% and 75% of their VO2max before (PRE) and after (POST) the intervention. All workloads were separated by 4-min rest periods, during which venous blood samples were collected (CT35, CT55, CT75). On the following 4 days after the cycling test, blood samples were obtained after an endurance training session (ET), a strength training session (ST) and on follow-up days 1 and 2 (F1 and F2).
RESULTS: In L-DAL, cortisol was lower during CT and on F1 at POST as compared to PRE (PRE vs. POST at F1: 348 ± 35 vs. 309 ± 31 nmol/l, $p<0.05$). Furthermore, in L-DAL, the total number of leukocytes was significantly lower during CT, after ET, after ST and on F1 at POST as compared to PRE (PRE vs. POST at CT35: 7.42 ± 1.26 vs. 6.51 ± 1.30, $p<0.01$; CT55: 8.09 ± 1.26 vs. 7.08 ± 1.19, $p<0.01$; CT75: 9.40 ± 1.67 vs. 7.89 ± 1.69, $p<0.01$; ET: 9.52 ± 2.57 vs. 7.99 ± 1.77, $p<0.01$; ST: 9.17 ± 2.14 vs. 7.89 ± 2.87, $p<0.05$; F1: 6.59 ± 1.22 vs. 5.77 ± 1.26 E9/l, $p<0.01$). This was due to a significantly lower neutrophil count in L-DAL during CT, after ET and on F1 at POST as compared to PRE. In M-DAL, lymphocytes were lower during CT and cortisol higher after ET at POST as compared to PRE.
CONCLUSION: The acute cortisol and leukocyte responses to exercise were suppressed after the training period especially in the group of lower dietary acid intake. These results suggest that increased intake of fruits and vegetables may suppress acute exercise-induced stress and immune response, and this effect may be sustained for up to 24 hours post-exercise.

#### THE EFFECTS OF 24-WEEK PREBIOTIC INTERVENTION ON MARKERS OF IMMUNITY AND UPPER RESPIRATORY AND GASTROINTESTINAL SYMPTOMS IN ELITE RUGBY UNION PLAYERS: A PILOT RANDOMISED CONTROLLED TRIAL

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INTRODUCTION: Elite athletes are exposed to physiological and psychological stressors that may impair immunity and increase the risk of upper respiratory (URS) and gastrointestinal symptoms (GIS). Gut microbes have a substantial influence on systemic immune function (Roberfoid et al., 2010). Dietary prebiotic galactooligosaccharides are effective at altering the gut microbiome and have been shown to reduce URS in academically stressed students (Hughes et al., 2011). Whether prebiotics could also reduce URS and GIS in elite athletes is unclear. Therefore, the aim of this study was to investigate the effect of a 24-week prebiotic intervention on markers of immunity and URS and GIS in elite rugby union players during a regular playing season.
METHODS: Thirty-three elite male rugby union players were randomised to receive 2.9 g/d of either Bimuno-galactooligosaccharide (B-GOS; n=16) or a maltodextrin placebo (PLA; n=17) for 24 weeks in a double-blind design. Daily URS and weekly GIS were self-reported using questionnaires. At baseline (B), 12 weeks (12W) and 24 weeks (24W) salivary immunoglobulin A (sIgA) and plasma C-reactive protein (CRP) and tumour necrosis factor alpha (TNF-α) were measured.
RESULTS: There was no between-group difference in URS incidence or severity, but the mean duration of episodes was shorter in B-GOS (7.4 ± 2.8 days) than PLA (9.8 ± 4.1 days) ($P = 0.04$). Area under the curve of weekly GIS scores were lower in B-GOS (Median [IQR], 50 [10.5-139.5]) than PLA (Median [IQR], 149 [69-208]) ($P = 0.03$). The number of symptom free weeks for GIS was higher in B-GOS than PLA ($P = 0.04$). SIgA secretion rate at B and 12W was not different between-groups however, at 24W it was greater in B-GOS (Median [IQR], 142

µg/min [94.9-155.0]) than PLA (Median [IQR], 86 µg/min [71.5-105.5]) (P = 0.01). Plasma CRP and TNF-α did not differ between groups across the study (P > 0.05).
CONCLUSION: Twenty-four weeks of a prebiotic B-GOS intervention reduced the duration of URS, the incidence and severity of GIS and enhanced sIgA secretory rate in elite rugby union players. These findings suggest that B-GOS has the potential to modulate immune function and reduce illness, which may improve an athlete's availability to train and compete.
References
Roberfroid, M., Gibson, G. R., Hoyles, L., McCartney, A. L., Rastall, R., Rowland, I., et al. (2010). Prebiotic effects: Metabolic and health benefits. British Journal of Nutrition, 104(S2), S1-S63.
Hughes, C., Davoodi-Semiromi, Y., Colee, J. C., Culpepper, T., Dahl, W. J., Mai, V., et al. (2011). Galactooligosaccharide supplementation reduces stress-induced gastrointestinal dysfunction and days of cold or flu: A randomized, double-blind, controlled trial in healthy university students. The American Journal of Clinical Nutrition, 93(6), 1305-1311.

## SIGNIFICANT IMPROVEMENTS IN COGNITIVE PERFORMANCE AND WELLBEING WITH A BIFIDOBACTERIUM LONGUM 1714-SERENITAS PROBIOTIC SUPPLEMENT – AN ATHLETE EXPERIENCE PROGRAMME

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INTRODUCTION: Intensive training is associated with changes in the composition of the gut microbiota in athletes. The implications of this may extend beyond physical health, affecting cognitive performance and mental wellbeing via the gut-brain axis [1]. Clinical studies have demonstrated strain-specific cognitive benefits of probiotic supplementation in healthy volunteers, yet real-world data in athletes is limited [1]. This athlete experience programme evaluated cognitive performance and wellbeing outcomes before and after 8 weeks of probiotic supplementation.
METHODS: Athletes volunteered or were referred to the experience programme by their nutritionist and/or coach, to receive a daily probiotic supplement containing Bifidobacterium longum 1714-Serenitas (1x10^9 colony-forming units) and B vitamins, for 8 weeks. Reaction time (Simple Reaction Time test), decision-making (adapted Stroop task), distractibility (adapted Flanker task) and perceived stress (Likert scale) were assessed via the Omics [TM] app at weeks 1, 3, 4, 6 and 8. Perceived sleep quality and energy levels were measured via an online survey prior to starting the programme and at week 9. Data analysis compared the Loading period (weeks 1-4) vs the Observation period (weeks 6-8), including paired samples T-test for cognitive performance data and perceived stress levels. Data are presented as percentage of athletes who improved and average percentage change over time.
RESULTS: 35 athletes completed the programme (75% aged 18-34 years, 25% aged 35-54; 81% male, 19% female; 61% team sports (football, rugby, netball, hockey), 39% individual sports (golf, cycling, athletics)). Significant improvements were observed for reaction time (63% of athletes; 4% average improvement, p=0.008) and decision-making (72% of athletes; 5% average improvement, p=0.006). 43% of athletes reported improvements in distractability, equating to a 3% average improvement, p=0.196 ns). Improvements in perceived stress were reported by 66% of athletes, with a 6% average improvement (p=0.015). Sleep quality and energy levels reportedly improved among 58% and 54% of athletes, respectively. 87% would recommend the 1714-Serenitas supplement to other athletes.
CONCLUSION: These real-world data suggest that supplementation with Bifidobacterium longum 1714-Serenitas was associated with improvements in cognitive performance, stress, sleep quality and energy levels in athletes, among whom marginal gains may significantly impact performance. Similar findings have been observed in pre-clinical and clinical trials of this strain without B vitamins [2,3], suggesting a strain-specific probiotic effect. Further research into the athletic applications of specific probiotic strains and their mode of action is warranted.
REFERENCES:
1. Marttinen M, et al. Nutrients. 2020;12(10):2936.
2. Allen AP, et al. Transl Psychiatry. 2016;6(11):e939.
3. Wang H, et al. Am J Gastroenterol. 2019;114(7):1152-1162.

## THE USE OF TART CHERRY SUPPLEMENTATION BY SPORT SCIENCE PRACTITIONERS, SUB-ELITE AND ELITE ATHLETES: PRACTICES AND ATTITUDES

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INTRODUCTION: Tart cherry (TC) supplementation has been shown to accelerate post-exercise recovery, enhance endurance performance and improve sleep duration and quality. The efficacy of dietary supplements depends on using an effective supplementation protocol, which may not always be the case in applied practice. Therefore we investigated the use of TC supplementation by sport science practitioners, sub-elite and elite athletes and compared this use to evidence based practice.
METHODS: An online survey (Qualtrics, WA, USA) was completed anonymously by sport science practitioners (professionally registered and providing supplementation advice) and athletes competing at various levels . Frequency analysis was conducted for all questions and the results were presented as percentage of responses. Chi squared analysis was used to assess the impact of professional experience on TC recommendations for sport science practitioners and the influence of the competition level on TC supplementation practices for athletes.
RESULTS: Thirty-five practitioners completed the survey. TC supplements were recommended to athletes by 46% of the respondents (11% - previously recommended TC supplements; 26% have not previously recommended TC supplements but were planning on doing so in the future). Fifty percent of those recommending TC supplements indicated enhancing exercise recovery as their goal, while 26% indicated improved sleep quality/duration. Acute TC supplementation and daily TC use during multi-day competition with a 2-3 day pre-load were the most recommended protocols (28% and 18%, respectively). Fifty-two percent of respondents were unsure of the optimal daily total polyphenol dose. Professional experience level did not alter TC use recommendations (p>0.05). Eighty athletes (52.5% elite ) completed the survey. Twenty -three percent of the athletes used TC supplements and 13% planned to use them. Improved exercise recovery and sleep duration/quality were the most indicated goals (71% and 32% of the respondents, respectively). Thirty-nine percent of athletes were using TC supplements acutely, 32% were supplementing chronically, with the rest utilising a combination of strategies. One day pre and post-load protocols were common (34% and 42%, respectively). No differences in the TC supplementation practices of sub-elite and elite athletes were identified (p>0.05).

CONCLUSION: TC supplements were used by and were of interest to a high proportion of sport science practitioners and to a smaller but nonetheless notable proportion of athletes surveyed. The main goals of the respondents when using TC supplements (enhancing exercise recovery and sleep duration and quality ) only partially matched the current evidence base, with sleep applications being insufficiently evidenced at present. Further, practices of both groups rarely aligned with the protocols found to be effective within the literature in terms of both supplementation duration and polyphenol dose.

# Invited symposia

## IS-SH03 Current trends on Mental Health in Sport, FEPSAC Invited Symposium

### DUAL CAREER EXPERIENCES PREDICT MENTAL HEALTH OUTCOMES IN EUROPEAN STUDENT-ATHLETES

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In recent years, there has been a sharp rise in academic and applied attention for mental health (MH) and well-being (WB) of athletes and their importance have been increasingly emphasized in light of the COVID-19 crisis and the Olympic and Paralympic games. Student-athletes form a commonly sampled subpopulation within mental health research. Nevertheless, a recent scoping review found that only limited attention has been directed towards examining the relationship between athletes' dual career (DC) experiences and their mental health. Therefore, as part of the Erasmus+ Sport project "Dual Careers for Mental Health" (DC4MH), we investigated athletes' DC experiences and MH/WB in six EU countries (Belgium, Denmark, Italy, Spain, Slovenia, Sweden). In total, 1175 student-athletes (age = 19.9, SD = 5.24; 51% female; 38% higher education) completed an online survey including, amongst others, the Mental Health Continuum Short Form (i.e. measuring General, Emotional, Social, and Psychological WB) and the newly developed DC experiences scale (i.e. measuring DC competencies, Negative DC experiences, and DC support).
Following Keyes' three category diagnosis of positive MH, 52% of student-athletes were categorized as "flourishing", 44% as "moderate MH", and 4% as "languishing". Significant linear relationships were observed between all dimensions of DC experiences and MH. Multiple linear regressions showed that DC competencies, negative DC experiences, DC support, Scandinavian background, resilience and MH literacy significantly predicted general WB (R2Adj = .49), emotional WB (R2Adj = .40), social WB (R2Adj = .38), and psychological WB (R2Adj = .42) in European student-athletes. DC competencies and resilience were the strongest predictors for general, emotional and psychological WB, while Scandinavian background was the strongest predictor for social WB. The study findings highlight the important connection between athletes' DC experiences and MH/WB. Developing a more detailed understanding of student-athletes' MH experiences can inform practitioners to develop research-based and contextually informed tools and initiatives focused on MH monitoring, MH literacy and psychological resilience-building strategies.

### 'RECALCULATING ROUTE': NARRATIVES OF ELITE ATHLETES IN THE ROAD TO TOKYO 2020 AND ITS IMPACT ON MENTAL HEALTH

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INTRODUCTION: The disruption of the Olympic cycle of Tokyo 2020 caused by the COVID-19 lockdown and the postponement of the Tokyo 2020 Olympic Games forced Olympic hopefuls to go through a series of uncertain and challenging phases. These, event and non-event, can be understood as two concurrent non-normative transitions that could have the potential to put mental health of elite athletes on risk. The aim of the present study is to explore the narratives of elite athletes during the different phases of the disruption of Tokyo 2020, understand how those evolve during time, and their impact on mental health.
METHODS: Eight elite athletes from a high-performance center in preparation for Tokyo 2020 (6 female and 2 male) took part in this longitudinal qualitative study. The data collection was done by a series of semi-structured online synchronous interviews that took place in three specific moments: during lockdown, in the beginning of the 'new normality' and in the pre-Olympic phase. The philosophical position of Interpretivism was used as a companion and extension of the thematic narrative analysis used for data analysis.
Results: Elite athletes define Tokyo 2020s preparation phase as a bumpy road that presented unclear conditions towards the final destination. During their road to Tokyo 2020, three specific time related narratives were identified: (a) lockdown: moving from threat to opportunity; (b) 'new normality': embracing uncertainty and (c) pre-Olympic phase: pulling the handbrake. Two more narratives, (d) giving up the control fallacies and (e) the adaptability as a distinction of being an athlete, were present during the whole preparation process and overlapped with the situational narratives. The overall preparation process showed that the influence of the environment (i.e., coaches, families) and psychological aspects such as resilience are a key protective factor when ensuring elite athletes' mental health.
Conclusions: The road to Tokyo 2020 has allowed us to identify that athletes possess a series of resources to recalculate their route in case of unexpected events and adapt to uncertain circumstances. In this sense, psychological protective factors, such as resilience and adaptability, should be included in career assistance programs as well as psychoeducation for the entourage. Future investigations should explore the experiences of the agents of the environment (i.e., coaches, families) in supporting athletes on non-normative transitions and to explore the post-Olympic transition in this disrupted Olympic cycle.

### EXPLORING BODY IMAGE DURING RETIREMENT FROM ELITE SPORT: PERSPECTIVES FROM RETIRED OLYMPIANS

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Pressure to be lean for athletic performance gains can lead athletes to adopt an unhealthy preoccupation with body weight and appearance. Athlete body dissatisfaction is prevalent across sports and can lead to disordered eating, negative affect, and poor mental health. Whether body image concerns persist into athletic retirement is a recent focus of research, with insights limited to survey-based data in sub-elite athletic samples. This is the first focused study to explore the meanings elite athletes ascribe to retirement body changes. We recruited 31 retired elite athletes, including 23 former Olympians, to participate in a semi-structured interview. Participants had been

retired for between 1 and 7 years (m = 3.9yrs). More than 25 hrs of interview data was transcribed verbatim and subject to a reflexive thematic analysis. We constructed 4 major themes to describe athlete experiences:1) A legacy of body-conscious culture 2) The struggle for "normal", 3) Loss of body as loss of self, 4) Holding on versus moving on. Athletes explained how the body surveillance culture of elite sport echoed into their post-sport lives. An Olympian identity is an embodied identity, so body changes represent a loss of the self. Accepting the inevitability of physical changes in retirement and finding new meanings and identities, eased body dissatisfaction for many, but the process was fraught with difficulties. Athletes' insights may support sport psychologists and elite sport organisations to devise strategies and policies to facilitate adaptation to body changes post-retirement.

# Oral presentations

## OP-SH18 Socio-ecological predictors of physical activity

### ARE MATURITY STATUS AND SEX DETERMINANTS IN A PHYSICALLY ACTIVE YOUNG POPULATION? INFLUENCE ON BODY COMPOSITION AND PHYSICAL FITNESS

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INTRODUCTION: Maturity cause changes in body composition and physical fitness in children, but it differs among children of the same chronological age as some individuals mature earlier or later than their peers. Evidence suggests that body composition and health in adulthood can be preceded by body composition and physical fitness during childhood and adolescence. Also, these parameters can be improved by physical activity. However, more evidence is needed to understand changes in body composition and physical fitness of active children and adolescents in different maturity states. Therefore, the study aimed to investigate the influence of maturity status and sex on body composition and physical fitness parameters in an active young population.
METHODS: 1682 active children and adolescents (aged 6-17) from rural areas engaged in extracurricular sports participated in this study. Participants were divided into four subsamples depending on sex (boys and girls) and sexual maturity status (prepubertal and pubertal). Data on body composition (body mass index, muscle mass, and fat mass) and physical fitness (20-m shuttle run test, handgrip strength, and vertical jump) were collected. Differences between groups were evaluated through two-way ANOVA (boys vs girls; prepubertal vs pubertal) and correlations were performed to evaluate the relationship between age and physical fitness parameters. The level of significance was set at $p<0.05$.
RESULTS: The results showed that pubertal athletes had higher body mass index, fat mass (kg) and muscle mass (kg) than the prepubertal in both sexes ($p<.05$). Boys had significantly higher muscle mass values than girls in both maturity groups ($p<.001$). In terms of physical fitness, the pubertal group performed significantly better in the 20 mSRT (stages), handgrip strength (kg) and countermovement-jump (cm) than the prepubertal group in both sex groups ($p<.05$). Boys reported significantly higher values in all physical fitness test than girls in both maturity groups ($p<.05$). Nevertheless, the relative data showed the opposite trend. Prepubertal group in both sexes showed a higher percentile value for all physical fitness parameters than the pubertal group ($p<.05$). It should be noted that prepubertal girls showed higher values in the 20 mSRT (pc) than prepubertal boys ($p<.001$).
CONCLUSION: This study suggests that absolute values of body composition and physical fitness improved in pubertal children, while percentile analysis reveals that pubertal children are less fit than prepubertal children. Furthermore, body composition and fitness showed a significant relationship with the maturation process. Thus, it is evident that extracurricular sports activities and physical education classes may not be sufficient to maintain fitness levels in pubertal adolescents.

### A STUDY ON THE FAMILY ENVIRONMENT AND THE IMPACT ON THE SCIENTIFIC FITNESS LITERACY OF CHINESE CHILDREN AND ADOLESCENTS DISTINGUISHING THE FIRST CAREGIVERS

PAN, X., ZHANG, Y., WANG, H., WU, D.

*CHINA INSTITUTE OF SPORT SCIENCE*

Scientific fitness literacy is a localised concept of physical literacy adapted to the Chinese context, measured and validated by the implementation of the National Survey on Fitness Activity. The family environment has a significant impact on psychology and behaviour of children and adolescents in sport. This study focuses on the impact of the home environment that distinguishes a childs first caregiver on SFL.
This study is based on data obtained from the 2020 pre-survey on the physical fitness activity status of children and adolescents by the General Administration of Sport of China . The valid samples recovered for each age group were 540 for ages 3-6, 522 for ages 7-9, 590 for ages 10-12, and 587 for ages 13-18. SPSS19.0 and AMOS22.0 were used for data analysis. The corresponding questionnaire was designed for four age groups(3 - 6, 7 - 9, 10 -12, 13 -18). After examining the reliability and validity of SFL in different age groups, and the best multiple analysis models for different age groups and different family environment sub-influencing factors on SFL were screened out using stepwise multiple regression analysis. we divided each age group into two comparison groups: parents as the primary caregivers (hereafter referred to as "PPC") and neither parent is the primary caregiver(hereafter referred to as "NPPC"), to investigate the differences and similarities in the SFL of children and adolescents by different caregivers.
For children in the 3-6-year-old NPPC group, most parental and family factors did not enter the model, suggesting that the development of childrens SFL shows little sign of any parental involvement and that the influence of the family environment is missing. The most significant sub-factors in 7-9-year-old PPC group is the childs screen time (television, various electronic devices), This phenomenon will become more pronounced as children and adolescents transition to adulthood. In the NPPC group, there is no logical explanation for the positive relationship between the number of electronics owned by households and SFL. We found that many sub-factors showed a lag in NPPC group compared to PPC group. For example, mothers played a role in the 3-6 year old PPC group, whereas it was at age 7-9 years in NPPC group that this factor started to enter the model. (mothers education). The same applies to the role of fathers ( 7-9 years PPC group, while 10-12 years NPPC group)and whether families are willing to pay for their children to attend sports classes(Across the PPC group at ages 7-9, 10-12, and 13-18, but only present in the 13-18 NPPC group model).

Comparing the different age groups, the influencing factors entering the regression model gradually decrease with age, the fewer interventions are available, and the harder it is to improve SFL by changing the family environment. Comparing the PPC and NPPC groups,the PPC group has a higher degree of explanation in the regression model than the NPPC group and more factors enter the model because the parents are not absent and both parents have an influence on their children by preaching and modeling. The PPC group therefore has more interventions and means at its disposal.

## A SOCIO-ECOLOGICAL EXAMINATION OF THE PRIMARY SCHOOL PLAYGROUND: PRIMARY SCHOOL PUPIL AND STAFF PERCEIVED BARRIERS AND FACILITATORS TO A PHYSICALLY ACTIVE PLAYGROUND DURING BREAK AND LUNCH-TIMES

GRAHAM, M.

*TEESSIDE UNIVERSITY*

Using Brofenbrenner's socio-ecological model as a conceptual framework, the objective of this study was to determine playground users (primary school staff and pupils) perceptions of the barriers and facilitators to a physically active school playground at an intra-personal (individual), inter-personal (social), environmental and policy level. Results from a series of qualitative interactions with children (n = 65) from years five and six (9 to 11 years old), and structured interviews with adult teachers (n = 11) revealed key differences in the child and adult perceptions of the playground and the purpose of break-times. A number of inter-related environmental boundaries and school policies were identified as restrictive to children's explorations and activity levels during 'free play' periods, which centred on resource availability, accessibility and health and safety. Further, traditional playground hierarchies act to promote and prevent physical activity engagement for different groups (e.g. gender and age). Finally, differences between the adult and child perception of the primary school playground were observed. Playground physical activity, during break-times appears to be affected by a number of variables at each level of the socio-ecological model. This study provides an opportunity for primary schools to reflect on primary school playground strategies and practices that are implemented at each level of the socio-ecological model to encourage a more effective use of the playground during school break-times.

## CREATING MOTIVATION ENVIRONMENT FOR ADOLESCENTS THROUGH RACKET SPORTS (RACKETLON) FOR LONG LIFE PARTICIPATION AND WELLBEING

GIAKOUVAKI, A., APOSTOLIDIS, N.

*NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS*

Introduction
The promotion of long life active participation in individual and team sports has a special influence on the specifics of the sport, the training process, sport environments, the form of competition and the experience of well-being. The aim of this study is to investigate the issue of intrinsic motivation and self - determination of adolescents who participate in racket sports such as Racketlon, to gain pleasure.
Methods
To determine the factors that motivate an individual to participate in a chosen leisure activity, the Participation Motivation Questionnaire (PMQ) which was introduced by Gill et al. (1983). The data were analyzed by descriptive statistics, factor analysis and one way ANOVA.
Results
The results of the factor analysis of the PMQ revealed the factors of achievement/status, team atmosphere, fitness, energy release, skill development, friendship and fun as basic motives for involvement. It is interesting that female participants have the same top four motives as males and that intrinsic motivation is equally important for both genders.
Discussion
One of the goals of Physical Education is that students acquire healthy and long-lasting sports as well as physical activity habits. This is an aspect that has led to the analysis of the benefits of leisure-time habits on students. When motivation is assessed regarding the participation in sport, the priorities and the processes of motivation should be understood so as to carry on and maintain physical activity. Individuals are motivated to sport because of internal factors, such as enjoyment, skill development and mastery, and external factors, such as rewards, improved health and wellbeing. Psychologists are interested in approaching the initial reasons why people get involved in sports as well as their commitment to participation. It has also been revealed that the motivation of participants in sporting competitions is different from that of participants in routine sport and recreational activities. Racketlon, as a complex sport, has a different approach as far as competition is concerned: winning in an individual Racketlon event is not as important as collecting points in all four events.
Bibliography:
Gill, D.L., Gross, J.B., & Huddleston, S. (1983). Participation motivation in youth sports. International Journal of Sport Psychology, 14(1), 11-14.
Key words: Self-Determination Theory (SDT), Leisure time, Individual sport (Racketlon), Well-being.

## MIGRATING TO A PHYSICALLY ACTIVE COUNTRY: CHANGES IN PHYSICAL ACTIVITY AND THE PERCEPTION OF THEIR CONTEXTUAL ATTRIBUTES

GONÇALVES, R., BATALAU, R., PALMEIRA, A.

*CIDEF - RESEARCH CENTRE FOR SPORT AND PHYSICAL EDUCATION*

Purpose: In the European Union (EU), 59% of the citizens claim that they never or seldom exercise or play sports, although there is a great difference between countries (e.g., 72% in Portugal vs. 30% in Sweden). So, migrating from a country to another may have different impacts on physical activity level (PA), but is understudied and may provide essential public health information. Therefore, the aim of this work was to analyze the association between emigration from an "inactive country" to an "active country" and PA, and the perception of contextual attributes for PA, in adults.
METHODS: In this cross-sectional study, 402 participants accessed an online survey. Of these, 83 finished met eligibility criteria: i) 18-65 years old; ii) have lived in an inactive country for at least 10 years; iii) migrated and now living in an active country for at least 6 months. An active country was defined as an EU country, where >8% "regularly" and <42% "never" exercise or play sport (EU averages, according to the Eurobarometer). A self-report assessed perception of contextual attributes for PA (NEWS-A) and PA (IPAQ-SF), in both contexts. Differences between contexts were examined through a paired sample t test. Effect sizes (r) were calculated, where values of .1, .3, and .5 repre-

sent a small, medium, and large effect, respectively. Pearson correlations and regression analysis assessed the associations among the variables.
Results: When participants emigrated from an inactive country to an active country, they increased their walking time (r=.55), moderate PA (MPA; r=.33), moderate-to-vigorous PA (MVPA; r=.21), and the total PA MET-min (r=.33) per week. The perception of walkability also changed, with eight dimensions increasing the perception of contextual attributes for PA when people migrated to an active country (r average =.43). While living in an inactive country, MVPA min/week and total PA MET-min/week were positively correlated with the perception of infrastructure and safety for walking (p≤ .028) and negatively correlated with crime (p≤ .004). These data suggest that people, in an inactive country, do not feel safe to be more active. These associations did not happen in the active country, where only the perception of lack of cul-de-sacs was positively correlated with MVPA min/week and total PA MET-min/week (p≤ .040), showing that more street connectivity awareness in the active country could explain the increase in PA. The regression analysis did not produce any significant results.
Conclusions: In our sample, migrating from an inactive country to an active country increased the PA and the perception of contextual attributes for PA. The correlations point to the possibility that PA promotion policies of the inactive countries constrain the integration of an active lifestyle in their populations. Future studies should investigate how their physical and psychosocial contexts may facilitate this, as well as individual factors such as motivation.

## 09:30 - 10:45

## Invited symposia

### IS-PN09 Glycogen metabolism in muscle: from bench to athletes

#### CARBOHYDRATE FEEDING OR RESTRICTION: FROM BENCH TO ATHLETES

MORTON, J.
*LIVERPOOL JOHN MOORES UNIVERSITY*

The aim of this talk is to present the current knowledge on how carbohydrate feeding or restriction affects exercise performance and adaptations to training. Recent findings on the differences between carbohydrate-intake before, during and after exercise and how this is related to glycogen content, substrate utilization and cell signaling pathways involved in oxidative adaptations within the muscles will be highlighted. The presentation will include considerations on how to translate laboratory findings to practical applications for endurance athletes in relation to various levels of carbohydrate intake around certain training sessions. James was the Head of Nutrition for Team Sky and Team Ineos between the period of 2015-2019, responsible for the implantation of the nutritional strategy underpinning 5 consecutive Tour de France victories, the philosophy of which was based on CHO periodisation.

#### EXERCISE, GLYCOGEN AND GLYCOGEN HANDLING PROTEINS IN SINGLE MUSCLE FIBERS

MURPHY, R.
*LA TROBE UNIVERSITY*

This talk will focus on the cellular abundance of glycogen and proteins required for glycogen regulation. Human muscle heterogeneity will be addressed by examining proteins in isolated single muscle fibres using western blotting, a technique pioneered by Robyn. To further provide knowledge around glycogen regulation, this talk will discuss muscle fibre type specificity of the array of glycogen handling proteins and presenting data obtained using micro-dissection techniques and discuss association of these proteins with glycogen. The manipulation of intramuscular glycogen content via exercise will form the basis of understanding how glucose uptake into muscle may be regulated and how the behaviour of glycogen handling proteins is affected by the exercise.

#### DOES SUBCELLULAR HETEROGENEITY IN GLYCOGEN METABOLISM IMPACT EXERCISE PERFORMANCE?

NIELSEN, J.
*UNIVERSITY OF SOUTHERN DENMARK*

Here the current knowledge on how the subcellular distribution of glycogen in skeletal muscle may impact exercise performance will be presented. Recent studies using quantitative microscopy have shown that the content of glycogen in skeletal muscle should be considered to be more than a global concentration of the cell, but also to be important local energy depots connected to specific energy requiring processes and related to distinct functions of the muscle fibers. The presentation will include recent findings ranging from studies conducted at isolated single muscle fibers to large-scale human interventions addressing aspects of spatial glycogen metabolism and their potential relationship to athletic performance. Joachim has been one of the leading investigators conducting quantitative microscopy with a focus on the subcellular distribution of glycogen.

## IS-BM04 Myocellular and neuromuscular aspects of blood-flow restricted (BFR) exercise

### MYOCELLULAR EFFECTS AND MECHANISMS OF ADAPTION WITH LOW-LOAD BFR RESISTANCE TRAINING

NIELSEN, J.

*UNIVERSITY OF SOUTHERN DENMARK*

Myocellular effects and mechanisms of adaption with low-load BFR resistance training
Blood-flow restricted (BFR) training has been established as a training modality capable of evoking significant improvements in mechanical muscle function (e.g., muscle strength) and skeletal muscle mass using low external exercise loadings (20-30%-1RM). Available data suggest that the training modality may serve as an effective alternative to traditional heavy-load resistance training when aiming to stimulate myocellular adaptations. However, the underlying physiological stimuli, upstream effectors and myocellular pathways responsible for the adaptive changes in myocellular morphology in response to BFR training remain elusive.
This presentation will review recent and novel evidence on myocellular adaptations and their underlying mechanisms with low-load blood-flow restricted training.

### NOVEL MRI TECHNIQUES TO ASSESS INTRAMUSCULAR FLUID SHIFTS IN ACUTE BFR EXERCISE

HADDOCK, B.T.

*RIGSHOSPITALET, COPENHAGEN UNIVERSITY HOSPITAL*

Apart from detailed anatomical imaging, recent advances in magnetic resonance imaging (MRI) include techniques capable of in vivo measurements of several physiological parameters. The application of blood flow restriction (BFR) when performing resistance training is known to alter muscle oxygenation and myocellular swelling. Novel quantitative MRI techniques allow rapid and accurate 3D measures of muscle oxygenation, macro-vascular blood flow, shifts in myocellular fluid content, and changes in extracellular fluid fractions. These in vivo measures of key parameters related to muscle oxygenation and myocellular swelling are of great interest in decoding the mechanisms behind the positive adaptations of BFR training.
This talk will present novel quantitative MRI data detailing the acute and post exercise physiological responses to established resistance exercise strategies using BFR versus free-flow (FF) loading conditions. Marked differences in these parameters are demonstrated between BFR and FF exercise conditions, which contribute to explain the anabolic potential of blood flow restricted muscle exercise.

### NEUROMUSCULAR PLASTICITY WITH ACUTE AND LONG-TERM BFR TRAINING: WHAT WE KNOW AND WHAT WE NEED TO KNOW

CENTNER, C.

*UNIVERSITY OF FREIBURG*

Numerous studies within the past two decades have demonstrated that an induction of a local hypoxic environment facilitates the adaptive responses of human skeletal muscle during low-load (LL) resistance training. Although positive adaptations following blood flow restriction (BFR) training have been reported on the level of both muscle structure and function, the underlying mechanisms behind these adaptations are not fully understood. Besides metabolic accumulation, recent evidence indicates that LL-BFR training may facilitate pronounced adaptations also at the neural level.
In this presentation, existing evidence on the acute and long-term effects of LL-BFR on central and peripheral neural markers will be summarized.



## IS-MH08 Epigenetics of Physical Activity and Healthy Ageing

### SEX-SPECIFIC EPIGENETIC DIFFERENCES IN RESPONSE TO EXERCISE TRAINING

EYNON, N.

*VICTORIA UNIVERSITY*

Males and females differ in nearly all complex traits, including both their normal and abnormal/aberrant (i.e. disease state) physiological responses, yet females have long been underrepresented in, or excluded from fundamental and clinical research. This has major implications for personalised and targeted health interventions and this is particularly true for exercise science. While sex differences have been variously attributed to sex chromosomes, hormones, differences in behaviour and environmental exposures, the Epigenetic basis for these differences remain to be elucidated.
Epigenetics determines how the cell uses its genetic information to perform its function, without changing the code of this genetic information. The epigenome is highly sensitive to environmental stimuli such as smoking, diet and exercise. The skeletal muscle epigenome is particularly sensitive to exercise, and exercise training programs caused widespread DNA methylation (an Epigenetic mark) shifts in genes that are relevant for skeletal muscle health.
The Gene SMART study, led by our group, is the first of its kind to comprehensively assess genetic and epigenetic markers that contribute to muscle health in a relatively large group (n = 200) of participants. Comprehensive phenotypic data and muscle biopsies have already been collected from 130 participants (n=100 males, and n=30 females) pre-and-post intense exercise. We combined the Gene SMART cohort and open access datasets and performed a powerful Epigenetic- Wide Association Study meta-analysis of sex in skeletal muscle, totalling n = 369 individuals (n = 217 males, n = 152 females). We first established a list of DNA methylation differences between males and

females, and explored their genomic context. We then integrated them with sex-biased gene expression, and inferred the potential downstream effects on skeletal muscle function.
Elucidating the exercise epigenome as well as the sex differences in molecular mechanisms is critical for developing deeper insight into the underlying mechanisms of exercise adaptations and facilitate the use of this information in future research and practice.

**THE EPIGENETIC LANDSCAPE OF PHYSICAL ACTIVITY AND HEALTHY AGEING**

SILLANPÄÄ, E.

*UNIVERSITY OF JYVÄSKYLÄ, FACULTY OF SPORT AND HEALTH SCIENCES, GERONTOLOGY RESEARCH CENTER..*

Human ageing is accompanied by a decline in muscle mass and strength, loss of physical independence as well as increased morbidity and mortality. The underlying molecular mechanisms behind these physiological changes remain poorly characterized. Physical activity is a cost-effective and simple intervention with great potential to decelerate the rate of cellular and molecular damage as well as the functional decline brought about by ageing.
As an interface between genome and external factors, epigenetics forms a fundamental link between genotype and environmental factors such as diet and exercise. DNA methylation, the most widely studied epigenetic mechanism, modifies gene function by responding to the internal and external environment. DNA methylation changes at specific CpG (cytosine nucleotide followed by a guanine nucleotide) sites are associated with chronological age. Ccollectively, data sharing through biobanks, as well as technological and statistical developments have offered promising tools for identifying epigenetic markers of biological age.
The novel epigenetic marks to measure ageing referred to as epigenetic clocks are weighted sums of DNA methylation at specific CpG sites. Epigenetic clocks are based on statistical models in which ageing phenotypes are predicted using genome-wide DNA methylation data, and optimal CpG sites are selected for the age predictor by the algorithm. Epigenetic clocks are able to predict both time-to-death and time-to-disease, making them fascinating tools to estimate effects of physical activity and other lifestyle habits on biological aging. Recently, the first epigenetic clock for muscle tissue, 'MEAT' (Muscle Epigenetic Age Test), was developed by the Eynon group, which emphasized the discrepancies in biological aging between tissues. Tissue-specific epigenetic ageing could provide insight on various exposures and their influence on health and morbidity.
This presentation will summarize recent studies that investigated associations between physical activity/function-related phenotypes and epigenetic aging in various tissues. Based on results from quantitative genetic models, common confounders such as genetic and social factors as well as other lifestyle habits will be discussed.

**THE ROLE OF MITOCHONDRIAL NON-CODING RNAS IN MUSCLE ADAPTATION TO EXERCISE**

LAMON, S.

*DEAKIN UNIVERSITY*

Mitochondrial adaptations play a central role in the beneficial effects of exercise. This is particularly relevant in metabolically active tissues such as skeletal muscle, which rely on the tight control of mitochondrial gene expression to ensure efficient mitochondrial function and adaptation. Despite the importance of mitochondrial signalling in exercise-induced adaptations, the molecular regulators of these responses are not yet fully elucidated.
Mitochondria retain a conserved genome from prokaryotic ancestors and mitochondrial gene regulation relies on communication between mitochondrial- and nuclear-encoded transcripts. Non-coding RNAs (ncRNAs) have regulatory roles in the modulation of gene expression. Emerging evidence demonstrates that regulatory ncRNAs, particularly microRNAs (miRNAs) and long ncRNAs (lncRNAs), localize within the mitochondria in diverse physiological and pathological states. These molecules present intriguing possibilities for the regulation of exercise-induced mitochondrial gene expression. Indeed, research suggests that all known miRNAs are encoded by the nuclear genome but can target mitochondrial genes, while lncRNAs can be encoded by the mitochondrial genome itself.
We used a human and a rat skeletal muscle model of aerobic exercise to investigate the role of mitochondrial miRNAs and lncRNAs in exercise adaptation. We first set up a new technique to extract human and rat skeletal muscle mitochondria with a high level of purity. To perform transcriptomic analyses of mitochondria-localised ncRNAs, we isolated intact mitochondria from cultured rat myoblasts and optimised a ribonuclease digestion approach to remove transcripts located exterior to mitochondria. We next determined optimal cDNA and adapter ligation conditions for the construction of small RNA sequencing libraries from low mitochondrial RNA input amounts. Human and rat RNA was then used to generate cDNA libraries for miRNAs and lncRNAs, respectively, which were sequenced using Illumina technologies. Mature human miRNA sequences were mapped to miRBase v22.0 and rate lncRNA sequences were mapped to the rat genome (Ensembl version 99).
Based on this, we identified over a profile of nuclear-encoded miRNAs localised within myoblast mitochondria pre- and post- an acute bout of aerobic exercise. Using the same approaches, we assess the whole mitochondrial transcriptome of purified human and rat skeletal muscle tissue, revealing the enrichment of numerous ncRNAs within the mitochondria subcellular compartment at rest and in response to exercise.
These results support our hypothesis that a level of ncRNA-mediated gene regulation takes place in the mitochondria. NcRNA-mediated regulation of the mitochondrial genome is therefore a relatively unexplored field that presents exciting possibilities to further our understanding of mitochondrial metabolism and exercise physiology.

## IS-AP09 Female athlete research - applications to performance, health and risk of injury (sponsored by Adidas)

### INSIGHTS INTO THE EFFECTS OF FLUCTUATING FEMALE HORMONES ON MUSCULOSKELETAL PROPERTIES AND INJURY RISK

LEGERLOTZ, K.

*HUMBOLDT UNIVERSITY BERLIN*

The effects of female sex hormones appear to be viewed and valued in light of weakening the women's body, with females being – be it consciously or unconsciously – viewed as less functioning, weaker or less well-adapted versions of men. In the context of the menstrual cycle, research often appears to start with the underlying – yet often implicit – assumption that female hormones, the menstrual cycle or menstrual bleeding are seen as something avoidable or undesirable. Consequently, it is assumed that female hormones or the menstrual cycle are responsible for higher rates of specific injuries or cycle-dependent reductions in performance. This deficit- and problem-oriented approach is mirrored in the underlying assumptions that often initiate research. For example, it is reflected by the mechanistic approach that has been applied to link female sex hormones such as estrogen to mechanical or functional weakness, interpreting physiological changes observed during the menstrual cycle as negative, and associating those changes with an increased risk of injury. Although the literature strongly suggests that there is an association of ACL ruptures with the preovulatory phase, this by itself does not explain why injury prevalence varies between phases, but it rather begs the question as to "why". It is crucial to not fall into the trap of mistaking a correlation for a causation, of overlooking the possibility that statistical effects can also be caused by a third variable, only hold true for some subgroups, or that further variables could be more relevant than the one regarded in one's own statistical model. Thus, to uncover the mechanism behind peaks in injury incidence during the menstrual cycle it is important to understand that it is not exclusively the estrogen level that varies with different phases of the menstrual cycle.
We would like to highlight that this deficit-orientated approach first may be affected by a biased view on exercising women, which may drive us to ask misleading research questions based on erroneous assumptions, and second by an oversimplification of a complex system, mistaking a correlation for a causality. We would like to show that if we change our assumptions and if we take other variables into account, we may come up with an alternative explanation regarding the observed association between the menstrual cycle and injury risk.

### INSIGHTS INTO THE EFFECTS OF HORMONAL CONTRACEPTIVES ON MUSCULOSKELETAL ADAPTATION AND INJURY RISK

HANSEN, M.

*AARHUS UNIVERSITY*

In elite sports, even small margins can be crucial in the medal race. In most countries, more than half of the young female population, including female athletes, use hormonal contraceptives. Nevertheless, knowledge is still sparse when it comes to the effects of all types of hormonal contraceptives on musculoskeletal tissues and cardiovascular parameters in relation to adaptation to training, performance and sports injuries.
Presently, oral contraception is the most widespread type of hormonal contraception. Oral contraceptives markedly change the sex hormonal profile since they suppress the endogenous sex hormone levels and induce daily fluctuations in synthetic sex hormones after ingestion of the oral contraceptive pill. Within the last years, the interest in non-genital effects of oral contraceptives in young females has risen, and both positive and negative effects of using oral contraceptives have been reported on markers of health, performance and injury risk. This suggests a need for sports specific and individualized approaches when guiding female athletes on the use of contraceptives. This presentation aims to provide the listener with an update based on the latest research findings in the field. Gaining the latest evidence within this field is relevant for researchers who include female participants in human trials, and for coaches and athletes who strive to optimize on all fronts.

### IMPROVING KNOWLEDGE AND COMMUNICATION ABOUT FEMALE HORMONAL CYCLES IN APPLIED SPORT SETTINGS

MCGAWLEY, K.

*MID SWEDEN UNIVERSITY*

Some research studies have suggested that prescribing certain types of training during specific phases of the menstrual cycle (MC) will lead to enhanced physiological adaptations, reduced health risks and improved performance. However, a recent systematic review and meta-analysis concluded that the quality of the existing evidence for organizing training around MC phases is generally quite poor, and that responses to phase-based training interventions vary between (and even within) individuals (McNulty et al. 2020). As such, general recommendations for training according to the MC are not considered appropriate. Similar findings have been presented in a related systematic review and meta-analysis that looked at the effects of hormonal contraceptive (HC) use on athletic performance, with a lack of high-quality scientific studies currently available and a great deal of between-study variation reported (Elliott-Sale et al. 2020). In both of these studies, individualised approaches are recommended.
In sports performance environments, an individualized approach to working with female athletes in relation to their hormonal cycles requires knowledge, resources and well-developed interpersonal relationships between athletes and coaches (Höök et al. 2021). However, a number of recent studies have reported that knowledge about the female hormonal cycle is typically poor among athletes and coaches (e.g., Solli et al. 2020; Larsen et al. 2020). Those topics poorly understood include the physical and psychological effects of hormonal fluctuations, typical MC symptoms, effects of HC use and the long-term health implications of amenorrhea, which is often normalised in weight-bearing and aesthetic sports. Moreover, athletes and coaches perceive female hormonal issues to be uncomfortable, awkward, embarrassing and taboo to talk about. A lack of MC monitoring and related documentation is also common, even at an elite level. Despite this lack of knowledge, avoided discussions and poor routines regarding female hormonal cycles, athletes and coaches have reported a desire to learn, communicate and monitor more. With organized structures and forums specifically relating to female hormonal issues currently lacking within applied sport settings, sports federations and athlete/coach development pathways, educational and communication models have been proposed to guide the process (Clarke et al. 2021; Höök et al. 2021).

This lecture will highlight recent advances in research relating to knowledge, communication and applied practice relating to female hormonal cycles, as well as frameworks for supporting female athletes in the pursuit of athletic excellence. While the science is complex and the application in sport settings is challenging, simple practices including monitoring, testing, feedback and continuous adjustment can have an impact on athlete performance, health and well-being.

## Oral presentations

### OP-PN34 Muscle damage and repair

#### HIGH-FREQUENCY BLOOD FLOW RESTRICTED RESISTANCE EXERCISE TO FAILURE INDUCES HIGHER CELLULAR STRESS IN MUSCLE FIBRES THAN A NON-FAILURE PROTOCOL

BJØRNSEN, T.1,2, HODY, S.3, RAASTAD, T.1,4, PAULSEN, G.2,4, WERNBOM, M.5, VÅRVIK, F.T.1,2, BERNTSEN, S.1, CUMMING, K.T.4,6

*1 UNIVERSITY OF AGDER . 2 NORWEGIAN OLYMPIC AND PARALYMPIC COMMITTEE. 3 UNIVERSITY OF LIEGE. 4 NORWEGIAN SCHOOL OF SPORT SCIENCES. 5 UNIVERSITY OF GOTHENBURG. 6 ØSTFOLD UNIVERSITY COLLEGE*

INTRODUCTION: High-frequency blood flow restricted resistance exercise (BFRRE) with sets performed to failure has been reported to induce pronounced cellular stress in both fibre types, with type I fibres being most affected (1). However, stress responses to frequent non-failure BFRRE protocols have not been investigated. Therefore, the purpose of the present study was to compare the effect of a failure vs. non-failure BFRRE protocol on the heat-shock protein (HSP) responses over a period of two 5-day-blocks of 7 BFRRE sessions, separated by 10 days of rest (RestWeek).
METHODS: Seventeen untrained men (25±6 yrs) had their legs randomly assigned to either failure- (FA; four sets to voluntary failure) or not to failure (Non-FA; 30-15-15-15 repetitions) protocol using unilateral knee extensions at 20% of 1 repetition maximum (1RM) with 30 seconds rest between sets. BFRRE was conducted with partial blood flow restriction (100 mmHg, 15cm wide cuff). Muscle samples obtained before, 2 h after the first session, during the RestWeek, and at 10 days post-intervention (Post10) were analyzed for αB-crystallin (αBc), HSP70 and myosin heavy chain by immunofluorescence and western blot (αBc and HSP70). Knee extension maximal voluntary isometric contraction (MVC) was measured up until Post10.
RESULTS: Two h after the first BFRRE bout, FA displayed a greater accumulation of αBc in the cytoskeletal fraction than Non-FA (FA: 11.4±12.5-fold vs. Non-FA 4.7±6.1-fold, p=0.007, Mean±SD), and both groups decreased αBc levels in the cytosolic fraction (FA: 24±19%, p<0.001; Non-FA 19±24%, p=0.001). FA also increased staining intensity (reflecting cytoskeletal-bound proteins) of αBc in type I fibres more than Non-FA 2h after BFRRE (FA: 161±194% vs. Non-FA: 81±118%, p=0.044), but not so in type II fibres (FA: 102±118%, p<0.001; Non-FA: 62±87%, p=0.017, no group difference, p>0.05). Staining intensity of HSP70 increased 2h after BFRRE in type I fibres (FA: 38±66%, p=0.009; Non-FA: 32±45%, p=0.028), and in type II fibres (FA: 26±53%, p=0.071; Non-FA:48±59%, p=0.001), with no group differences. FA increased cytoskeletal HSP70 at Post10 (FA: 87±185% vs. Non-FA 22±65%, p=0.057), and type I fibre staining intensity of HSP70 at RestWeek (FA: 122±231% vs. Non-FA: 28±41%, p=0.010), compared to Non-FA. In addition, only FA increased αBc staining intensity in type I fibres from baseline to RestWeek (FA:40±54%, p=0.017; Non-FA: 28±63%, p=0.131). MVC was decreased in both groups by ~30% 2h after BFRRE, and ~10% after the first block of BFRRE (RestWeek), but only FA had reduced MVC at Post3 and Post10 (5-8%, all p<0.05).
CONCLUSION: The high-frequency BFRRE protocols to failure and not to failure stressed both fibre types acutely and during short-term training, as evident by the HSP responses. Overall, the FA protocol induced greater stress responses compared to the Non-FA protocol, especially in type I fibres.
(1) Bjørnsen et al. (2021). J Appl Physiol 1;131(2):643-660

#### THE EFFECTS OF THREE DIFFERENT ECCENTRIC EXERCISE MODES ON TEMPORAL SYMPTOMS OF EXERCISE-INDUCED MUSCLE DAMAGE

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INTRODUCTION: Greater symptoms of exercise-induced muscle damage (EIMD) are commonly reported after eccentric-based exercises than other contraction modes [1], which may confer a greater protective effect (repeated-bout effect) from EIMD symptoms in subsequent exercise bouts [2]. Various eccentric exercise modes are frequently investigated in research and used in athletic settings, therefore the purpose of this study was to compare the effects of downhill running (DHR), drop jumps (DJ) and isokinetic eccentric contractions (Isok) on functional, molecular and perceptual EIMD measures.
METHODS: Participants were randomised into either one of three experimental groups (DHR [N = 6], Isok [N = 6], DJ [N = 6]) with DHR (30 min, ~70%VO2max, 15% decline), Isok (100 unilateral isokinetic eccentric contractions at 50% MVC), and DJ (100 drop jumps from a height of 0.6 m; 5 sets of 20 jumps with 1 min rest between sets). Maximum voluntary isometric contraction of knee extensor force, perception of pain, and creatine kinase (CK) concentration were measured before and 24, 48, 72 and 96 hr after eccentric exercise using dynamometry, a visual analogue scale (VAS), and reflectance photometry, respectively.
RESULTS: A significant ($P \leq 0.05$) increase was detected in CK at all time points from baseline for DHR (Mean Δ 24hr = 75%, 48hr = 74%, 72hr = 34%, 96hr = 27%), DJ (Mean Δ 24hr = 82%, 48hr = 83%, 72hr = 65%, 96hr = 62%) and Isok (Mean Δ 24hr = 51%, 48hr = 29%, 72hr = 28%, 96hr = 13%). Similarly, there was a significant decrease in MVC at all time points from baseline for DHR (Mean Δ 24hr = 14%, 48hr = 10%, 72hr = 7%, 96hr = 5%), DJ (Mean Δ 24hr = 22%, 48hr = 4%, 72hr = 7%, 96hr = 6%) and Isok (Mean Δ 24hr = 14%, 48hr = 12%, 72hr = 15%, 96hr = 10%). Finally, VAS was also significantly increased across all time points from baseline for DHR (Mean Δ 24hr = 57%, 48hr = 62%, 72hr = 55%, 96hr = 8%), DJ (Mean Δ 24hr = 61%, 48hr = 60%, 72hr = 33%, 96hr = 25% from baseline) and Isok (Mean Δ 24hr = 25%, 48hr = 13%, 72hr = 9%, 96hr = 0%). There was no significant difference between groups in any measure.
CONCLUSION: The significant functional impairment, elevated CK and pain evident for several days following different eccentric exercise modes have important implications for exercise prescription, performance and injury risk in the days after unaccustomed eccentric exercise. However, the similar temporal responses are indicative that the specific mode of eccentric contractions (DHR, DJ, Isok) did not differentially influence the magnitude of functional, molecular or perceptual EIMD responses.

1. Friden & Lieber (1992). Med Sci Sports Exerc. 24, 521-530.
2. Hody et al. (2019). Front Physiol. 10, 536.

**REPEATED BOUT EFFECT: NEUROMUSCULAR AND CARDIORESPIRATORY RESPONSES DURING DOWNHILL WALKING IN RELATION TO MUSCLE FUNCTION LOSS**

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INTRODUCTION: It has been well established that performing a bout of unaccustomed, predominantly eccentric exercise may result in a long-lasting muscle function deficit (>24 h) and in a set of symptoms (e.g., muscle soreness, increased levels of circulating proteins). It is also well established that repeating the same bout within few weeks results in reduced loss of muscle function and symptoms of muscle damage compared to the initial bout. It has been suggested that neural, mechanical and cellular adaptations may explain the protection conferred by a single bout of eccentric exercise, called the "repeated bout effect" (RBE).
Currently, there is no consensus about how the adaptations involved in the RBE could affect neural (muscle activation) and mechanical (muscle/tendon elongation) behavior during a second bout of eccentric-biased exercise. Moreover, while it is well known that neural/mechanical behavior could affect running/walking economy, no study investigated cardiorespiratory changes for a given running/walking speed in a RBE context. The aim of the present study was to: 1) quantify any mechanical, neural or cardiorespiratory changes that occur between two identical eccentric biased exercises separated by two weeks; 2) explore whether these parameters were associated with muscle function loss or any muscle damage markers.
METHODS: 15 participants performed two sessions of 45-min loaded downhill walking (DW) separated by 2 weeks. Oxygen consumption (VO2), heart rate (HR), rating of perceived exertion (RPE), muscle architecture of the vastus lateralis (VL) and EMG activity of the VL, rectus femoris (RF), biceps femoris (BF), gastrocnemius medialis (GM), soleus (SOL) and tibialis anterior (TA) muscles were assessed during the downhill walking. Maximal voluntary contraction (MVC) torque, delayed-onset muscle damage (DOMS), knee range of motion (ROM), creatine kinase (CK) and myoglobin (Mb) were assessed before (PRE), within 1h (POST) and 4h after the exercises (POST), and the days after the two sessions (24h, 48h, 72h and 168h).
RESULTS: MVC torque measured 24h after the DW was reduced by 22.8 ± 11.7 % and 7.4 ± 8.2 % for the first (DW1) and the second (DW2) DW. DOMS, ROM, Mb, and CK were also significantly reduced after DW2 compared to DW1 ($p < 0.01$). Muscle activation (RF and SOL EMG activity), cardiorespiratory (HR and VO2) and subjective (RPE) responses were significantly decreased during DW2 compared to DW1 ($p < 0.05$). Muscle architecture analyses are in progress.
CONCLUSION: As expected, we found a reduced loss of muscle function and symptoms of muscle damage after the second bout compared to the initial bout of downhill walking. Protective adaptations conferred by the first bout induce a lower perceived exertion and cardiorespiratory responses when the same exercise is repeated within few weeks. Neural and mechanical adaptations could partly explain the lower perceptual and physiological responses during a second bout of eccentric biased exercise.

**EFFECTS OF A STANDARD VS. A MODIFIED RESISTANCE TRAINING PROGRAM TARGETING INTRAMUSCULAR CONNECTIVE TISSUES ON MUSCLE ARCHITECTURE, ECHOGENICITY AND ISOMETRIC STRENGTH**

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INTRODUCTION: Older muscles typically present a fibrotic phenotype, possibly related to a blunted cellular response of the network of intramuscular connective tissue (IMCT) to physical loading1. A recent study testing various acute exercise stimuli indicated that plyometric jumps and foam rolling may provoke a greater expression of IMCT-related genes than conventional resistance exercise2. To follow up on these findings, a longitudinal study comparing conventional and IMCT-targeted resistance training programs based on cellular, imaging-based and functional parameters is currently being conducted. Here, the first data on muscle architecture, ultrasound echogenicity and isometric strength are reported.
METHODS: Nine (4 males, 66.3 ± 3.0 yrs, 171.1 ± 6.1 cm, 73.8 ± 10.4 kg) and 10 (3 males, 67.7 ± 4.3 yrs, 168.8 ± 7.5 cm, 68.9 ± 12.5 kg) older subjects were assigned to a conventional (CONV-G) and IMCT-targeted (IMCT-G) training group, respectively. Both groups engaged in 16 weeks of full-body resistance training 3 times/week. Targeting the knee extensor muscles, CONV-G performed 2-4 sets of 15-10 repetitions of leg extensions at 60-85% of 1-RM in all sessions. In the IMCT-G, one weekly session was dedicated to leg extensions as in CONV-G, but in the other two sessions plyometric jumps (2-4 sets, 20-12 jumps) were performed on a specific trampoline device (Tramp Trainer TT). All sessions in the IMCT-G were concluded with foam rolling (1-2 sets, 10 passes) on all sides of the thigh. Ultrasound (SonoSite Micromaxx) and isokinetic dynamometry (Contrex MJ) were used to measure vastus lateralis fascicle pennation angles and echogenicity as well as isometric knee extension strength before, halfway through (8 weeks) and at the end of the intervention. Time × group ANOVAs were used for statistical analyses.
RESULTS: Pennation angles increased from 7.4 ± 1.6° pre-training to 8.2 ± 1.7° (week 8) and 8.9 ± 1.5° (week 16) ($F(2,34) = 5.43$, $p = 0.009$). Mean echo intensities increased non-significantly from 93.7 ± 20.3 to 95.7 ± 19.7 (week 8) and 98.0 ± 22.6 (week 16). Isometric knee extension strength increased in both groups by 22.0 ± 21.6% at week 8 and 29.9 ± 22.3% at week 16 ($F(2,34) = 26.36$, $p < 0.001$). For none of the outcome parameters, significant between-group differences or interaction effects were found.
CONCLUSION: Plyometric jumps and foam rolling acutely induce a strong expression of genes encoding the biosynthesis of various matrix metallopeptidases2. However, incorporation of these stimuli into a standard resistance training program failed to provoke significant changes in muscle echogenicity, indicative of adipose and fibrous tissue infiltrations. Despite an 88% difference in conventional, heavy-weight resistance training volume, both CONV-G and IMCT-G training were similarly effective in increasing pennation angles and muscle strength.
References
1 Wessner et al. (2019), Eur J Sport Sci 19(3):354-64
2 Gumpenberger et al. (2020), Int J Mol Sci 21(19):7089

# Oral presentations

## OP-PN38 Physiology II

### IS CEREBRAL DEOXYGENATION RATE DURING PURE NITROGEN BREATHING AN ADDITIONAL METRIC OF HYPOXIC SENSITIVITY?

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INTRODUCTION: Hypoxic chemosensitivity is a key parameter of adaptation to hypoxia and is generally assessed by measuring the hypoxic ventilatory response (HVR), for example by performing the Richalet test (RT). There are other HVR tests such as the pure nitrogen breathing test (N2T) performed only at rest. Most studies on hypoxic chemosensitivity have focused on cardiorespiratory parameters, but cerebral oxygenation responses may also be of interest. Accordingly, the present study aimed to investigate the relationship between cerebral deoxygenation and HVR during RT and N2T.
METHODS: Twenty-eight healthy participants (Mean ± SD; age 26 ± 2 years; height 175 ± 11 cm; weight 70 ± 12 kg) underwent RT and N2T. In the RT, participants performed four 4-min stages on a cycle-ergometer: resting in normoxia, resting in hypoxia (FIO2 = 0.115), exercising in hypoxia, exercising in normoxia. Exercise intensity was set at 30% of normoxic peak oxygen uptake. In the N2T, participants were exposed in a lying position to a series of 10 periods of pure N2 breathing (random 1-8 consecutive breaths). Minute ventilation ($\dot{V}E$), pulse oxygen saturation (SpO2), and cerebral deoxyhemoglobin (HHb) in the prefrontal cortex were continuously monitored by metabolic cart (Ergocard CPX Pro), pulse oximeter at the earlobe (Nonin), and near-infrared spectroscopy (PortaLite), respectively. In both tests, HVR was calculated as $\dot{V}E$ plotted against SpO2 (HVRRT and HVRN2T, respectively). The linear regression of the slopes of each HHb increase during N2 exposures (S(HHB)N2T) was used as an index of cerebral deoxygenation rate.
RESULTS: HVRRT was similar to HVRN2T (0.469 ± 0.264 vs. 0.484 ± 0.365 L/min/%/kg, P = 0.97). A significant inverse correlation was observed between S(HHB)N2T and HVRRT (R2 = 0.34, P = 0.001). S(HHB)N2T was also correlated to the nadir SpO2 value measured during N2T (P = 0.03) and to the normoxia-to-hypoxia increase in resting $\dot{V}E$ during RT (P = 0.03).
CONCLUSION: The inverse correlation between S(HHB)N2T and HVRRT (i.e., meaning the smaller the cerebral deoxygenation rate during breathing N2, the higher the HVR during the RT) suggests that cerebral deoxygenation might be a potential predictive metric of hypoxic sensitivity. Indeed, a good HVR is known to play a pivotal role in the adaptation to hypoxia and our results indicate that it is accompanied by better preservation of brain oxygenation in the prefrontal cortex. The correlations between S(HHB)N2T and both SpO2 nadir during N2T and normoxia-to-hypoxia increase in resting $\dot{V}E$ during RT strengthen the present assumption. Further studies are requested to evaluate if this easy-to-set-up N2T could be implemented along with HHb measurement as a complementary or alternative measurement to RT. It would also be of interest to assess its potential application to screen high-altitude travelers for AMS risk.

### WHAT PARAMETERS DEFINE MAXIMAL APNEA DURATION?

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INTRODUCTION: The current world record of static breath-holding is set at an astonishing 11 min 35 s in male and 9 min 2 s in female. In order to accomplish such apnea performances, individuals must be able to store large amounts of oxygen and conserve this oxygen efficiently during apnea. Additionally, they should be able to withstand hypoxia (low oxygen levels) and hypercapnia (high carbon dioxide levels) in blood and tissues. Previous research has already gained some insights in the fascinating physiological responses to breath-holding, but a lot of pieces are still missing to the puzzle. The aim of this study is therefore to explore the determining physiological parameters in order to perform longer apneas and to investigate why men can perform longer apneas than women.
METHODS: 28 physically active individuals (23 ± 3 years old), 16 males (180 ± 6 cm; 73.2 ± 7.5 kg) and 12 females (168 ± 8 cm; 64.3 ± 5.8 kg), naïve to apnea participated in this study. All subjects were medically screened for contra-indications. Lung function tests were performed and hemoglobin mass (Hb mass) was determined using the optimized CO-rebreathing method. ANOVA was used to compare differences in apnea duration, Hb mass and vital capacity (VC) between male and female subjects. Linear regressions were used to examine the relation between apnea duration, Hb mass and VC.
RESULTS: Male subjects had an average breath-hold time of 199 s ± 46 s while female subjects could hold their breath on average for 148 s ± 53 s ($p = 0.011$). Hb mass was on average 853.9 ± 106.6 g in men and 618.2 ± 69.1 g in women ($p < 0.001$). Also VC was higher in men with a mean value of 6.1 ± 0.7 L versus a mean value of 4.7 ± 0.6 L in women ($p < 0.001$). Both Hb mass ($p = 0.011$; $R^2 = 0.186$) and VC ($p = 0.001$; $R^2 = 0.336$) showed a significant positive correlation with maximal apnea duration.
CONCLUSION: A higher Hb mass and greater lung volume seems to lead to longer apnea durations. Since men exhibit a higher Hb mass and VC, we expect men to have higher oxygen (O2) storage and carbon dioxide (CO2) buffer capacity which contribute to a longer apnea duration.

### EVIDENCE FOR VOLUME-DEPENDENT CROSS-LEARNING DURING 10 WEEKS OF UNILATERAL HEAVY RESISTANCE TRAINING

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INTRODUCTION: Unilateral training protocols allow one individual to undergo two different treatments within the same timeframe, allocated to each of the two limbs. The benefit of such designs includes increased statistical power, due to within-individual comparisons, with accompanying reductions in required resources. Despite of this, training interventions seldom employ unilateral designs, which is likely due to potential cross-learning effects between the two limbs, whereby training of one limb induces gains in strength in the contralateral limb, as reported in a number of studies. Although the presence of such cross-learning effects is widely accepted, it has proven difficult to conclude on this perspective, due to several methodological issues with previous studies. The goal of the current study was to investigate the potential cross-learning effects during a 10-week unilateral training intervention with two different training volumes or lack thereof.

METHODS: Healthy untrained subjects (♂:12, ♀:27, 24.4±3.9 yrs) participated in a 10-week whole-body training intervention, wherein the legs were exposed to either of three interventions, i) no training, ii) three sets of 10RM resistance training (RT), or iii) six sets of 10RM RT, performed three times per week in a contralateral manner (leg press and knee extension). For these interventions, participants performed either of five combinations: 0-3, 0-6, 3-6, 0-0 and 3-3. Muscle strength was assessed as 1RM (leg press and knee extension) and isokinetic strength (0°/sec, 60°/sec and 240°/sec), performed 4 times during the initial 3 weeks of training and 2 times in week 11. Average weighted mean changes after familiarization were used in analyses. Muscle mass was assessed as mid-thigh muscle thickness (m. vastus lateralis and m. vastus intermedius, ultrasound) in weeks 1, 3, 7 and 11. Group * Time effects were evaluated using mixed-effects models.
RESULTS: Strength development in non-trained legs showed an interaction effect with the training volume performed by the other leg (group * time P=0.011), increasing 6.9 % in 0-6 (95% CI: 1.7, 12.4) and 2.0 % in 0-3 [-2.8, 7.0] compared to 0-0. This was not seen in the 3-set leg (group * time P=0.110). For muscle thickness, neither non-trained legs nor three-set legs displayed contralateral spillover from the trained leg (non-trained legs, group * time P=0.728; three-set leg, group * time P=0.728).
CONCLUSION: In contralateral training designs, cross-learning may affect strength outcome in non-training control limbs, but not muscle mass. The extent of the contralateral training effect seems to be influenced by the prescribed training volume in the trained limb.

**COMPARISON OF AEROBIC FITNESS PARAMETERS WITH DIFFERENT PATTERNS OF VAGAL REACTIVITY FOLLOWING THE ORTHOSTATIC TEST AT REST IN HEALTHY MEN**

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INTRODUCTION: The vagal tank theory is still a metaphor and its applicability in the sports field is not yet fully understood. In human aerobic performance, higher resting vagal activity can lead to saturation vagal activity with a reduction in performance. So, the degree of vagal reactivity (VR) after the orthostatic test (OT) may be a better index and thus make the vagal tank theory more applicable in this area. Therefore, this study aimed to compare the aerobic fitness parameters in men with different VR patterns after the OT at rest.
METHODS: Sixty-three healthy men were evaluated after the OT, and a maximal cardiopulmonary exercise test (CPX) was realized in the sequence. Volunteers were divided into two subsamples of VR based after an OT: low VR (GLRV n = 21), aged 28.5 ±6.2 years, and body mass index (BMI) of 24.4 ± 2.5 kg/m2, and high VR (GHRV n = 21), aged 23.6 ±3.7 years and BMI of 23.3 ± 2.5 kg/m2. The first group was characterized with VR values ≤ 1st tertile and the second group with VR values ≥ 3rd tertile. A Polar RS800® was used to record the RR-interval series at rest for 5 minutes in the supine (sup) and orthostatic (ort) positions. The heart rate variability was analyzed by Kubios software, and the vagal marker was assessed by the pNN50 index. The VR (ΔpNN50) was calculated by subtracting pNN50ort from pNN50sup. The aerobic fitness parameters derived from CPX were: Oxygen Uptake (VO2), velocity associated with VO2 (V-VO2) at the anaerobic threshold (AT), respiratory compensation point (RCP), maximum effort (MAX), and the total time of effort (EXT-time). If the data met the normality assumptions or not (Shapiro-Wilk test), the inferential analyses were run either with the independent t-test or the Mann-Whitney test with a two-tailed $p \leq 0.05$.
RESULTS: We observed a higher value of VR on the GHVR [ΔpNN50: -49.5 (-54.4 - -42.0)%] compared GLVR [ΔpNN50: -7.1 (-12.5 - -1.5)%] ($p < 0.01$). We did not observe any difference between groups (GHVR vs GLVR) on VO2AT [21.5 (19.8 - 24.2) vs 19.9 (17.1 - -24.9) ml.kg-1.min-1] , VO2RCP (39.3 ± 6.6 vs 37.9 ± 7.8 ml.kg-1.min-1) and VO2MAX (47.8 ± 7.6 vs 45.4 ± 7.9 ml.kg-1.min-1) ($p \geq 0.28$). However, GHVR presented higher values of V-VO2 at the AT [V-VO2AT: 6.3 (6.1 - 6.5) km/h], RCP (V-VO2RCP: 9.8 ± 1.5 km/h) and MAX (V-VO2MAX:13.1 ± 1.3) compared GLVR [V-VO2AT: 5.6 (5.2 - 6.0)km/h; V-VO2RCP: 8.7 ± 1.0km/h; V-VO2MAX: 11.2 ± 0.9 km/h] ($p \leq 0.01$). We also observed differences in EXT-time on GHVR (662.2 ± 51.2 seconds) compared GLVR (609.0 ± 58.5 seconds) ($p < 0.01$).
CONCLUSION: The aerobic fitness parameters as V-VO2 (AT, RCP, and MAX) and EXT-time were higher on GHVR than GLVR, despite the same value of VO2 (AT, RCP, and MAX). These results clarify the relationship between higher levels of VR and different classical markers of aerobic fitness. Therefore, this study suggests that the greater VR after the OT, the better its running economy and performance despite the similar VO2 values at AT, RCP, and MAX in healthy men.

**CANNABIS WITH PREDOMINANT THC, BUT NOT CBD, REDUCES CYCLING PERFORMANCE IRRESPECTIVE OF INHALATION METHOD**

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INTRODUCTION: Cannabis is amongst the most widely used recreational substances in the world, primarily for the psychotropic effects of the cannabinoid delta-9-tetrahydrocannabinol (THC), and purported anti-inflammatory, analgesic, anxiolytic, and sleep-promoting effects of the cannabinoid cannabidiol (CBD). Recreational, collegiate, and elite level athletes have reported cannabis and cannabinoid use for a variety of reasons, including perceived ergogenic benefit. However, the effects of cannabis and isolated cannabinoids on exercise performance are poorly characterized. The current study assessed the effects of inhaling cannabis on cycling performance. We further tested the impact of accentuated levels of cannabinoids (THC or CBD) and the method of inhalation.
METHODS: 14 Healthy participants (9M, 5F; VO2max: 50.6±7.6 mL/kg/min) completed 10-min submaximal intensity cycling, followed by a self-paced 20-min functional threshold power test (FTP). Tests were performed under 1) control conditions, 2) after smoking cannabis high in THC (S-THC), 3) after inhaling vaporized cannabis high in THC (V-THC) and 4) after inhaling vaporized cannabis high in CBD (V-CBD) using a dry-flower vaporizer. Indirect calorimetry was performed, and ratings of perceived exertion were recorded throughout exercise.
RESULTS: During submaximal cycling, heart rate was greater in both THC conditions, regardless of inhalation method, compared to control and V-CBD (Control: 116±24bpm, S-THC: 130±18bpm, V-THC: 134±16bpm, V-CBD: 115±19bpm; all $p \leq 0.05$). Oxygen consumption [VO2 (Control: 1764±209mL/min, S-THC: 1838±246mL/min, V-THC: 1688±184mL/min, V-CBD: 1700±217mL/min)] and carbon dioxide production [VCO2 (Control: 1475±226mL/min, S-THC: 1562±208mL/min, V-THC: 1416±177mL/min, V-CBD: 1415±214mL/min) were higher during S-THC compared to both V-THC and V-CBD (lowest common p=0.05). During the 20-minute FTP, average power output was lower in THC conditions compared to control and V-CBD conditions (Control: 218±72W, S-THC: 208±72W, V-THC: 203±73W, V-CBD: 216±72W; each $p \leq 0.05$). Despite reduced average power during the FTP in S-THC and V-THC, there were no differences in heart rate, oxygen consumption, or ratings of perceived exertion across conditions (all $p > 0.05$).
CONCLUSION: These findings suggest that inhalation of cannabis containing the psychotropic cannabinoid THC, reduces cycling performance irrespective of inhalation method. This likely occurs due to a reduction in gross efficiency, evidenced both by accentuated physiological responses to a fixed submaximal workload, and similar responses to a near-maximal effort, despite reduced power output. Additional-

ly, cannabis predominantly containing the non-psychotropic cannabinoid CBD appears to have no effect on cycling performance or the physiological and perceptual responses to exercise.

# Oral presentations

## OP-MH16 Breast cancer/colorectal cancer

### EFFECTS OF LIFESTYLE INTERVENTIONS ON CARDIOMETABOLIC HEALTH IN NON-PHYSICALLY ACTIVE BREAST CANCER SURVIVORS AT RISK OF RECURRENCE: A RANDOMIZED CONTROLLED TRIAL

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INTRODUCTION: Impaired cardio-metabolism, fat accumulation, and low-grade chronic inflammation are associated with an increased risk of breast cancer (BC) development and recurrence [1-3]. Moreover, adjuvant treatments for BC negatively impact maximal oxygen uptake (VO2max) [4]. Interventions aiming at improving metabolic syndrome and cardiorespiratory fitness in BC survivors (BCS) are needed to reduce the risk of comorbidities and improve BC outcomes. This randomized controlled trial assessed the effects of a 12-week aerobic exercise intervention on metabolic syndrome related risk factors and VO2max in non-physically active BCS.
METHODS: 41 BCS (women; stages 0-II; non-metastatic; age 51.6±7.0 years; non-physically active) with a risk factor for recurrence due to metabolic or endocrine disorders underwent a 12-week lifestyle intervention based on nutrition and exercise. Women were randomly allocated to an intervention (IA) or a control (CA) arm. In addition to counselling on diet habits and physical activity, which were provided to both arms, IA performed a 12-week remotely (1 session/week) and on-site (2 sessions/week) supervised aerobic exercise training program having progressive increases in exercise intensity (40%-70% of heart rate reserve) and duration (20-60 min). Participants estimated VO2max, %fat mass (%FAT), glycemia (GLY), LDL, and triglycerides (TRI) were assessed before (t0) and after (t1) the lifestyle interventions. A repeated measure MANOVA (α=0.05), followed by univariate ANOVAs, were used to assess the effects of time (t0 and t1, repeated measure), intervention (IA and CA), and their interaction on VO2max, %FAT, GLY, LDL, and TRI.
RESULTS: Significant multivariate effects were found for time ($p<0.001$) and its interaction with intervention ($p=0.019$), whereas no significant multivariate effect was found for intervention ($p=0.401$). Univariate analyses showed a significant effect of time on LDL (t0=132.7±30.7, t1=122.3±26.9, $p=0.003$) and %FAT (t0=31.7±7.1, t1=29.9±6.5, $p<0.001$) levels of both groups, which decreased, while no significant changes over time were found on VO2max ($p=0.342$), GLY ($p=0.875$), and TRI ($p=0.348$) levels. The interaction between time and intervention was significant only on the VO2max levels ($p=0.037$), which increased in IA (t0=31.0±6.7, t1=32.5±6.0) and slightly decreased in CA (t0=31.7±4.5, t1=31.1±4.7), whereas no significant differences were found between IA and CA GLY ($p=0.407$), LDL ($p=0.080$), TRI ($p=0.441$), and %FAT ($p=0.128$) changes over time.
CONCLUSION: Lifestyle interventions attenuated metabolic syndrome risk factors by reducing LDL and %FAT. However, only a structured and supervised exercise prescription improved VO2max in BCS, supporting the inclusion of supervised clinical exercise programs into BCS treatment and survivorship care plans.
References:
1. Pasanisi P, et al., Int J Cancer, 2006
2. Calip GS, et al., Breast Cancer Res Treat, 2014
3. Lauby-Secretan B, et al., N Engl J Med, 2016
4. Peel AB, et al., J Am Heart Assoc, 2014

### EFFECTS OF HEAVY-LOAD STRENGTH TRAINING DURING (NEO-)ADJUVANT CHEMOTHERAPY ON MUSCLE STRENGTH AND MUSCLE CELLULAR OUTCOMES IN WOMEN WITH BREAST CANCER

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INTRODUCTION: (Neo-)adjuvant chemotherapy for breast cancer has deleterious effects on skeletal muscle mass, muscle cells, and muscle function (1,2). Physical exercise during treatment may counteract some of these negative effects. However, the effects of strength training (ST) only are not well documented. The aim of the current study was to investigate if heavy-load ST during (neo-)adjuvant chemotherapy treatment counteracts deleterious effects on skeletal muscle fiber CSA, myonuclear content and satellite cell number in women diagnosed with breast cancer.
METHODS: Women diagnosed with stage I-III breast cancer were randomly allocated into a strength training intervention group (INT, n=23) and a waiting list control group (CON, n=17). The INT group performed supervised heavy-load ST twice a week over the course of chemotherapy treatment (approximately 16 weeks) whereas the CON group was encouraged to continue with their usual activities. Testing of muscle strength and collection of muscle biopsies from m. vastus lateralis was performed before the first cycle of chemotherapy (T0) and after the end of chemotherapy treatment (T1).
RESULTS: One repetition maximum increased in the intervention group in both chest press (10.2±8.2%, $p<0.01$) and leg press (11.1±7.7, $p<0.01$) from T0 to T1 whereas no significant changes occurred in the control group. The percent change from T0 to T1 was different between groups ($p<0.01$).
Preliminary data from a subset of the muscle biopsies showed no significant change and no differences between groups in muscle fiber cross-sectional area (CSA) (INT n=6, CON n= 4), myonuclear content (INT n=13, CON n= 5) or satellite cell content (INT n=11, CON n= 8) in neither muscle fiber type 1 nor muscle fiber type 2.
CONCLUSION: The ST program was effective in increasing the muscle strength in women treated for breast cancer during (neo-)adjuvant chemotherapy treatment. There were, however, no changes in muscle fiber CSA or other cellular outcomes after strength training. Both the lack of reduction in muscle fiber CSA during chemotherapy in the control group and the lack of increase in the intervention group contrasts with a previous study that reported reduced muscle CSA after usual care and increased muscle CSA after strength training combined with high-intensity interval training (1). In fact, in our data, there was a tendency to a negative effect of ST on muscle CSA, myonu-

clear content, and satellite cell content. However, our results are preliminary, and results might change when analyzes of all biopsies are finished.

REFERENCES:
1. Mijwel et al., FASEB J, 2018, 32(10):5495-5505.
2. Klassen et al., J Cachexia Sarcopenia Muscle, 2017, 8(2):305-316.

**IMPACT OF A SELF-DETERMINATION THEORY-BASED EXERCISE INTERVENTION ON COLORECTAL CANCER PATIENTS' PSYCHOLOGICAL AND BEHAVIORAL OUTCOMES DURING ADJUVANT CHEMOTHERAPY: A PRELIMINARY QUALITATIVE REPORT**

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Introduction
Physical activity (PA) improves survival, reduces death, and entails physical and psychological benefits in colorectal cancer (CRC) patients throughout oncological treatment. However, such exhaustive toxic regimens have side effects that reduce patients' quality of life and their PA levels [1]. Given these circumstances, the development of appropriate programs to support motivation towards PA in these patients represents an important challenge to address by researchers and healthcare professionals. In this qualitative study, we explore the effects of a 6-month exercise program grounded on self-determination theory (SDT) on basic psychological needs satisfaction and different psychological and behavioral consequences in CRC patients under adjuvant chemotherapy. Theoretical frameworks such as SDT could help to optimize exercise interventions and their health outcomes [2].
Methods
Sixteen CRC patients enrolled in a motivational exercise program participated in the study (Mage = 64, SD = 11.58). The sample also included six relatives and the whole oncology team (three oncologists and two nurses) of the hospital where the program was delivered (Hospital Universitario Puerta de Hierro, Spain). The intervention (FIT-CANCER) consisted of three 60-min sessions per week (face-to-face and online modality), and began with the start of patients' chemotherapy. Sessions were designed including motivational techniques from SDT with the purpose of satisfying patients' needs for autonomy, competence, relatedness, and novelty. Qualitative data were collected through semi-structured interviews and observation (field notes), and were analyzed following thematic analysis.
Results
The CRC patients felt their needs for autonomy, competence, relatedness, and novelty were satisfied during the SDT-based exercise program, giving rise to positive psychological and behavioral outcomes during the chemotherapy process. Among these, patients reported enhanced self-esteem, better mood and optimism, greater vitality and well-being, and increased sociability due to their participation in the program. Additionally, patients showed a high engagement with the exercise program, and increased their knowledge about physical exercise after participating on it.
Conclusion
Our results highlight the importance of implementing motivational exercise programs to enhance patients' functioning and well-being during the chemotherapy treatment.
References
1. Vallance, J. K., and Courneya, K. S. Social-cognitive approaches to understanding exercise motivation and behavior in cancer survivors. In G. C. Roberts and D. C. Treasure (Eds). Advances in motivation in sport and exercise (p. 299-326). 2001. Human Kinetics.
2. Ntoumanis et al. A meta-analysis of self-determination theory-informed intervention studies in the health domain: effects on motivation, health behavior, physical, and psychological health. Health Psychol Rev, 2021, 15(2): p. 214-244.

**EFFECTS OF EXERCISE ON SYSTEMIC INFLAMMATION IN PATIENTS WITH BREAST CANCER: A RANDOMIZED CONTROLLED TRIAL**

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INTRODUCTION: Exercise training has been proposed as a means to regulate systemic inflammation during and after cancer treatment. However, the effects of exercise on systemic inflammation remain uncertain in patients with breast cancer. The aim of this study was therefore to evaluate the effect of exercise on systemic inflammation in patients with breast cancer.
METHODS: This study is a secondary analysis of a multicenter randomized controlled trial (EBBA II, NCT02240836). Women 18-75 years of age with newly diagnosed stage I-II breast cancer were eligible. Included patients were randomized 1:1 to standard care plus exercise (EX) or standard care alone (CON) stratified by menopausal status. Standard care consisted of surgery potentially followed by radiation, chemotherapy, and endocrine therapy. The exercise intervention was initiated 3 weeks after surgery and consisted of supervised, group-based, aerobic high-intensity interval training as well as strength training for 60 min 2x/week combined with home-based, moderate-intensity, aerobic training for 150 min/week for 12 months. Blood samples were collected before surgery, at 6 months and at 12 months and analyzed for plasma concentrations of C-reactive protein (CRP), interleukin (IL) 1β, IL-6, IL-8, IL-10 and tumor necrosis factor-α (TNF-α). Intention-to-treat analyses of between-group differences in changes from pre-surgery to 12 months were performed using linear mixed-effects models. Subgroup analyses were performed for patients receiving adjuvant chemotherapy. To increase model compliance, outcomes were analyzed on log-scales and estimated differences were back-transformed and reported as relative ratios (RR) with 95% confidence intervals (CI).
RESULTS: Among 491 breast cancer patients (age: 55±10 yrs, BMI: 25.5±4.7 kg·m2) 52% received chemotherapy, 80% received radiation, and 56% received endocrine therapy. Preliminary analyses show between-group differences for CRP (RR: 1.08, 95%, CI: 0.87 to 1.33, P= 0.50), IL-1β (RR: 0.99, 95%CI: 0.78 to 1.25, P= 0.94), IL-6 (RR: 1.03, 95% CI: 0.92 to 1.15, P= 0.63), IL-8 (RR: 0.97, 95%CI: 0.89 to 1.04, P=0.37), IL-10 (RR: 1.04, 95%CI: 0.94 to 1.14, P=0.50), or TNF-α (RR: 1.02, 95%CI: 0.97 to 1.07, P=0.50). In the subgroup analyses of patients receiving chemotherapy, we found a larger reduction in IL-10 in EX compared with CON (RR: 1.15, 95%CI: 1.01 to 1.32, P=0.046), whereas no between-group differences were found for CRP (RR: 1.15, 95%CI: 0.88 to 1.51, P= 0.32), IL-1β (RR: 0.94, 95%CI: 0.69 to 1.28, P= 0.68), IL-6 (RR: 1.07, 95%CI: 0.92 to 1.25, P= 0.36), IL-8 (RR: 0.97, 95%CI: 0.89 to 1.06, P= 0.52) or TNF-α (RR: 1.04 , 95%CI: 0.97 to 1.12 , P=0.27).
CONCLUSION: Among these breast cancer patients, a 12 months exercise intervention post surgery has no effect on systemic CRP, TNF-α, IL-1β, IL-6 or IL-8 but may reduce IL-10 in patients receiving chemotherapy.

# Oral presentations

## OP-AP09 Strength training

### THE EFFECT OF A FOUR-WEEK STRENGTH AND POWER PROGRAM ON SPRINT PERFORMANCE IN COURT-BASED WHEELCHAIR ATHLETES

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INTRODUCTION: It is well documented that strength and power training has positive effects on sprinting performances in able-bodied athletes, but there is a lack of evidence investigating if the same could be said for wheelchair athletes. Therefore, the purpose of this study was to investigate if a four-week strength, power and resisted sprint training program improved maximal strength, power and sprint speed performance in male court-based wheelchair athletes, post a COVID-19 detraining period.
METHODS: Sample size calculations identified that 10 participants were needed for this study (determined from a similar explosive strength intervention in wheelchair athletes measuring acceleration over 20m (Ozmen et al., 2014), where effect size was dz = 1.03). Therefore, five national and seven international level male wheelchair athletes, with strength training experience were recruited for the study (Age; 29 ± 11 years, Mass; 79.44 ± 15.36 kg, Wingspan; 178.21 ± 13.14 cm, Training Age 6 ± 3 years). Participants Pre and Post strength and power intervention testing consisted of 3RM bench press, 2.5m, 5m and 10m sprint times and seated medicine ball throw for distance. The training intervention consisted of three training sessions per week, two gym-based session and one resisted sprints session. The gym based sessions were 60 – 75 minutes in duration, consisting of one heavy strength day, and one ballistic day. The resisted sprint program consisted of resisted sprints using an (EXER-GENIE® speed trainer, Thousand Oaks, CA, USA), set at a light resistance of 3 – 6kg. Analysis included a Wilcoxon S-R test (sprints), and a paired t-test (Med ball throw and 3RM), $\alpha = 0.05$.
RESULTS: We identified improvements in 2.5 m (Pre Median 0.96 sec vs Post Median 0.90 sec, $z = 2.46$, $p = 0.014$), 5m sprint (Pre Median 1.90 sec vs Post Median 1.79 sec, $z = 3.07$, $p = 0.002$), 10m sprint (Pre Median 3.45 sec vs Post Median 3.34 sec, $z = 2.94$, $p = 0.003$), Seated medicine ball throw (mean increase 12.64cm; 95%CI [5.42 to 19.85cm], $p = 0.003$, Cohen's dz = 1.11 [Large]) and 3RM bench press (mean increase 6.04kg; 95% CI of difference [4.70 to 7.39kg], $p \leq 0.001$, Cohen's dz = 2.85 [Very Large]).
CONCLUSION: The results of this four-week intervention show that heavy strength, power and resistance training was sufficient in improving maximal strength, power and sprint speed performances in court-based wheelchair athletes, post a COVID-19 detraining period. This supports previous work in this area that suggests that heavy strength training along with explosive strength be it from ballistic strength exercises or resisted sprint work should be utilised more with wheelchair athletes to promote an increase in sprint acceleration.
REFERENCE: Ozmen, T. et al. (2014) 'Explosive strength training improves speed and agility in wheelchair basketball athletes', Revista Brasileira de Medicina do Esporte, 20(2), pp. 97–100. doi: 10.1590/1517-86922014200201568.

### NEUROMUSCULAR ADAPTATIONS TO LONG TERM VS PERIODIC INCLUSION OF ISOMETRIC TRAINING

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INTRODUCTION: The inclusion of isometric training (ISO) has been reported to improve strength and the performance various sports related skills (Lum and Barbosa, 2019; Lum et al., 2021). However, no study has compared the adaptations to long term (>24 weeks) and periodic inclusion of ISO. The aim of the study was to compare the effects of including isometric training for consecutive 24 weeks (CISO) against a periodic inclusion (PISO) of this mode of training, on strength and dynamic performances.
METHODS: 24 elite floorball athletes (age: 23±2.7 years, stature: 1.74±2.08 m, body mass: 72.7±14.4 kg) were randomly assigned to the control (CON), CISO, or PISO group. Athletes completed 20-m sprint, countermovement jump (CMJ) and isometric mid-thigh pull (IMTP) during pre-test and were tested on week 6, 12, 18 and 24. All groups performed a similar strength training program twice per week. However, two sets of squats were replaced with isometric squat in CISO for all 24 weeks, but only on weeks 1-6 and 13-18 for PISO.
RESULTS: A significant main effect for time was observed for 5-, 10-, and 20-m sprint time, CMJ height, peak force, peak power, time to take-off, modified reactive strength index, IMTP peak force, relative peak force and force at 200 ms (P= <0.001-0.037). CISO resulted in greater improvement in 5-m sprint time than CON at week 24 (P=0.024, g=1.17). Both CISO and PISO resulted in greater improvements in 10-m sprint time than CON at various time points (P=0.007-0.038 and 0.038, g=1.07-1.44 and 1.18, respectively). CISO and PISO resulted in greater improvements in 20-m sprint time than CON at week 6 (P=0.007 and 0.025, g=1.65 and 1.40, respectively). While no significant difference in percentage change in CMJ height between groups, a small to large effect was observed in favour of CISO as compared to CON (P=0.179, g=0.90) and PISO (P =0.542, g=0.49) at week 24. Similarly, no significant difference in the change in all IMTP measures. However, a moderate effect in favour of CISO and PISO as compared to CON was observed for IMTP peak force (P =0.413, g=0.58 and P=0.560, g=0.56, respectively) at week 24.
CONCLUSION: The current results support the findings of previous studies, indicating that the inclusion of ISO is beneficial to both strength and dynamic performance as compared to dynamic resistance training alone. However, while CISO seems to result in greater positive effect on 20-m sprint and CMJ performance, there was no clear difference on its effect on maximal strength as compared to PISO.

### THE EFFECTS OF DIFFERENT VELOCITY LOSS THRESHOLDS DURING BENCH PRESS TRAINING WITH LIGHT LOADS

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INTRODUCTION: In recent years the practicability of velocity-based training (VBT) approach for monitoring and real-time prescription of resistance training (RT) intensity and volume has been demonstrated [1,2]. In this regard, it has been shown that higher velocity loss (VL) thresholds (25-50%) maximized muscle hypertrophy, while lower VL thresholds (<25%) evoked positive neuromuscular-related adaptations using an intensity-matched design training, from 70 to 85% one-repetition maximum (1RM), in the bench press (BP) exercise [2]. However,

it is currently unknown if these findings could be extrapolated to lower intensities. Therefore, this study aimed to compare the effect of four VL thresholds – 0% (VL0), 15% (VL15), 25% (VL25) and 50% (VL50) – on strength gains during the BP exercise using intensities ranging from 40% to 55% 1RM.
METHODS: Forty-seven males were randomly and assigned to four groups: VL0 (n=10), VL15 (n=13), VL25 (n=12) and VL50 (n=12) that followed an 8-week (16 sessions) VBT program in BP. A progressive loading BP test was performed before (Pre) and after (Post) training. From this test the following variables were calculated: a) average mean propulsive velocity (MPV) attained against all absolute loads common to Pre- and Post-training (AV); b) average MPV attained against absolute loads that were lifted equal or faster than 0.8 m·s−1 at Pre-training (AV≥0.8); c) average MPV attained against absolute loads that were lifted slower than 0.8 m·s−1 at Pre-training (AV<0.8); d) 1RM.
RESULTS: No significant group × time interactions were noticed for any of the variables analyzed (all P>0.05). Significant time effects were observed for all variables (all P<0.001). All groups showed significant improvements in 1RM, AV, AV<0.8 (P < 0.001-0.05). The VL15, VL25 and VL50 interventions showed significant gains in AV≥0.8 (P < 0.001-0.05), but this was not found for VL0.
CONCLUSION: These findings indicate that after an 8-week VBT program carried out in the BP using light loads (40% to 55% 1RM), a VL threshold of 15% provides a sufficient training stimulus to improve strength performance to a similar magnitude than higher VL thresholds (25% and 50%), despite the considerable differences in the training volume accumulated by each group.
REFERENCES
1. González-Badillo & Sánchez-Medina. Int J Sports Med, 2010.
2. Sánchez-Medina & González-Badillo. Med Sci Sports Excer, 2011
3. Pareja-Blanco et al. Scand J Med Sci Sports, 2020.

**EFFECT OF SIX WEEKS' IN-SEASON HIGH VS. MODERATE-INTENSITY RESISTANCE TRAINING ON STRENGTH, POWER AND MUSCLE SORENESS IN MALE ACADEMY SOCCER PLAYERS**

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INTRODUCTION: Strength and conditioning (S&C) coaches in youth soccer actively seek to improve sport specific actions, such as acceleration, sprinting and jumping, through a variety of training methods, of which resistance training (RT) is a central component [1]. However, recently published research suggests that soccer S&C coaches typically implement three sets of eight repetitions at a moderate intensity, when aiming to develop strength in-season. Further, from this PhD project, two limiting factors reported by S&C coaches for incorporating RT into their programmes are time constraints and concerns regarding delayed onset muscle soreness (DOMS) following RT. The aims of this study were to investigate the impact of high- vs. moderate-intensity RT vs. pitch-based soccer training only on changes in strength, power, and speed, and to compare DOMS between training groups in male academy soccer players (ASP).
METHODS: Twenty-two ASP (18±1 years-old) were assigned to either a high-intensity RT (HRT: n=8), moderate-intensity RT (MRT: n=7) or a soccer training-only control group (CON: n=7). HRT completed 2x4 parallel back squat (PBS) repetitions at 90% single-repetition maximum (1RM), while MRT performed 3x8 PBS repetitions at 80% 1RM, both once a week for six-weeks in-season alongside regular soccer training. CON performed pitch-based soccer training only for six weeks. All groups completed the following pre- and post-training assessments: 3RM PBS; bilateral vertical and horizontal countermovement jump (CMJ) height/distance; squat jump (SJ) height; and 20m sprint. DOMS was assessed via visual analogue scale after each training session throughout the six-week period.
RESULTS: HRT and MRT experienced similar increases compared to CON in absolute PBS 3RM (+16±8% vs. +27±16% vs. +2±3%, p<0.001), SJ height (+6±6% vs. +11±7% vs. -7±6%, p=0.001), CMJ height (+8±3% vs. +10±6% vs. -4±10%, p=0.008) following training. Further, there was a greater increase in PBS 3RM relative to body mass following HRT than MRT and CON (+23±8% vs. +16±14% vs. +3±4%, p=0.001) and horizontal CMJ distance improved in HRT but not in MRT or CON (+11±5%, +7±7% and +2±4%, respectively, p=0.011). Sprint time did not change in any group (p>0.05). HRT volume was 58±15% lower than that of MRT (p<0.001) and DOMS measured throughout training did not differ between groups (p=0.487).
CONCLUSION: These findings suggest that one HRT session a week is an efficient method to improve lower-limb strength and power in ASP in-season compared to MRT and pitch-based soccer training only. Importantly, HRT achieved this with 58% less training volume than MRT, and similar DOMS to soccer training alone, thus highlighting the effectiveness of HRT and supporting its incorporation into a standard in-season ASP training programme.
References:
1. McQuilliam SJ, Clark DR, Erskine RM, et al. Free-Weight Resistance Training in Youth Athletes: A Narrative Review. Sports Medicine 2020. DOI: 10.1007/s40279-020-01307-7.

## Oral presentations

### OP-BM08 Biomechanics and jumping II

**THE INFLUENCE OF ASSISTED AND RESISTED VARIABLE RESISTANCE BACK SQUAT ON SUBSEQUENT COUNTER MOVEMENT JUMP PERFORMANCE**

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INTRODUCTION: Back squat warm-up activities using elastic band (EB) resistance in combination with free weight resistance (FWR) can improve subsequent countermovement jump (CMJ) performance (1), a phenomenon termed post-activation performance enhancement (PAPE). However, these improvements are reported using a traditional EB attachment site that creates additional downwards resistance (RES) with no data available of alternative positioning that would create upwards EB assistance (ASS). Therefore, the aim of this study was to compare the influence of two EB attachment sites (RES and ASS) with FWR alone following a task-specific comprehensive warm-up on subsequent CMJ performance.
METHODS: Fifteen active males (age = 25.5 ± 3.5 y, height = 1.7 ± 6.2 m, mass = 80.5 ± 9.9 kg) volunteered to participate in this study and completed three conditions (FWR, RES, ASS) in a randomised order each separated by at least 48 h. During each condition the participants

completed baseline 1 (BL1) CMJ measures and then performed a task-specific comprehensive warm-up consisting of 5 mins of cycling, two sets of 5 bodyweight squats, 5 continuous CMJs at 70% of perceived maximum and finally, maximal CMJs were performed every 30s until 3 consecutive jumps were within 3% of jump height. This was followed by baseline 2 (BL2) CMJs and participants then performed 3 back squats of either RES, ASS or FWR at 85% 1-RM with 35% of load generated during the ASS and RES EB conditions. CMJs were then performed 30 s, 4 min, 8 min and 12 min later.
RESULTS: Significant ($p < 0.05$) increases in the ASS condition from BL1 in jump height (4.6-11.8%) and power (3.3-8.0%) occurred at 30 s, 4 min, 8 min, 12 min and from BL2 in jump height (3.9-6.9%) and power (3.0-4.6%) at 30 s, 4 min were observed. Similar significant increases were observed in the RES condition in jump height from BL1 (4.7-10.3%) and power (2.4-6.5%) at 30 s, 4 min, 8 min, 12 min and from BL2 in jump height (4.1-5.3%) and power (2.7-4.0%) at 30 s, 4 min, 8 min. Again, significant increases were observed in the FWR condition in jump height from BL1 (4.5-9.0%) and power (3.0-5.4%) at 30 s, 4 min, 8 min and from BL2 in jump height (3.5%) and power (1.8%) but only at 30 s.
CONCLUSION: The implementation of EB variable resistance during back squats utilising either the ASS and RES attachment sites elicited greater increases in jump performance compared with the FWR condition. The different attachment methods of the EB during back squats alter the loading characteristics allowing the lifter to operate at near maximal levels for a greater proportion of the lift providing a greater stimulus, which may potentially explain the greater and prolonged increase in subsequent jump performance.
REFERENCES
1. Mina et al. (2019). Scand J Med Sci Sports. 29(3):380-392.

### PRINCIPAL COMPONENT ANALYSIS OF DYNAMIC AND KINEMATIC PREDICTORS OF MAXIMUM VERTICAL JUMP ON TRAINED AND UNTRAINED PERFORMERS

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INTRODUCTION: Muscle stretch-shortening cycle (SSC) is a common element at several sports with reversible action on lower limbs at countermovement (CM) namely in running and jumping [1]. At lower limbs, muscle SSC has been assessed on maximum vertical jumps (MVJ) due to its standard protocol, experimental control, and accessibility on long CM at countermovement jump (CMJ) and short CM at drop jump (DJ) for comparison with squat jump (SJ) without CM [2,3]. Nevertheless, high dimensionality, strong correlation and time dependence of dynamic and kinematic data on MVJ point for the need of dimension reduction while preserving maximum explained variability. Also, according to the objective of strength training it is determinant to detect principal factors to be trained [4].
METHODS: For this reason, we applied principal components analysis (PCA) to dynamic and kinematic predictors of MVJ on trained and untrained male performers. Trained group (T) is composed by nT=16 athletes of the Portuguese national volleyball team (21.4±3.1)yrs, (85.2±5.8)kg mass and (1.93±0.04)m height, and untrained group (U) composed by nU=6 students of sports and physical education degree, without specific sports records or injuries, ages (21.5±1.4)yrs, (76.7±9.3)kg mass and (1.79±0.06)m height.
Each group performed a total of 3 SJ, CMJ and DJ, with acquisition of ground reaction forces (GRF) by an AMTI BP2416-4000CE force plate at 1000 Hz and Mini Amp MAS-6. Best repetition of SJ, CMJ and DJ was selected for each subject based on flight time method and vertical GRF was used to obtain 51 dynamic and kinematic predictors of MVJ. Selected variables were grouped on four communities of (i) time-force-impulse (t-F-I), (ii) force-velocity-power (F-v-P), (iii) force-displacement-work (F-z-W) and (iv) global (t-F-I-v-P-z-W) community of whole-body center of gravity. PCA was applied to each community and results were compared among T and U groups.
RESULTS: Differences were detected with higher number of principal components (PC) of scree value above 1 at T in relation to U group, with T group presenting higher PC at CMJ and DJ than SJ, whereas explained variance presented higher values at U group (i) 96.9%, 96.7%, 92.4%; (ii) 97.0%, 97.5%, 98.0%; (iii) 93.4%, 99.6%, 97.6%; (iv) 97.7%, 100%, 100% at SJ, CMJ, DJ than T group (i) 92.0%, 89.3%, 89.7%; (ii) 90.2%, 95.5%, 93.6%; (iii) 85.5%, 84.6%, 89.5%; (iv) 92.8%, 95.6%, 95.5%. Differences were also detected on first two PC loads at (i) - (iv) factors for U and T groups on SJ, CMJ and DJ.
CONCLUSION: PCA conduced to differences at explained variances on (i) - (iv) factors with the need of larger number of PCs on T than U group to explain the same variance corresponding to higher variable complexity at T in relation to U group.
1. Komi PV (2003) Strength and Power in Sport. Blackwell Science
2. Carvalho et al (2002) Proc. 7th ECSS p 865
3. Rodrigues et al (2020) Proc. 25th ECSS p 143-144
4. Zatsiorsky VM et al (2006) Science and Practice of Strength Training (2 ed). Human Kinetics

### ALTERED LOADING ABSORPTION AFTER DROP JUMP AND DROP LANDING IS RELATED TO LOWER MUSCULAR PRE-ACTIVATION TIME, IN ATHLETES WITH CHRONIC ANKLE INSTABILITY

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INTRODUCTION: Chronic Ankle Instability (CAI) is a condition characterized by neuromuscular, range of motion, and postural control deficits that predispose athletes to reinjure. Previous data have shown altered landing strategies in people with CAI when compared to healthy controls. Whether these adaptations are related to ankle muscles activation patterns, has not been documented. This knowledge would be of much use for programing physical rehabilitation protocols to prevent the progression of CAI. Thus, our purpose was to determine the relationship between ground reaction force (GRF) parameters and muscle pre-activation time (PaT), among subjects with and without CAI, after a drop jump (DJ) and a drop landing (DL).
METHODS: 30 young volunteers were classified in two groups (CAI, n = 15; Control (CON), n = 15) according to the recommendations of the International Ankle Consortium. Groups were similar in height, body mass and gender distribution. Each participant performed 5 DJ and 5 DL from a platform of 40 cm height, landing on a force plate recording GRF and synchronized to surface electromyography (sEMG) signals from tibialis anterior (TA), peroneus longus (PL) and peroneus brevis (PB). The GRF signals were low pass filtered (20 Hz), normalized to body weight, and then processed to calculate the maximal GRF (FMax) and the loading rate (LR) from the time of initial contact to when FMax was achieved. Signals from sEMG were band pass filtered (10-450 Hz) and then processed (RMS 20 ms, 10 ms overlap) and compared to initial contact time to calculate PaT. Comparisons among groups were performed using Mann-Withney test, and correlations using Spearman test. A p value <0.05 was considered as significant.
RESULTS: FMax was larger for CAI after DJ (CAI 3.4±0.6 N/N vs CON 3.0±0.3 N/N; $p<0.01$) but was not different from CON after DL. LR was larger for CAI after both DJ (CAI 35.7±13.3 N/N*s vs CON 24.5±10.0 N/N*s; $p<0.01$) and DL (CAI 41.3±10.4 N/N*s vs CON 35.0±5.9 N/N*s;

p<0.01). PaT was smaller in PB for CAI after DJ (CAI 187.1±199.2 ms vs CON 374.4±325.2 ms; p<0.01) and DL (CAI 166.9±176.1 ms vs CON 437.3±348.5 ms; p<0.01). TA PaT was larger for CAI after DL (CAI 152.0±77.9 ms vs CON 114.1±30.3 ms; p<0.01) but was not different from CON after DJ. No differences were found in PL PaT in both jumps. Moderate negative correlations were found for LR with PB PaT after DJ (r=-0.42; p<0.01) and DL (r=-0.31; p=0.02), and with PL PaT after DJ (r=-0.46; p<0.01). Fmax had a small negative correlation with PB PaT after DJ (r=-0.26; p=0.04), and a small positive correlation with TA PaT after DL (r=0.27; p=0.04).
CONCLUSION: Subjects with CAI exhibit less GRF absorption after dropping from a medium altitude, which is related to a lower PaT from relevant muscles around the ankle. This condition might contribute as a major risk factor for ankle reinjure. Patients with CAI might benefit from including loading absorption strategies derived from muscular control in their rehabilitation protocols.

### ARE FOOT POSTURE AND MORPHOLOGICAL DEFORMATION ASSOCIATED WITH ANKLE PLANTAR FLEXION PERFORMANCE AND VERTICAL DROP JUMP KINETICS ?

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INTRODUCTION: The human foot is composed of passive elastic and active components that allow energy absorption and generation during jumping [1]. Previous studies have shown that individuals with a stiffer foot medial longitudinal arch displayed greater isokinetic ankle plantarflexion peak torque and vertical stiffness during a vertical drop jump task (VDJ) [2,3]. However, the degree of relationships between these tasks and various foot posture and morphological deformation measurements are not clearly understood. Therefore, we hypothesized that foot morphological deformation will be associated with ankle plantarflexion performance and VDJ kinetics whereas foot posture will not. We also hypothesized that the association with foot morphological deformation in 3 dimensions will be greater than 1 or 2 dimensions.
METHODS: In thirty-height healthy participants (n=18 females, 29.2±5.0yrs, body mass index (BMI) 22.8±2.7), we assessed the foot posture using the Foot Posture Index and the foot morphological deformation in 1, 2 and 3 dimensions using the Arch Height Index Measurement System [4]. Ankle plantarflexion performance in different contraction modes was assessed in prone position using an isokinetic dynamometer whereas kinetic variables during eccentric and concentric VDJ subphases were analyzed using two force platforms. A principal component analysis (PCA) was applied to the ankle plantarflexion and kinetics performance data. To understand the relationship between the identified principal components (PCs) and foot morphological deformation outcome a Pearson product moment correlation (r value) was used.
RESULTS: PCA revealed 12 PCs that captured more than 99% of the variability within the data. On these PCs, only 2 were found with correlations ≥ 0.4 with VDJ jump height performance (PC1 : r = 0.47; PC2 : r = 0.79). PC1 was made up of 12 variables whereas PC2 was made up of 11 variables highlighting 4 clusters of participants with different performance strategies and neuromuscular capacities. However, no PCs identified within the ankle plantarflexion and kinetics performance data showed a clear correlation (r <0.3) with foot posture or foot morphological deformation outcomes.
CONCLUSION: While foot posture and foot morphological deformation remain of interest in characterizing foot morphology across individuals, these parameters may not influence ankle plantarflexion performance and VDJ kinetics. These findings highlight the lack of clinical relevance of static and passive foot evaluations in predicting dynamic foot function. Further studies should focus on the validation of specific dynamic foot measures (eg. active stiffness, strength) in order to help clinicians at understanding the role of the human foot at enhacing lower limb and ankle performance.
References:
1. Smith RE et al. (2021). J Exp Biol. 224(13).
2. Snook AG et al. (2001). Foot Ankle Int. 22(3):234-240.
3. Grozier CD et al. (2021). J Biomech.118:110322.
4. Fraser JJ et al. (2021). Foot (Edinb). 46:101717.

## Oral presentations

### OP-BM14 Muscle Tendon Function

### INCREASING PRELOAD INCREASES MUSCLE FASCICLE STRETCH AMPLITUDES BUT NOT RFE DURING MAXIMAL VOLUNTARY ECCENTRIC DORSIFLEXION CONTRACTIONS

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INTRODUCTION: Muscle fascicle kinematics can be decoupled from muscle-tendon unit (MTU) kinematics due to MTU compliance, so that muscle fascicles can even shorten during MTU lengthening [1]. Understanding how preload affects decoupling during MTU lengthening contractions is important for residual force enhancement (rFE) studies as the magnitude of rFE increases with increasing stretch amplitude [2]. Therefore, this study aimed to evaluate how different preloads (PL) affect fascicle stretch amplitudes during maximal voluntary eccentric MTU contractions of the human tibialis anterior (TA) and the rFE elicited by these contractions.
METHODS: Participants (n=4) were in a reclined sitting position (~68° recline, ~90° knee flexion) with their right foot attached to a modified footplate that was connected to a dynamometer crank arm. After a standardized warm-up, participants performed 3 maximal voluntary fixed-end reference contractions at shank-footplate angles of 5° dorsiflexion (REFS) and 35° plantarflexion (REFL) in a randomized order. Three maximal voluntary MTU lengthening contractions per condition were then performed from REFS to REFL at 40°/s in a randomized order at 0% (PL0), 50% (PL50), and 100% preload (PL100) of the REFS peak torque. Participants received real-time visual feedback of their ankle joint torque, which they attempted to keep within two predefined torque ramps that were 2.5% above and below a target torque, and were instructed to contract as hard and fast as possible when the dynamometer crank arm started moving. Participants held each contraction for 4 sec after the end of the crank arm rotation. Torque, crank arm angle, and TA muscle activity were recorded at 2 kHz using a 16-bit ADC and TA muscle architecture changes were recorded using B-mode ultrasound at 50 fps.

RESULTS: Muscle activity amplitudes (REFL: 0.58±0.20 V, PL0: 0.54±0.19 V, PL50: 0.53±0.23 V, PL100: 0.48±0.21 V), net active torques (REFL: 47.8±26.1 Nm, PL0: 52.4±26.8 Nm, PL50: 49.1±24.6 Nm, PL100: 46.4±22.8 Nm) and fascicle lengths were similar across conditions (REFL: 68±12 mm, PL0: 68±13 mm, PL50: 68±14 mm, PL100: 69±14 mm) during a 1-sec hold phase from 2.5 sec after the end of stretch. Fascicle stretch amplitudes during the dynamometer-imposed rotations increased with increasing preload (PL0: 17±2 mm, PL50: 21±1 mm, PL100: 25±1 mm). rFE reported as percentage of REFL did not increase with increasing preload (PL0: 11.2±10.2%, PL50: 4.7±6.9%, PL100: -0.9±13.9%).
CONCLUSION: Preliminary results suggest that: i) a greater preload increases fascicle stretch amplitudes during in vivo MTU lengthening, and; ii) greater fascicle stretch amplitudes do not increase rFE following maximal voluntary eccentric dorsiflexion contractions.
REFERENCES
[1] Griffiths, J. Physiol., 1991
[2] W. Seiberl et al., JEK, 2015.

## PLANTAR FLEXION SHORTENING PERFORMANCE IS ENHANCED AFTER ECCENTRICALLY INDUCED PRELOAD COMPARED TO A TORQUE-MATCHED FIXED-END CONTRACTION PRELOAD

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INTRODUCTION: In stretch-shortening cycles (SSCs) an eccentric muscle action is directly followed by a shortening contraction. The work during the shortening phase of SSCs exceeds the work of shortening contractions without preceding stretch [1]. Several factors influence this so-called SSC-effect [2]. One of the most discussed mechanisms is related to the preload before shortening. We are interested if the same amount of preload differently affects work during shortening if the preload was either produced by a fixed-end contraction with increased intensity or by eccentrically-induced force enhancement.
METHODS: Electrically stimulated ankle plantar flexor torque was assessed during preloaded shortening and SSC contractions (range 25° at 40°/s), with a (low) intensity evoking ~ 30% of the maximum voluntary torque (N=14; ongoing ultrasound-based analysis of muscle dynamics). To match identical preload before shortening, a second stimulation intensity (high) was used to reach identical eccentric preload torque values measured in SSCs. Three different protocols are presented: 1) preloaded shortening with constant low intensity (SHO); 2) shortening with high stimulation intensity during preload and low stimulation intensity during the shortening phase (SHO-matched); 3) SSC with constant low intensity (SSC). Repeated-measures ANOVA determined differences in torque before shortening and mechanical work during shortening between conditions ($\alpha$=.05).
RESULTS: Torque of SHO-matched and SSC at the onset of shortening were identical (p=.974). Compared to SHO, shortening work during SSC and SHO-matched was 1.9 (± 0.5) and 1.8 (± 0.4) times increased (p<.001), respectively. Additionally, work during shortening in SSC was higher than during SHO-matched (p=.001).
CONCLUSION: Stretch-induced history dependent effects possibly play a more significant role for shortening work in SSCs beyond just increasing the torque at the beginning of the shortening. Increased preload substantially impacts the work during shortening, apparent in conditions with higher intensity for fixed-end preload (SHO-matched) compared to constant low stimulation intensity (SHO). But when the same amount of increased preload was eccentrically induced (SSC), even higher work was performed in the successive shortening. The same amount of preload torque in SHO-matched and SSC should result in the same amount of tendon-based passive-elastic recoil effects. However, during fixed-end preload the contractile unit initially shortens, whereas during eccentric preload the muscle lengthens and triggers mechanisms of (residual) force enhancement [2]. Despite identical amount of preload, the mechanisms of force enhancement, likely related to titin [3], seem to counteract force depressing effects during shortening, leading to the additionally increased work.
REFERENCES:
[1] Bosco et al. (1987). Eur J Appl Physiol,56(2), 138–143.
[2] Seiberl et al. (2015). Physiol Rep, 3(5).
[3] Tomalka et al. (2020). Front Physiol 11:921.

## IN VIVO EXAMINATION OF THE LINK BETWEEN MUSCLE ARCHITECTURE AND MUSCLE FUNCTION

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INTRODUCTION: The links between sarcomere arrangement and force production, suggest relationships between muscle architecture and function [1]. However, recent theoretical considerations debate the links [2] and the few studies investigating the actual relationships in vivo are not all in agreement. While e.g. rate of torque development has been linked to pennation angle, fascicle length was not related to explosive torque [3], but to isokinetic joint work [4]. Thus, we examined relationships between muscle architecture and muscle function, and assessed the agreement of methods to measure muscle architecture.
METHODS: Three different ultrasound-based approaches were used to assess the relationships between vastus lateralis fascicle length, pennation angle and thickness, and the mechanical output of the muscle (i.e. force and work) in twenty-one healthy participants. Muscle architecture was analysed in panoramic ultrasound scans at rest with the knee fully extended and in regular scans at an angle close to maximum torque (60º), at rest and during maximum contraction. Isokinetic and isometric strength tests were used to estimate maximum muscle force and work production at various velocities. Pearson correlation coefficient was used to assess the relationships (P<0.05).
RESULTS: Measurements of fascicle length, pennation angle and thickness obtained with different methods correlated mostly moderately with each other (r=0.40-.074). Fascicle length measured at 60º at rest was significantly correlated with force produced during high velocity knee extension (400ºs-1, r=0.46) and with joint work during isokinetic knee extension (r=0.44 at 200ºs-1 and r=0.57 at 100ºs-1), but we did not find significant correlations between fascicle length or pennation angle and any other measure of force production or muscle work. Muscle thickness was significantly correlated to maximum force for all measurement methods (r=0.44-0.73).
CONCLUSION: Correlations between fascicle length and muscle mechanical output were stronger for the measurement at rest with the muscle close to optimal length, suggesting that the slack in full knee extension and the measurement under contraction attenuate the functional significance of architecture. Overall, these findings highlight the limitations of current methodological approaches to measure fascicle length and pennation angle in vivo, which may explain ambiguous findings on their relationship with function in previous studies. They also challenge our current interpretation of static architecture measurements as predictor for muscle performance.
[1] RL Lieber and J Fridén, Muscle Nerve (2000).
[2] RL Lieber, J. Biomech. (2022).

[3] TM Maden-Wilkinson et al., Eur. J. Appl. Physiol. (2021).
[4] JF Drazan et al., Biology Open (2019).

## FORCE REDEVELOPMENT AFTER STRETCH-SHORTENING CYCLES AND ITS RELATION TO RANGE AND SPEED OF MUSCLE ACTION

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INTRODUCTION: Stretch shortening cycles (SSC) are the most common muscle action in sports or daily locomotion. During the concentric phase of a SSC, muscle force, work and power are increased when compared to pure shortening contractions (CON) [1]. This is called the SSC-effect and is discussed to be related to elastic energy preservation, reflex activity, preactivation and history dependence of muscle action [2]. To better understand potential history dependent effects present during SSCs, this work focused on the redevelopment of isometric post-shortening force after SSC compared to CON muscle action, where differences between SSC and CON contractions cannot be explained by all other proposed mechanisms [2].
METHODS: Eleven subjects performed submaximal plantar flexion contractions on a dynamometer using electrical nerve stimulation, including isometric, lengthening, CON and SSC contractions at 60% of individual maximum (velocities: 40/120°/s; ROM: 15/25°). Additionally, two synchronized ultrasound probes and 3D motion capturing were used to control kinematics and muscle-tendon unit behavior. Variables of interest were muscle force and rate of force redevelopment (RoFR) after shortening.
RESULTS: The SSC-effect was confirmed in all tested conditions. At the end of shortening, forces following SSC contractions were higher than after CON ($p<0.001$), yet both reduced compared to the isometric reference condition ($p<0.001$). RoFR post-shortening was significantly increased in fast conditions ($p<0.001$) with a tendency of an increased RoFR in SSC contractions when compared to CON ($p=0.065$). 2s post-shortening forces were decreased by 7-15% when compared to the isometric reference in all conditions ($p<0.01$) with no difference between CON and SSC ($p=0.4$). For fast contractions, statistical parametric mapping (SPM) revealed increased forces after SSCs up until 0.28-0.4s post-shortening when compared to CON ($p<0.02$).
CONCLUSION: Following SSC and CON contractions, forces were reduced compared to an isometric reference [3]. The increased forces at the end of shortening following SSC compared to CON could still be explained by changed muscle-tendon interaction during shortening. However, the lasting differences in post-shortening force during the isometric holding between fast CON and SSC contraction (same muscle length and contraction intensity) indicate history dependent effects. Thereby, our results suggest that range of motion seems to be less relevant for high RoFR than the speed of the muscle action. Both the less depressed forces post shortening as well as the better RoFR could be beneficial in consecutive SSC contractions by possibly influencing mechanical efficiency.
REFERECES
[1] Cavagna et al., 1968. J. Appl. Physiol.
[2] Seiberl et al., 2015. Physiol Rep.
[3] Edman, 1976. Acta Physiol. Scand.

## STRETCH-SHORTENING CYCLES OF THE VASTUS LATERALIS VARY WITH ERGOMETER ROWING INTENSITY IN HIGHLY TRAINED ROWERS: AN EMG AND ULTRASOUND CROSSOVER TESTING

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INTRODUCTION: A rowing cycle involves leg flexion and subsequent leg extension. This flexion-extension cycle enhances power output by about 10% compared with leg extension only [1], which is thought to occur because rowing cycles induce active stretch-shortening cycles (SSCs) of the knee extensors at the muscle fascicle level. SSCs enable up to 50% higher muscle force, work, and power output during the shortening phase compared with isolated muscle shortening [2]. However, it remains unknown whether rowing cycles cause active muscle fascicle stretch as the knee extensors have long in-series elastic tissues that can decouple fascicle and muscle-tendon unit (MTU) length changes [3]. Thus, the present study examined muscle fascicle kinematics of the vastus lateralis (VL) during rowing cycles at two rowing intensities and at the same rowing intensity with two techniques.
METHODS: Fifteen young, sub-elite, male rowers (19.5 ±1.6yr; 1.94 ± 0.06m; 91.9 ±5.4 kg; 2,000-m time-trial personal best: 456 ±33W; weekly training volume: 17.8 ±4.1h; rowing experience: 7.5 ±2.8yr) performed 60-s rowing intervals on an ergometer using a traditional style at a low (LiR) and high intensity (HiR) and a micro-pause style at a low intensity (MpR). Muscle activity amplitudes, knee joint angles, and muscle fascicle length changes from the left-sided VL were quantified using surface electromyography, inertial measurement units, and B-mode ultrasound imaging, respectively.
RESULTS: All rowing conditions showed active fascicle stretch during late knee flexion ($p \leq 0.001$, SMD $\geq 0.72$) and subsequent active fascicle shortening throughout knee extension. Active fascicle stretch duration, amplitude and velocity (rANOVA: $p \leq 0.001$, $\eta p2 = 0.49$) were not significantly different (post-hoc: $p \geq 0.17$; SMD $\leq 0.26$) between LiR and MpR, but were significantly increased during HiR (post hoc: $p \leq 0.001$; SMD $\geq 0.70$). The percentage of rowing cycles that involved active fascicle stretch (rANOVA: $p \leq 0.001$, $\eta p2 = 0.95$; post-hoc: $p \leq 0.001$, SMD $\geq 0.87$) was also significantly higher for HiR (98.3 ±12.9%) compared with both LiR (65.0 ±48.1%) and MpR (68.3 ±46.9%).
CONCLUSION: Rowing involves SSCs of the VL at both the MTU and muscle fascicle levels, but the amount of active stretch differs between rowing intensities, with the longest, largest, and fastest active stretch occurring during HiR. SSC-based mechanisms may therefore contribute more to rowing performance during HiR than LiR or MpR.
[1] S. Held, et al., 10% Higher Rowing Power Outputs After Flexion-Extension-Cycle Compared to an Isolated Concentric Contraction in Sub-Elite Rowers, Frontiers in Physiology. 11 (2020) 521.
[2] C. Bosco, et al., Relationship between the efficiency of muscular work during jumping and the energetics of running., European Journal of Applied Physiology and Occupational Physiology. 56 (1987) 138–43.
[3] R. Griffiths, Shortening of muscle fibres during stretch of the active cat medial gastrocnemius muscle: the role of tendon compliance., J Physiol. 436 (1991) 219–236.

## Oral presentations

### OP-MH18 Brain and cognition (AGUEDA)

#### ASSOCIATION OF INFLAMMATORY MARKERS WITH GRAY MATTER VOLUMES IN COGNITIVELY NORMAL OLDER ADULTS: THE ROLE OF CARDIORESPIRATORY FITNESS. THE AGUEDA TRIAL.

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INTRODUCTION: Inflammatory markers are chronically elevated during aging. At this stage, inflammation has been associated with higher prognosis of neurodegenerative disorders, cognitive decline, and brain damage. This, in turn, might indicate a link between age-related inflammatory changes and neuropathological processes, including gray matter reductions. Conversely, cardiorespiratory fitness (CRF) is involved in the protection against chronic diseases associated with low-grade inflammation. Thus, we aim (i) to examine the association of interleukin-6 (IL-6) and C-reactive protein (CRP) levels with total gray matter volume in cognitively normal older adults; and (ii) to examine whether CRF may attenuate this relationship.
METHODS: This study included cross-sectional data from 77 older adults aged 65-80 years (54% females) participating in the AGUEDA randomized controlled trial. Plasma IL-6 levels were determined by an enzyme-linked immunosorbent assay (ELISA) and plasma levels of CRP were determined by nephelometry. All T1-weighted images were collected on a 3.0 T Siemens Magnetom Prisma Fit scanner. Gray matter volume was calculated using Diffeomorphic Anatomical Registration Through Exponentiated Lie algebra (DARTEL). CRF was assessed using the 6-minutes walking test. Model 1 was controlled for sex, age and years of education, and model 2 was additionally adjusted by CRF. Alphasim and Hayasaka were calculated for the statistical threshold.
RESULTS: IL-6 was negatively associated with gray matter volume ($p<0.001$) in the left inferior temporal gyrus ($k=132$; $t=-3,57$) in model 1. After CRF adjustments, this association was attenuated ($k=88$; $t=-3,49$). IL-6 was not positively related to gray matter volume in any region of the brain. In addition, CRP was not positively or negatively related to gray matter volume in any brain region.
CONCLUSION: The present study shows IL-6, but not CRP, may negatively influence gray matter volume in the left inferior temporal gyrus in cognitively normal older adults. CRF could partially attenuate the association between IL-6 and gray matter volume. Exercise-based randomized controlled trials will help to determine whether exercise-induced changes in these inflammatory markers might influence brain structure in older adults.

#### METABOLIC RISK AND GRAY MATTER VOLUME IN COGNITIVE NORMAL OLDER ADULTS (AGUEDA TRIAL): THE MODERATING ROLE OF MUSCULAR STRENGTH

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INTRODUCTION: Metabolic risk is associated with poorer brain health in older adults. Current evidence reveals a positive and important role of muscular strength for lower metabolic risk and higher gray matter brain volumes, separately, although this last association has been scarcely explored. Muscular strength may moderate the relationship between metabolic risk and brain volumes, but this has not been investigated. Thus, the aim of the present study is: (i) to determinate whether gray matter brain volumes change according to metabolic risk in cognitively normal older adults, and (ii) to test the moderating role of muscular strength on this association.
METHODS: Eighty cognitively normal older adults aged 65 to 80 years from the AGUEDA trial were included in a cross-sectional analysis. We calculated the metabolic risk considering waist circumference, triglycerides, high density lipid cholesterol, glucose, and blood pressure levels. A dichotomic variable was computed to indicate low (0-1 factors) or high (2-5 factors) metabolic risk. T1-weighted images were collected using a 3.0-Tesla Siemens Magnetom Prisma Fit scanner. Maximal muscular strength was determined by a handgrip dynamometer, using the average of the maximum value achieved with each hand. A whole voxel-based morphometric analysis was performed to determinate the differences in gray matter brain volumes between the low vs. high cardiometabolic risk participants, including age, sex and educational level as covariates. Alphasim and Hayasaka correction were applied to cluster size thresholding. The between-group significant eigenvariate values were then extracted to test the moderating role of muscular strength on the association between those values and the cardiometabolic risk using the Johnson-Neyman technique. This technique highlights the specific cut points of the moderator (muscular strength) in which the association between the predictor (cardiometabolic risk) and the outcome (gray matter brain volumes) appears or disappears.
RESULTS: Participants at high cardiometabolic risk had lower gray matter volumes compared to those at low risk in six clusters ($p<0.001$): superior frontal gyrus ($k=70$ and 159, for left and right), left inferior frontal gyrus ($k=89$), left postcentral gyrus ($k=146$), right superior temporal gyrus ($k=330$) and left cerebellum crus I and declive ($k=1029$). Moderation analysis revealed that the low vs high metabolic risk differences in gray matter brain volumes were moderated by muscular strength ($p<0.05$; >30.5 to < 48.5 kg) in all of the brain cluster mentioned above, except for the superior temporal gyrus and the cerebellum declive.
CONCLUSION: The present study demonstrates that cognitively normal older adults at high cardiometabolic risk have lower gray matter volume in several cortical regions and cerebellum, compared to those at low metabolic risk. In addition, muscular strength moderates the association between cardiometabolic risk and the gray matter brain volumes in those regions.

**THE ASSOCIATION BETWEEN GAIT VARIABILITY PARAMETERS AND GRAY MATTER VOLUME IN COGNITIVELY NORMAL OLDER ADULTS: A CROSS-SECTIONAL ANALYSIS FROM THE AGUEDA TRIAL.**

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INTRODUCTION: Greater gait variability is a predictor of dementia, and it has been associated with a higher risk of falls and frailty in the elderly. There is growing evidence on the relationship between gait parameters and gray matter volume in the brain. For example, inter-steps inconsistency, defined by poorer equilibrium control, uncoordinated movements, and greater sway, has been shown to be correlated with less gray matter volume in the brain in older adults with mild cognitive impairment. However, there is still a need to examine such associations in cognitively normal older adults. Thus, the aim of this study was to examine the associations between gait variability parameters and gray matter volume in cognitively normal older adults.
METHODS: Sixty-five cognitively normal older adults aged 65-80 years (37 women) participated in this cross-sectional analysis from the AGUEDA trial. The Optogait system (Microgate, Italy) was used to assess gait variability parameters. Participants walked back and forth across a track made up of two bars (i.e., a transmitting and a receiving optical signal bar) set 1-meter apart at their maximum walking pace for 5 minutes, recording a minimum of 150 steps. The bars were 5-m long (5 segments of 1-m each), and two cones were placed 2-m apart at each end of the track, so the participants had to turn around the cone and walk through the track again. The coefficient of variation (CV) of stride length (cm), stride time (sec), cadence (steps/min) and double steps support time (sec) were calculated as gait variability parameters. A 3.0 T Siemens Magnetom Prisma Fit scanner was used to acquire T1- weighted structural brain images. The gray matter volume was determined by voxel-based brain morphometric analysis. The associations between gait variability parameters and gray matter volume were assessed by individual general linear models (one model for each gait parameter) with age, sex, and years of education as covariates. The clusters were reported after applying AlphaSim spatial extent threshold and Hayasaka corrections.
RESULTS: Main results showed a negative association ($p<0.001$) between cadence and gray matter volume in the anterior cingulate cortex ($k = 152$; $t = -3.6$). In addition, stride length, stride time and double steps support time were not negatively related to gray matter in any brain region, after applying corrections. There were no statistically significant positive associations between any gait variability parameter and gray matter volume in any region of the brain.
CONCLUSION: Greater cadence variability, but none other gait parameter, was associated with less gray matter volume in the anterior cingulate cortex. This result suggests that poor gait performance and impaired gait regulation may negatively influence gray matter volume in the aging brain. Further experimental studies should examine the impact physical activity could have over gait variability, and in turn, gray matter volume in the elderly.

**AN UPDATE ON THE RESISTANCE STRENGTH EXERCISE PROGRAM FROM THE AGUEDA (ACTIVE GAINS IN BRAIN USING EXERCISE DURING AGING) TRIAL**

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INTRODUCTION: The aim of the present study is to provide an update on the exercise program implemented in the AGUEDA trial, a randomized controlled trial investigating the effects of a resistance training program on brain health in cognitively normal older adults.
METHODS: A total of 85 cognitively normal older adults aged 65 to 80 years were randomized into an exercise or a control group. Participants from exercise group performed upper and lower limb exercises using elastic bands and theirs own body weight as main resistance. The exercise load was based on the execution time, the resistance of the elastic bands (seven ascending intensities), and the exercises difficulty (three levels). The exercise program lasted 24 weeks and included 3 sessions/week. Participants perceived maximal perceived exertion (RPE) using perceived exertion scale from 1 to 10 and intrinsic motivation, using Feeling Scale from -5 to 5, were recorded each session.
RESULTS: Of the 44 participants from the exercise group, 29 (19 females) have already completed the 24 weeks of exercise, accumulating a total of 2,016 training sessions with a 96.5% attendance rate. The mean total duration of these sessions was 70±4 min; specifically, 7.63±1 min dedicated to the warm-up, 57.2±3 min to the main part, and 5.42±1 min to the cool-down. The mean RPE achieved was 5.41±1. Pre- and post-session intrinsic motivation scores were 3.07±0 and 3.34±0 (difference's $p<0.001$), respectively.
CONCLUSION: The present study details the progress made in the resistance strength exercise program of the AGUEDA trial so far. This may serve public health professionals who wish to implement such evidence-based program and test its brain health effects in cognitively normal older adults.

**IDEAL CARDIOVASCULAR HEALTH AND MEMORY PERFORMANCE IN COGNITIVELY NORMAL OLDER ADULTS: PRELIMINARY RESULTS FROM THE AGUEDA TRIAL**

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INTRODUCTION: Physical activity contributes to maintaining cardiovascular and brain health during aging. Increasing numbers of Ideal Cardiovascular Health (ICVH) factors has been associated with a lower risk of dementia and lower rates of cognitive decline[1]. Particularly, ICVH factors could influence memory (subjective and objective) in healthy older adults, which is closely related to a higher risk of developing dementia [2]. Our objective was to examine the associations of individual and combined ICVH factors with subjective and objective memory performance in cognitively normal older adults.
METHODS: We analyzed baseline (cross-sectional) data of 71 cognitively normal older adults aged 65 to 80 years from the AGUEDA trial. The 7 ICVH factors proposed by The American Heart Association [3] were classified as "ideal" or "not ideal": smoking, body mass index (BMI), physical activity, diet, cholesterol, blood pressure, and glucose. The Subjective Cognitive Decline (SCD) was defined by obtaining ≥5

points in the subjective memory decline scale [4], plus no impairment in the Montreal Cognitive Assessment test. Visual memory was assessed by Rey-Osterrieth Complex Figure (ROF) and episodic memory by Rey Auditory Learning Verbal Test (RALVT). Sometimes variables were inverted so that a high score indicated a better performance (i.e., retroactive interference and proactive interference). Sex, age, and educational level were included as covariates in the models.
RESULTS: Among 71 participants, the mean age was 70.8 (SD 3.7) years, 58% women. The mean ICVH score was 3.2 (SD 1.2), higher in women than men (p=.01). 17% of participants had more than 5 ICVH factors. Individual ideal criteria and the ICVH score were not associated with SCD score (Rho:-.065, p=.60). Individual ICVH factors were not associated with objective memory performance (i.e., visual or episodic memory), except for blood pressure. Ideal blood pressure was associated with better performance in episodic memory (Coefficient:1.16, IC95% .08 to 2.24 for retroactive interference). In addition, participants with ≥5 ICVH factors showed similar performance in visual and episodic memory compared to those with <5 ICVH factors (all p>0.05).
CONCLUSION: ICVH factors were not associated with subjective memory performance. Except for blood pressure, ICVH individual factors or ICVH score may not influence visual and episodic memory in cognitively normal older adults. Future, more extensive studies should examine the influence of ICVH on memory performance and other cognitive indicators during aging.
References
1. Samieri C, et al. 2018. DOI: 10.1001/jama.2018.11499
2. Livingston G, et al. 2020. Doi: 10.1016/S0140-6736(20)30367-6.
3. Lloyd-Jones DM, et al. 2010. Doi: 10.1161/CIRCULATIONAHA.109.192703.
4. Wolfsgruber S, et al. 2015. DOI: 10.1212/WNL.0000000000001399.

## Oral presentations

### OP-SH11 Socio-ecological factors and sport participation

#### CAN ECOLOGICAL LANDSCAPE BE A USEFUL CONCEPT FOR UNDERSTANDING PHYSICALLY INACTIVE CHILDRENS RELATIONSHIP TO PHYSICAL ACTIVITY IN EVERYDAY LIFE?

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To understand how physically inactive children relate to physical activity (PA) there is a need to utilize concepts allowing for a structured ideographic approach. Bronfenbrenners (2005) various theoretical models has been widely utilized within sport and health science. A common critique has been that the model, often illustrated as concentric circles, is too static and, thus, not accounting for the complexity of how culture informs human development (Vélez-Agosto, 2017).
In order to push bioecological thinking forward and to develop a more dynamic perspective, we use the concept 'ecological landscape'. Our purpose here is to make visible how barriers and openings within various ecological systems interact and, thus, create a unique landscape for every individual child's relationship with PA. The concept ecological landscape refers to the sum of the relationships between an individual child and its multidimensional environment. It is grounded in field theory (Lewin, 1952), bioecological theory (Bronfenbrenner, 2005) and integrates sociocultural perspectives (Veléz-Agosto et al., 2017). We consider the relationship between children and PA to be shaped by barriers and openings in the ecological landscape. These barriers and openings are derived from various ecological systems and are of different nature (both culture, nature and mixtures of these). Together they create a landscape that characterizes the path to PA. Experiences of the barriers and openings are created in interaction with the child and its unique characteristics. Thus, the landscape is subjectively constructed and unique to each child. The landscape is ecological because the child and its environment is inevitably intertwined. If one of the parts changes, so does the other. Learning always involves change in perception. To equip a child with resources, competences, and beliefs means that the landscape will change and new openings will be visible.
The potential in using the concept of ecological landscape lies in the ability to qualitatively, and at an appropriate level of abstraction, make visible how aspects of the inactive child's relationship with the environment influence behavior. This makes it possible to start from a subjective position and investigate the weight of various influences. A further potential is to use the concept as a methodological tool that may open up for participatory action research. In the research process, inactive children may develop an increased awareness of their own ecological landscape.
Bronfenbrenner, U. (2005). Making Human Beings Human: Bioecological Perspectives on Human Development. SAGE.
Lewin, K. (1952). Field theory in social science: selected theoretical papers. Tavistock.
Vélez-Agosto, N. M., Soto-Crespo, J. G., Vizcarrondo-Oppenheimer, M., Vega-Molina, S., & García Coll, C. (2017). Bronfenbrenner's Bioecological Theory Revision: Moving Culture From the Macro Into the Micro. Perspectives on Psychological Science. 12(5), 900–910.

#### THE MUTABILITY OF SPORTS PARTICIPATION AND THE EMERGENCE OF INFORMAL SPORTS AMONG NORWEGIAN YOUNGSTERS

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Introduction
Despite a growing body of evidence suggesting that establishing wide sporting repertoires during youth is related to ongoing engagement in sports, little is known about how youngsters' sporting careers develop during the teenage years. In particular, there is a lack of knowledge about developments in forms of participation. By providing detailed analysis of cohorts of young Norwegians as they progressed through lower-secondary school and into upper-secondary school (13–16-year-olds), this study provides insights into how different sporting forms wax and wane during a particularly important period typically marked by heavy drop-out and drop-off from sports.
METHODS: Data were obtained from a longitudinal cohort study of Norwegian youngsters attending 11 lower secondary schools. Annual surveys were conducted from grade 8 through grade 9 to grade 10. Appropriate analyses for repeated measures and between-subjects were used to examine changes in sports participation frequency and sporting forms over time as well as differences in participation between the sexes respectively.

RESULTS: The results showed the cohort sustained their sports participation rates over the three years. Girls' sports participation declined slightly but significantly overall. For boys, there were no significant changes. Nor were there any significant differences in sports participation frequencies between sexes at age 15–16. While team games decreased for all between grades 8 and 10, the decrease was only significant for football and handball among girls and hockey for boys. Strength training increased significantly in popularity among both boys and girls over the three-year period.
Discussion
We suggest that the reasons for the relatively stable and high sports participation rates observed are due to mutable participation patterns where the youngsters shifted and changed between different sporting forms. The observed patterns suggest a convergence between the sexes, contributing to narrowing gender gaps in sports participation. Growth in the popularity of strength training across the whole sample underlines the increasing centrality of health and fitness and informal sports through the life-stage of youth for both sexes. The findings then, suggests that drop-out from organized, club-based sport does not necessarily signal drop-out from sport per se, it might also signal an intensification of the trend towards more informal activities. That being said, organized sport has not faded into the participatory background. Our data suggest that boys remain more likely than girls to sustain involvement in sports typically done in organised forms, while girls on the other hand, reported more pronounced shifts towards less organized orientations towards participation. This may throw some light on the steeper decline in organized sports participation among girls compared to boys during youth.

## ELITE ATHLETES AND PARENTHOOD - FINANCIAL CONDITIONS, (SUPPORT) STRUCTURES AND FAMILY PLANNING

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Elite athletes as parents have received greater attention in recent years, which has raised questions regarding the possibilities of combining an elite career with family life. Research in this area has increased during the 2000's. Palmer and Leberman's study (2009) of mothers found that balancing time between family and elite sports was difficult; this is also found in other studies (Andreasson et al, 2018). Time seems to be a key issue when committing to a sporting career and having children. The purpose of this study is to explore and analyse elite athletes' view of combining elite sports and parenthood from a financial and structural perspective. As analytical tools Mills ideas of personal troubles and public issues is relevant as well as theories surrounding parenthood and gender equality.
An online survey directed to active elite athletes was used. The survey consisted of questions about financial conditions, support and the structuring of their sporting activities. I received 27 answers from athletes who had children and 11 from those who did not have children. The results show that about half of those who have children say that their financial situation has been worse since they had children. Two thirds do not feel they have support from their national association. There is a lack of support for bringing children to competitions, which was an expressed wish for some. About half of the respondents said that the association need more knowledge about combining elite sports and parenthood.
Both groups have elite sporting colleagues that have had children during their career. Those who do not have children express that it will be important to try to plan when to have children, so it does not collide with important competitions. This is something that those who had children did not say to the same extent.
The conclusion is that the associations are not offering support to the elite athletes, according to the athletes. The athletes wish there were more support to bring children to competitions but also for the association to show support for their situation. Some even expressed that the association were uninterested in their situation. The athletes' wish for support can be perceived as an opinion that combining elite sports with parenthood is a public issue that the association need to help them with. However, the lack of support they receive may be interpreted as a perception of this situation as a personal trouble that the athletes have to figure out for themselves (cf. Mills, 1971/2002). There may be a gap in the perception of this situation between athletes and the associations.
References
Andreasson, Johansson & Danielsson (2018) Becoming an Ironman triathlete. Extreme exercise, gender equality and the family puzzle. Sport in society, 21, 9, 1351-1363
Mills (1971/2002) Den sociologiska visionen. Arkiv förlag.
Palmer & Leberman (2009) Elite athletes as mothers: Managing multiple identities. Sport management review, 12, 241-254

## LIKE FATHER, LIKE DAUGHTER - A QUALITATIVE STUDY OF FATHER-DAUGHTER DUOS IN PROFESSIONAL SOCCER

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Introduction
Wilson, Wilson, and Baker (2018) have noted that there are many anecdotes of sporting talent that runs in families. Nevertheless, there is a lack of studies concerning the dynamics within such families where expertise passes down through generations. The purpose of the study was therefore to investigate the perceived role and importance of fathers in father-daughter duos in professional soccer.
Method
Informants consisted of two Norwegian father-daughter duos in soccer (n = 4). Both fathers had played for the Norwegian national team, and their daughters are current professional players that have represented Norway at U-23 national team level or higher. Individual semi-structured interviews were conducted by telephone. All informants were asked about their own sport development, as well as questions about fathers' involvement in their daughter's career. Interviews were verbatim transcribed and thematic analyzed.
Results
All informants described a developmental pathway consisting of large amounts of play and practice activities throughout development, with increased emphasis on deliberate forms of practice from adolescence. Informants also highlighted factors that contributed to understand their play and practice involvement, including access to local soccer fields and influential coaches and siblings. Furthermore, four themes related to paternal influence on daughter's careers emerged: 1) role models (e.g., transmitting values and daughters being inspired to achieve what their dad had achieved), 2) active involvement (e.g., fathers playing with and/or coaching their daughter), 3) expert advice (fathers using their own experience and expertise to advise), and 4) support (e.g., emotional support, avoiding pressure).
Discussion
While notions have been made about multiple sporting generations, the present study is to our knowledge the first to investigate the perceived role and importance of fathers in professional father-daughter duos. Informants highlighted paternal influence that were enabled by their experience as former professional athletes, including providing expert advice and their daughters being inspired by their

achievements. Furthermore, findings also included paternal involvement that may be applied by parents without previous professional sport careers, including playing sport with their child and providing support.
Reference
Wilson, S., Wilson, M., & Baker, J. (2018). Parental sport achievement and the development of athlete expertise. European Journal of Sport Science, 19, 1-10. doi:10.1080/17461391.2018.1551424

**INFLUENCE OF THE SOCIAL AND SPORTING CONTEXT ON THE DEVELOPMENT OF SPANISH PARALYMPIC ATHLETES**

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Introduction
Whether an athlete reaches the highest level in any discipline will be determined by many factors. In the performance of Paralympic athletes, it is of paramount importance to understand the sporting context (Blauwt and Lezzoni, 2014) as they face numerous social and environmental barriers (Díaz et al., 2019) that limit the sporting participation of people with disabilities (Díaz et al., 2019).
Method
The sample consists of 28 Spanish Paralympic women who have participated and won at least one medal in a Paralympic Games held in the 21st century (Sydney 2000, Athens 2000, Athens 2004, Beijing 2008, London 2012, Rio 2016 and Tokyo 2020). This is a qualitative research as the interview was used as an instrument for the collection and analysis of information.
Results
Among the results referring to the sporting context, most of the sportswomen interviewed were influenced by a family member or friend, or by medical recommendation in order to gain confidence and independence due to their disability. Regarding the social context, the sportswomen interviewed acknowledged the great help they received from their families during the training process, as well as from their friends, but to a lesser extent. On the other hand, they emphasized that at no time did their family and friends put any kind of pressure on them.
Conclusions
Most of them highlighted the figure of the coaches because of the constant motivation they receive from them. However, some of the women interviewed stated that the coaches, in some cases, gave them stress and anxiety. On the other hand, the closest social environment (family and friends) is essential during the training stages for the athletes as they exert a strong influence. In addition, there is the psychological support that they have given them in the hardest stages, especially in high performance.
References
Blauwet, C.A., y Iezzoni, L.I. (2014). From the Paralympics to Public Health: Increasing Physical Activity Through Legislative and Policy Initiatives. Physical Medicine and Rehabilitation Physician Journal, 6, 4-10. doi.org/10.1016/j.pmrj.2014.05.014
Díaz, R., Miller, E.K., Kraus, E., y Fredericson, M. (2019). Impact of Adaptive Sports Participation on Quality of Life. Sports Medicine and Arthroscopy Review, 27(2), 73–82. doi.org/10.1097/JSA.0000000000000242

## Oral presentations

### OP-MH24 Exercise therapy

**EFFECTS OF A HOME-BASED WHOLE-BODY HIGH-INTENSITY INTERVAL TRAINING ON NEUROMUSCULAR AND CARDIORESPIRATORY FITNESS**

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INTRODUCTION: Developing effective home-based exercise interventions is important for people living far from fitness or rehabilitation facilities, more so in the context of social-distancing during the COVID-19 pandemic (1). Therefore, the present study investigated the neuromuscular and cardiorespiratory fitness adaptations to a home-based, video-directed, high-intensity interval training using only body weight as resistance (WB-HIIT).
METHODS: Twenty-seven healthy adults (23 ± 1 years) were assigned to the WB-HIIT group (N=14) or to a control group (maintenance of habitual lifestyle) and took part to pre- and post-intervention evaluations. The neuromuscular assessments included 3 repetition maximum (3RM) leg press, knee extensor maximal isometric voluntary contraction (MVC), voluntary activation (VA; using the interpolated twitch method) and muscular endurance (quantified by the time to task failure [TTF] at 30% MVC). Maximal oxygen consumption (VO2max) and aerobic power (Wmax) were determined during an incremental cyclo-ergometer test. The 8-week WB-HIIT (3 sessions/week) consisted in a 3-min warm-up followed by 4 bouts of 30 s all-out whole-body exercises (squats, lunges, mountain climbers, jumping jacks, modified burpees…) interspaced with 30 s of active recovery. The training sessions were performed at home by means of videos containing oral directives for each exercise and simultaneous demonstration. Heart rate (HR) was recorded during sessions using a HR monitor and the Polar Beat app.
RESULTS: None of the parameters changed significantly in the control group. Maximal and mean HR recorded during the WB-HIIT sessions were respectively 88 ± 5 % and 74 ± 5 % of maximal HR. The VO2max (+5%; P=0.03) and Wmax (+7%; P=0.01) increased significantly after WB-HIIT. The 3RM and MVC torque increased by 14% (P<0.001) and 8% (P=0.04), respectively. VA tested during the MVC did not change significantly (P=0.27) after WB-HIIT. However, there was a negative correlation (r= -0.77; P<0.01) between subjects' initial VA level and VA change (%), and a positive correlation (r=0.74; p<0.01) between VA change (%) and MVC torque increase (%). Finally, TTF was improved by 26% (P=0.025) after WB-HIIT.
CONCLUSION: The home-based WB-HIIT, performed during the pandemic period, induced improvements in cardiorespiratory fitness as well as in isometric strength, 3RM and muscular endurance. The negative relation between initial VA and VA change suggests a greater effect in subjects with lower initial VA, which resulted in a positive impact on maximal torque.
Reference:

1. Wilke J, et al. Train at home, but not alone: a randomised controlled multicentre trial assessing the effects of live-streamed tele-exercise during COVID-19-related lockdowns Br J Sports Med. 2022 Feb 15:bjsports-2021-104994. doi: 10.1136/bjsports-2021-104994
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**THE IMMEDIATE EFFECT OF EXERCISE INTENSITY ON MOOD AND PERCEIVED EXERTION OF ADULTS WITH DEPRESSIVE DISORDER**

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INTRODUCTION: Numerous studies have shown that exercise is effective at reducing depressive symptoms. However, because of the heterogeneity of exercise programs, optimal exercise intensity has yet to be established (1). Moderate intensity has been suggested as an ideal solution (2), but, both low and high intensity exercise interventions have produced positive outcomes, rendering results equivocal (3). This study aimed at investigating the immediate effect of a single bout of interval training at different intensities.
METHODS: Fifteen participants (12F, 39.7±14.1 years), that suffered from mild to moderate depression (Beck-II scores: 17-22) and, who were assessed with a high physical activity level (IPAQ) (4), participated in a low (~50-60% HRmax) and a moderate-to-vigorous (MTV) intensity exercise session (~70-80% HRmax). Participation order was randomly counterbalanced with a period of 3-4 days apart. Both sessions included interval training with load corresponding to body weight and of 45 min duration. Before and right after cessation of exercise, participants completed the profile of mood state questionnaire (POMS) and the Borg rate of perceived exertion scale. Furthermore, heart rate was recorded (Polar M430) for 5 min before and throughout execution of both sessions and was used to determine HR levels at rest and at 1st and 2nd min of recovery phase. Two-way RM ANOVAs (time x exercise intensity) and paired t-tests were performed to test for possible differences.
RESULTS: A significant main effect of time was found since immediately post both exercise sessions, participants' mood (PRE: 18.8±2.6, POST: -8.9±1.3; P<0.001) and perceived rate of exertion scores (PRE: 14±0, POST: 10±1; P<0.001) were improved. Exercise intensity did not have a significant effect either on mood (LOW: 3.6±20.5, MTV: 6.3±20.2; P<0.05) or perceived rate of exertion (LOW:12±3, MTV:13±4; P<0.05). Exercise intensity did not significantly differentiate HR responses at recovery (1st min: LOW: 20±8, MTV: 16±8 bpm; P<0.05; 2nd min: LOW: 25±8, MTV: 21±12 bpm; P<0.05), whereas HR levels at rest were similar between intensities (LOW: 80±12, MTV: 79±12 bpm; P<0.05). No significant interaction was found in any parameter.
CONCLUSION: Present results support previous studies reporting a significant decrease of depressive symptoms after moderate intensity training. It has been suggested that the effect of exercise on depression is independent of the dose, intensity or type of exercise (1) and the improvement in mood and rate of perceived exertion after the low intensity session suggests it. The similar rate of cardiac recovery evidenced in both intensities lends further support. In conclusion, a single bout of low or MTV exercise intensity seems to have a beneficial effect on mild-to-moderate depressed adults.
REFERENCES:
1) Yie et al., Front Psychiatry, 2021
2) Paolucci et al., Biol Psychol, 2018
3) Chu et al., Mental Health Phys Act, 2009
4) IPAQ. Available at http://www.ipaq.ki.se/

**LONG TERM PHYSICAL ACTIVITY IMPROVES THE QUALITY OF LIFE AND ENRICHED ENVIRONMENT ATTENUATES DEPRESSION, IN ELDERLY**

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INTRODUCTION: Physical activity is progressively being recognized as a key element in the whole management of successful aging. Nevertheless, only a prolonged engagement in regular exercise might allow the expected benefits. Moreover, the gradual multy-sensory deterioration, by providing less stimulation to the areas of the brain, accelerates the decline in elderly. Environmental factors and active lifestyles seem to positively influence the neurodegenerative processes, promoting adherence and compliance, decreasing stress and the risk of depression (Zhang, S., et al 2021). The purpose of this study was to show the effects of physical activity programs on the quality of life and depression of an over-50 age sample assessed after 6, 12 and 24 months.
METHODS: One hundred and seventy-eight subjects (aged 62.12 ± 7.88) were randomly assigned to two experimental conditions: Aerobic and Strengthening training in standard environment (AS) and Low-impact Exercise (LE) in enriched environment, 3 days per week. Before and after intervention, quality of life (SF-36) and depressive disorder (GDS) assessment questionnaires were administered.
RESULTS: The univariate analysis showed no significant differences after 6 and 12 months in SF-36 for both the experimental groups, while only AS showed a significant improvement after 24 months (f=11.14; p= 0.001). Conversely, regarding GDS, a significant improvement in depression scores, after 6 months, were found in LE groups (f=8.922; p= 0.001) and these values remain constant up to 24 months while AS did not show significant differences between among 6,12 and 24 months.
CONCLUSION: High level of fitness, gained after AS, improved a good perception of quality of life estimated on the scales of physical, emotional and social functioning, vitality, psychological well-being, which correlated with health, but only after a long-term adherence to exercise (Choi, J et al 2021).
Regarding changes in depression, the results suggested that an exercise program organized in an enriched environment is more effective in attenuating depressive symptoms than a traditional program. Exercise training organized in a context which offers many opportunities for physical activity, with sensory and intellectual stimulations, might improve the depressive symptoms.

### PHYSIOLOGICAL AND PERCEPTUAL DIFFERENCES BETWEEN NORMOBARIC HYPOXIA AND TERRESTRIAL ALTITUDE: A RANDOMIZED CONTROLLED CROSSOVER STUDY

HOHENAUER, E.1,2,3,4, FREITAG, L.1, COSTELLO, T.J.5, KUENG, T.2, TAUBE, W.3, HERTEN, M.1, CLIJSEN, R.1,2

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INTRODUCTION: Much hypoxia research has been carried out in a hypobaric environment but investigations between normobaric hypoxia (NH) and hypobaric hypoxia (HH) are lacking [1]. Therefore, the aim of this study was to investigate, if there is a difference between NH and HH and to compared it to normobaric normoxia (NN) on a) cognitive performance, b) physiological and perceptual response during sub-maximal exercise and c) on the autonomic nervous system, stress response and self-perceived ratings under rest.
METHODS: Healthy volunteers (n=10 females, n=10 males, 27.6±6.2 yrs) underwent 4 experimental sessions. In NN, participants were tested in the laboratory at ∼550m whilst under NH, an altitude of ∼3000m was simulated. During terrestrial altitude, participants spend two days (HH1 and HH2) at ∼3000m in the Swiss alps. The participants conducted in each condition a cognitive performance test (CPT) and a submaximal step-test (modified Harvard step-protocol). During the CPT, cerebral tissue oxygenation index (cTOI) and cognitive performance outcomes (throughput, accuracy and reaction time) were assessed. During the submaximal step-up test, heart-rate (HR), SpO2, quadriceps femoris muscle oxygenation index (mTOI), perceived exertion, mean arterial pressure, lactate and dyspnea were collected. At rest, salivary cortisol, HR-variability (HRV), symptoms of acute mountain sickness (AMS) and sleep quality were assessed.
RESULTS: During CPT, cTOI was higher in NN vs NH (ΔcTOI 5.03±1.4%, p=0.001) and higher in NN vs HH1 (ΔcTOI 5.14±1.4%, p=0.001) with no differences between NH and HH1 and HH2. Δaccuracy, Δreaction time didn't change between groups during CPT. During the step task, SpO2 was higher in NN vs all hypoxic conditions (ΔSpO2 NN vs NH: 6.0±0.6%, p<0.001, ΔSpO2 NN vs HH1: 7.8±0.6%, p<0.001, ΔSpO2 NN vs HH2: 6.3±0.6%, p<0.001). SpO2 was also higher NH vs HH1 (ΔSpO2 1.7±0.6%, p=0.008). HR was lower in NN vs NH (ΔHR 5.4±2.6 bpm, p=0.04) and lower in NN vs HH2 (ΔHR 11.2±2.6 bpm, p<0.001) during the step-task and lower in NH vs HH2 (ΔHR 5.8±2.6 bpm, p=0.03). At rest, parasympathetic- and sympathetic nervous system were more negatively affected in HH2 vs NH (p<0.05) whereas symptoms of acute mountain sickness were higher at HH1 vs all other conditions (p<0.01 for all).
CONCLUSION: In conclusion, this study demonstrates, that the physiological responses to systemic, moderate hypoxia are different between NH and HH. SpO2, cardiovascular and HRV were more negatively affected in HH compared to NH. Nevertheless, this study also shows the different inter-individual responses to hypoxic environments which should be investigated in future studies under controlled and standardized conditions.
1. Coppel, J, et al., The physiological effects of hypobaric hypoxia versus normobaric hypoxia: a systematic review of crossover trials. Extreme Physiology & Medicine, 2015. 4:2

### FEASIBILITY AND ACCEPTABILITY OF AN ADAPTED PHYSICAL ACTIVITY TOOL (MATCH) TO PREVENT IATROGENIC DECLINE DURING HOSPITALIZATION IN OLDER ADULTS: IS THE TYPE OF CARE UNIT AN ISSUE?

AUBERTIN-LEHEUDRE, M.

*UNIVERSITÉ DU QUÉBEC À MONTRÉAL*

INTRODUCTION: In older adults, hospitalization leads to iatrogenic decline, which accelerates the spiral of autonomy loss. Implementing physical activity (PA) as clinical care would be a solution to counteract this deleterious process. Previously, we showed that MATCH, an adapted and unsupervised PA program, seemed feasible, acceptable and effective in geriatric assessment units (GAU) and even in covid-19 units. Nevertheless, the reasons for hospitalization of older adults are diverse, leading them to be admitted to different geriatric care units. Thus, we aimed to evaluate the implantability, feasibility, and acceptability of MATCH in 3 geriatric units (post-acute care (PAC) vs. rehabilitation unit (RU) vs. GAU).
METHODS: All patients admitted to the 3 geriatric units during the study period were assessed by the physician to verify eligibility and to prescribe the MATCH PA program. Inclusion rate, prescription rate, and time to implementation as well as adherence and acceptability but also physical performance were assessed.
RESULTS: Of the 390 patients admitted, 140 were eligible. Among these patients, 114 (RU: n=41; GAU: n=43; PAC: n=30) accepted the care MATCH. The median time to implementation was acceptable and similar between the 3 units (day: RU:2.59 vs. PAC:3.27 vs. GAU:1.26). Rehabilitation health professionals found the MATCH program adequate for patients admitted on the 3 units (% of adequacy: RU:71.4 vs. PAC:75 vs. GAU: 73.7). Although the patients were free to do their exercises, more than half of them did the exercise prescription twice a day (% of patients: RU:85.6 vs. PAC:69.9% vs. GAU:91.2%). The walking goal was achieved at 100% by all patients from the 3 units. Finally, grip strength (Jamar+), functional capacity (SPPB), lower limb strength (takaï equation via 10 rep chair test) and muscle endurance (30 sec chair test) improved significantly for all the patients independently of the unit.
CONCLUSION: Implementing MATCH during hospitalization appears to be feasible and acceptable in addition to increase physical health of older adults, independently of the type of unit care. A randomized controlled trial is needed to confirm our promising results regarding this pragmatic exercise tool .

## 11:00 - 12:15

### Invited symposia

### IS-BM05 The Accurate Assessment of the Neuromuscular System in Sports Science

#### THE ORIGINS AND IMPLICATIONS OF BIAS IN SURFACE ELECTROMYOGRAMS

VIGOTSKY, A.

*NORTHWESTERN UNIVERSITY*

Surface electromyograms (sEMG) are the primary measure used to draw inferences regarding neuromuscular excitation. In doing so, investigators assume that sEMG amplitude accurately represents the degree of a target muscle's electrical activity. In this talk, I will discuss the validity of this assumption, especially as it pertains to bipolar sEMG. First, I will review the biophysics of muscle fiber action potentials and how they give rise to the interference sEMG. From first principles alone, one can see how biases in—or systematic effects on—the sEMG amplitude may present themselves and influence inferences when, for example, comparing sEMG amplitudes between muscles. For instance, the angle of pennation appreciably affects sEMG amplitude due to how the action potentials travel through space relative to the electrodes. Next, I will discuss experimental evidence demonstrating how biases can arise in sEMG experiments and the extent to which these biases can affect inferences. Such evidence indicates that muscle length changes and other nonstationarities have massive effects on observed amplitudes, even for identical neural input. Finally, I relate this evidence to applications of sEMG amplitudes in sports science, including comparisons between exercises and during highly dynamic movements—inferences from bipolar sEMG are often untenable, considering the biases described. Yet, hope is not lost! In closing, I will present why there is reason to believe more advanced methods, including high-density sEMG, can help overcome several of these biases to enable more accurate inferences concerning neuromuscular excitation in sports science.

#### IS THE VARIABILITY IN EMG SIGNALS JUST NOISE?

HODSON-TOLE, E.

*MANCHESTER METROPOLITAN UNIVERSITY*

One of the key aims when recording an EMG signal in any experiment, is to maximise the physiological content and minimise non-physiological signal components. In doing so we often talk about minimising 'noise' in recorded signals. In signal processing, the term noise be used to reflect these unwanted signal modifications. It can also be used to mean that recorded signals are random or unpredictable, and at first glance an EMG signal may appear to contain such random variation.In many examples human movement (and other natural phenomena) we find that variability in the measure of interest (e.g., stride length or speed) can in fact show clear patterning, or structure, when assessed as a function of time. This structure indicates a temporal organisation to the variability (structure), that is non-random and is considered to contain useful information related to the underlying system control. Structure in the fluctuations of a person's stride times or pedal cycle durations can be generated by simple mechanical mechanisms or by the neural command signals reflected in EMG signals. For example, we can consider structure in raw EMG signals may reflect fluctuations in the firing rates of recruited motor units and therefore may not be as 'noisy' as they first appear.
Recently developed methods of quantifying signal structure provide measurements of features of signal structure in a physical time scale (e.g., milliseconds, or number of pedal cycles), which is usefulfor physiological interpretation and comparison to other biomechanical or physiological measures. Here we will therefore explore the application of a sample entropy-based measure of signal structure, entropic half-life (EnHL), to assess EMG signals, focusing on those recorded during cycling on a stationary cycle ergometer. This will include discussion of the potential for signals recorded from high-density surface EMG arrays to be assessed using such techniques to improve understanding of underlying motor control strategies.

#### WHAT WE NEED TO KNOW FOR DETECTING HIGH-DENSITY SURFACE EMGS IN SPORTS SCIENCE

VIEIRA, T.

*POLITECNICO DI TORINO*

The first two lectures will present considerations for the valid application of surface electromyography. The first talk will deal with the sources of bias undermining the assumption that the amplitude of surface electromyograms (EMGs) is a proxy of muscle excitation. The second talk will focus attention on the possibility of overcoming these sources of bias when sampling surface EMGs from multiple skin locations. At this point, we expect one to acknowledge high-density technology may be the most accurate means of assessing the timing and the degree of muscle excitation. However, the open issue remains: How can high-density surface EMGs of high quality be collected in the highly dynamic conditions inherent to sports science? Addressing this question requires:
I) The ability to discriminate signals of high quality from signals of low quality
The quality of surface EMGs is not directly related to the bias discussed in the first talk, but to the signal-to-noise ratio (SNR). Ideally, the surface EMG contains a collection of action potentials generated within the target muscle. How well these action potentials are represented in the surface EMG depends on how much noise is present in the signal, with noise being broadly defined as fluctuations in the skin electric potential associated with non-physiologic sources under direct control of the experimenter. The SNR, and thus the signal quality, scales with how much greater the amplitude of action potentials is relative to variations in the skin electric potential resulting from the movement of cables, inappropriate cleansing of the skin and power line interference. Overcoming bias is possible only when the collected EMG has a sufficiently high SNR.
II) A minimally encumbering, robust system for acquiring high-density EMGs
Valid inferences for sport necessitate that subjects be allowed to move freely with surface EMGs. Otherwise, wearing an encumbering, acquisition system would itself constitute a source of bias. In addition to facilitating movement, systems for the acquisition of high-density EMGs in dynamic conditions should be robust to the sources of noise described in the previous point. Thus, the ideal acquisition system

should eliminate cables connecting electrodes to the amplifiers, use miniaturize, lightweight acquisition modules, and employ a wireless communication protocol.
In this talk, I will cover the two points above. I will discuss the meaning of sufficient quality, providing didactic examples on how high-density surface EMG helps discriminate signal quality and overcome bias. I will then show the high-density acquisition system that we recently developed, suitable for sports science applications, and illustrate how it has been used for the detection of high-quality, high-density EMGs from elite athletes during the challenging 100 m sprint.

# Oral presentations

## OP-PN14 Ergogenic Aids II

### EFFECT OF CAFFEINE ON TIME TO EXHAUSTION, TIME PERCEPTION AND PERCEIVED FATIGUE IN ACTIVE SUBJECTS

WEIPPERT, M., GUBE, M., BRUHN, S., SCHRÖDER, T., TILLMANN, M., BEHRENS, M.

*UNIVERSITY OF ROSTOCK*

INTRODUCTION: Caffeine (CAF) has been shown to improve endurance performance probably due to its effects on the central nervous system resulting in a decreased effort perception. Although effort perception is considered an important determinant of endurance performance and a contributor to perceived fatigue, further aspects related to perceptual-discriminatory, affective-motivational, and cognitive-evaluative dimensions might play a role (Venhorst et al., 2018). Therefore, we investigated the effect of oral CAF ingestion on endurance performance, perceived fatigue, and its determinants.
METHODS: For this purpose, 35 recreationally active subjects (17 females, age: 23 ± 4 yrs) participated in a randomized, counterbalanced cross-over study. Peak power output was determined in a familiarization session. Subsequently, the effect of 6 mg*kg-1 of CAF, compared to placebo (PLA), on time to exhaustion (TTE), perceived fatigue, perceptual-discriminatory (effort, exercise-induced bodily sensations), affective (valence, arousal, dominance), and cognitive-evaluative determinants (action crisis, attentional focus) as well as time perception (i.e., time production precision) and heart rate during cycling at 65% peak power was investigated. Data were analysed with repeated measures ANOVAs and paired t-tests.
RESULTS: No effect of CAF was found on TTE ($p = 0.552$, Cohen's $d = 0.235$), perceived fatigue, as well as its perceptual-discriminatory, affective, and cognitive-evaluative dimensions. In contrast, time production precision was better during CAF at the beginning and did further improve with increasing perceived fatigue, while it decreased during PLA (interaction of time × condition: ($p = 0.020$, $\eta^2 = 0.163$). There were no significant differences in mean heart rate between CAF and PLA ($p = 0.402$, Cohen´s $d = 0.506$).
CONCLUSION: While TTE, perceived fatigue, and its determinants were not affected by a dose of CAF during constant-load exhaustive cycling in recreationally active subjects, precision of time perception during exercise was improved. This might be explained by improved general attention following CAF ingestion. Further investigations are needed to clarify whether CAF can thereby positively affect pacing behaviour and performance in time trial paradigms.

### QUANTIFICATION OF CAFFEINE AND ITS MAIN METABOLITE PARAXANTHINE FROM DRIED BLOOD SPOTS (DBS) AFTER DIFFERENT FORMS OF ORAL CAFFEINE ADMINISTRATION

TUMA, C., BRAUN, H., THOMAS, A., THEVIS, M.

*GERMAN SPORTS UNIVERSITY COLOGNE*

INTRODUCTION: Caffeine is a widespread ergogenic aid used in mass sport as well as in competitive
sport. To alter athletic performance, it is used in many forms: as caffeinated drinks, caffeine anhydrous or caffeinated chewing gums. Studies have already shown a difference in plasma pharmacokinetics after consumption of caffeinated chewing gum and caffeine capsules (Kamimori et al., 2002). Over the last years the number of caffeine containing supplements in diverse administration forms have significantly increased. Consequently, the aim of the study is to investigate their different mechanisms of action. For this purpose, the influence of five different administration forms on the caffeine and paraxanthine blood concentration were analyzed.
METHODS: 200 mg caffeine in five application forms was administered to 16 healthy young adults in a randomized cross-over design: capsule, tablet, drinking ampule, chewing gum and pouches. Samples were taken in form of 20 µl Dried Blood spots (DBS) at 16 different points in time in a two-hour time frame after caffeine administration. Samples were analyzed by a validated UHPLC-MS/MS method. Area under the curve (AUC), maximum concentration (cmax), time to maximum concentration (tmax) and change from baseline to cmax (Δcmax) were calculated using Excel 2019 . Shapiro-Wilk test for normality of data, parametric and non-parametric tests were calculated using SPSS 28.
RESULTS: Data evaluation show highly intra- and interindividual differences depending on baseline concentration and administration form. Classification of three groups based on baseline caffeine concentration were made. One-way ANOVA analysis revealed significant differences ($p<.001$) between group 1 (baseline concentration < 1 µg/ml) and group 3 (baseline concentration > 10 µg/ml).
Tukey post-hoc analysis showed a significantly increased cmax in three out of five administration forms and a significantly increased AUC in all administration forms for higher baseline concentration (group 3) ($p < .05$) .
Total cmax is highest after tablet ingestion (405 ± 155µg/ml) and tmax is shortest after pouche administration (31 ± 19 min).
Steadily increasing paraxanthine concentrations demonstrate a constant rise in metabolization rate of caffeine shortly after ingestion.
CONCLUSION: The results of this study support recent findings that caffeine absorption and metabolism vary depending on administered form of caffeine. It confirms that absorption is fastest, when already beginning through buccal mucosa.
Baseline caffeine concentration significantly influences the rate of caffeine absorption and maximal caffeine concentration after the ingestion of 200mg caffeine.
These findings should be taken into consideration whenever athletes use caffeine to enhance sports performance.
References
Kamimori, et al. (2002), The rate of absorption and relative bioavailability of caffeine administered in chewing gum versus capsules to normal healthy volunteers. Int J. Pharm., 234(1), 159–167

## APPLE PUREE AS A NATURAL FRUCTOSE SOURCE PROVIDES AN EFFECTIVE ALTERNATIVE FOR FUELLING HALF-MARATHON RUNNING PERFORMANCE

REYNOLDS, K.M., JUETT, L.A., JAMES, L.J., MEARS, S.A.

*LOUGHBOROUGH UNIVERSITY*

INTRODUCTION: Carbohydrate intake during endurance exercise in an effective and recognised strategy to improve performance. A natural, food first approach is attractive as it may appeal to athlete dietary choices and help overcome potential health concerns associated with artificial fructose sources. However, data on meaningful performance outcomes and associated gastrointestinal (GI) upset to food-based carbohydrate supplements in runners are limited. We aimed to examine half-marathon running performance and GI comfort of two different fructose sources (natural and artificial) ingested during exercise, as part of a glucose-fructose supplement.
METHODS: Eleven healthy runners (two female, nine male, 32 ± 8.4 y, 1.75 ± 0.08 m, 67.1 ± 7.9 kg) completed a familiarisation (eight miles) and two half-marathon races (13.1 miles) on a flat out and back L-shaped loop. In total 60 g of carbohydrate was consumed (24 g at 0, and 12 g at 3.1, 6.1 and 9.1 miles) with a 2:1 glucose:fructose ratio. Fructose was provided through pure crystalline fructose (GF) (artificial fructose source) or apple puree (AP) (natural fructose source), with additional maltodextrin added to achieve the desired glucose:fructose ratio. Water was provided ad libitum at the same time points. Spilt times and overall GI comfort (0-10 scale) was assessed at 0, 3.1, 6.1, 9.1 and 13.1 miles. Blood and urine samples, and other subjective measures were collected pre and post run. Participants were blinded to the study aim and were told the study was to investigate the effect of different carbohydrate sources, both providing an optimal dosage.
RESULTS: There was no difference in half marathon performance between trials (AP 89:52 ± 09:33 min; GF 88:44 ± 10:09 min; P=0.684) and there was no difference in pacing over the splits (P=0.264), or mean heart rate (AP 171 ± 2 beat/min; GF 175 ± 1 beat/min; P<0.001). GI comfort was not different between trials (post: AP 5±3, GF 3±2, P=0.305), but did increase over time (P<0.001). There was no difference in voluntary fluid intake (AP 409 ± 206 mL; GF 294 ± 149 mL; P=0.094), sweat rate (P=0.707), dehydration accrued (P=0.507) or plasma volume change (AP -0.2 ± 7.2%; GF 2.2 ± 6.4%; P=0.349) between trials. Plasma osmolality increased pre- to post-race (AP 0.290 ± 0.003 to 0.294 ± 0.002 mosmol/kg; GF 0.290 ± 0.002 to 0.294 ± 0.003 mosmol/kg; time effect P<0.001) in both trials, but was not different between trials (interaction effect P=0.935). Similarly, plasma albumin, creatine kinase, creatinine, glucose, myoglobin and ureic acid were not significantly different between trials (interaction effect P≥0.215), but increased pre- to post-race (P<0.001).
CONCLUSION: Apple puree as a natural fructose source was as effective as artificial fructose in supporting half-marathon running performance without increasing GI symptoms.

## SHATAVARI SUPPLEMENTATION IN POSTMENOPAUSAL WOMEN IMPROVES HANDGRIP STRENGTH AND UPREGULATES PROTEINS AND PATHWAYS INVOLVED IN SKELETAL MUSCLE ADAPTATIONS TO TRAINING STIMULI.

OLEARY, M.

*UNIVERSITY OF EXETER*

INTRODUCTION: Shatavari is an understudied but widely available herbal supplement that contains steroidal saponins and phytoestrogenic compounds. One previous study showed that shatavari enhances strength gains in young men engaged in resistance training (Anders et al. doi: 10.3390/ jfmk5010004). We hypothesised that shatavari may be of particular benefit for postmenopausal muscle health since estradiol deficiency contributes to sarcopenia in women.
METHODS: In a randomised double-blind trial, 20 postmenopausal women (68.5 ± 6 years) ingested either placebo (N = 10) or shatavari (N = 10; 1000 mg/d, equivalent to 26,500 mg/d fresh weight shatavari) for 6 weeks. Handgrip and knee extensor strength were measured at baseline and at 6 weeks. Vastus lateralis (VL) biopsy samples were obtained. Functional and immunoblotting data are presented as difference scores (Week 6—baseline, median ± interquartile range). Tandem mass tag global proteomic analysis of skeletal muscle samples was conducted. Data were normalised to total peptide amount and scaled using a reference sample across experiments. Data were filtered using a 5% FDR. Log2 transformed fold change (week 6 vs baseline) was calculated and Welch's t-test was performed to compare placebo (N = 5) and shatavari (N = 7) samples. Over-representation analysis (ORA) of significantly upregulated proteins was conducted in Reactome (v79). Quantitative pathway enrichment analysis was performed using Reactome Pathway Analysis with Down-weighting of Overlapping Genes (PADOG).
RESULTS: Handgrip (but not knee extensor) strength was improved by shatavari supplementation (shatavari +0.7 ± 1.1 kg, placebo −0.4 ± 1.3 kg; p = 0.04). Myosin regulatory light chain phosphorylation, a known marker of improved myosin contractile function, was increased in VL following shatavari supplementation (immunoblotting; placebo −0.08 ± 0.5 a.u., shatavari +0.3 ± 1 arbitrary units (a.u.); p = 0.03). Shatavari increased the phosphorylation of Aktser473 (Aktser473 (placebo −0.6 ± 0.6 a.u., shatavari +0.2 ± 1.3 a.u.; p = 0.03) in VL. 76 VL proteins were found to be differentially expressed between placebo and shatavari. ORA demonstrated that shatavari upregulates proteins and pathways involved in protein translation (p <0.0001) and the metabolism of RNA (p = 0.006). PADOG indicated that shatavari upregulates pathways involved in elastic fibre formation (p = 0.03), transmission across chemical synapses (p = 0.04), integrin cell surface interactions (p=0.02) MAPK signalling (p=0.01) and integration of energy metabolism (p=0.01).
CONCLUSION: Shatavari may improve muscle function and contractility via myosin conformational changes. Proteomic analyses indicate that shatavari may support muscle adaptation responses to exercise stimuli, via protein synthetic, neural and integrin-MAPK mediated force sensing and transduction mechanisms. Further investigation of its utility in conserving and enhancing musculoskeletal function is warranted.

## POTENTIAL ANTI-FATIGUE EFFECTS OF HERBAL PREPARATION (HEMOHIM) WITH KOREAN MEDICINAL PLANTS

SEO, J.1, BAE, J.2, JIANG, S.1, SHIN, C.1, AHN, S.1, SUNG, Y.1, KIM, D.1, SONG, W.1,3

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INTRODUCTION: Nowadays, deterioration of quality of life due to chronic fatigue has been one of the major health problems in the community. Fatigue can be defined as a subjective experience, and includes such symptoms as physical and mental tiredness. Previous studies reported that fatigue is involved with decrease in physical fitness. Interests in strategies that help to delay the onset of fatigue and improve exercise performance are also increasing. HemoHIM is a mixture containing traditional Korean medicinal plants, including Angelica gigas Nakai (Apiaceae), Cnidium officinale Makino (Umbelliferae), and Paeonia lactiflora Pallas (Paeoniaceae). The herbal preparation has been proved effective in exercise performance and fatigue level in an animal study before. Therefore, the purpose of this study was to evaluate the effects of HemoHIM on fatigue level and exercise performance in healthy adults.

METHODS: 96 people with fatigue were recruited in the randomized, placebo-controlled, double-blind clinical trial. They were randomly assigned to the HemoHIM group (HG: n=48) and the placebo group (PG: n=48). Each subject consumed HemoHIM or placebo every day for 8 weeks. In visit-1 (week -2), VO2 max was measured by performing a cycle ergometer test to assess the eligibility. The subjects meet the criteria were then randomly assigned to either HG or PG in visit-2 (week 0). Each subject visited the laboratory 4 times. Body composition, vital signs, dietary intake, fatigue level (Fatigue severity scale, FSS), cardiorespiratory endurance (cycle ergometer test), muscle strength (grip strength), biochemical markers, and adverse events were measured at each visit.
RESULTS: There were no significant differences between groups in the characteristics at the baseline. HemoHIM significantly decreased the total score of the FSS compared to the PG on visit-3 (week 4, p=.019), and this decrease was maintained until visit-4 (week 8, p=.002). The exercise distance to exhaustion in HG was significantly increased compared to the PG (p=.040). In addition, HemoHIM also significantly increased lactate immediately after the ergometer test (p=.011) and 30-minute after the test (p=.036) compared to the PG. However, there were no significant differences in body composition, vital signs, dietary intake, and muscle strength between groups before and after intervention.
CONCLUSION: One of the adaptations to training is increased tolerance to lactate, which is the ability to continue exercise in the condition of increasing lactate level in the blood. In this study, the significant increase in lactate levels immediately after the ergometer test is considered to be identical to the training effect. In addition, the decrease in FSS score and the increase in exercise distance suggested the delay in the onset of fatigue. Therefore, this study showed that HemoHIM induces anti-fatigue effects, specifically in the lactate tolerance. This study may have potential applications in the nutritional supplement industry in the future.

## Invited symposia

### IS-MH09 Exercise, fitness, and brain health during childhood: from healthy to clinical population

#### CHILDHOOD FITNESS AND COGNITION: THE MODERATING ROLES OF INTRA- AND INTER-INDIVIDUAL DIFFERENCES IN COGNITIVE AND ACADEMIC PERFORMANCE

KAMIJO, K.

*CHUKYO UNIVERSITY*

Accumulating evidence has shown the beneficial effects of regular physical activity (PA) and the associated improvements in physical fitness on cognitive and academic performance in children. However, several recent large-scale randomized controlled trials have failed to find such beneficial effects, leaving room for doubt on the causal link between childhood fitness and cognition. To identify possible factors underlying the lack of consensus in the literature, our group has focused on intra- and inter-individual differences in cognitive and academic performance.
In the first study (Ishihara et al., 2020), we reanalyzed data from three randomized controlled trials, in which the effects of a PA intervention on cognitive performance were examined, with a cumulative total of 292 participants (9–13 years). This study aimed to examine whether the effects of PA interventions on cognitive performance are moderated by baseline performance. The results indicated that cognitive improvements resulting from PA interventions were greater in children with lower baseline cognitive performance.
In the second study (Ishihara et al., 2021), we analyzed data from a two-year longitudinal study, to investigate the association between changes in aerobic fitness and academic performance of 469 junior high school students by focusing on intra-individual variability in school grades. This study specifically examined whether improvements in aerobic fitness had differential effects on an individual's worst and best grade points. The results indicated that improvements in aerobic fitness were associated with an improvement in the worst grade points, however, no such longitudinal association was observed for the best grade points.
Collectively, these findings suggest that the beneficial effects of PA interventions and fitness improvements are moderated by intra- and inter-individual variability in cognitive and academic performance. In other words, if baseline performance is too high (i.e., the cognitive task or academic test is too easy), the beneficial effects of PA interventions and fitness improvements might not be detected. Based on these findings, this presentation will describe the current limitations and future directions in childhood exercise-cognition studies.
Ishihara T, Drollette ES, Ludyga S, Hillman CH, Kamijo K. (2020). J Clin Med, 9(7).
Ishihara T, Morita N, Nakajima T, Yamatsu K, Okita K, Sagawa M, Kamijo K. (2021). NPJ Sci Learn, 6(1), 8.

#### SELECTIVE ASSOCIATIONS OF PHYSICAL FITNESS COMPONENTS WITH BRAIN STRUCTURE AND FUNCTION IN CHILDHOOD OBESITY: IMPLICATIONS FOR ACADEMIC PERFORMANCE

ESTEBAN-CORNEJO, I.

*UNIVERSITY OF GRANADA*

Obesity is a major public health concern for developed and developing countries. Over the past years, childhood obesity has more than doubled worldwide. Beyond the consequences of obesity on physical health, childhood obesity may compromise brain health by influencing both brain structure and function. Indeed, obesity has been associated with detectable structural differences in the brain, as well as with worse executive function and academic performance, as compared to normal-weight children. Parallelly, physical fitness might have a positive impact on brain health, resulting in better academic performance, and may thus attenuate the negative effect of overweight and obesity on brain during childhood. Thus, examining the potential benefits of physical fitness for brain health in the context of overweight and obesity during early stages of life is of critical relevance. Using data from a Spanish study of children with overweight/obesity (i.e., ActiveBrains Project), we examined how different components of physical fitness associate with brain structure (global and regional gray matter volume, surface and cortical thickness, global and regional white matter volume, and global and regional white matter microstructure) and brain function (hippocampal functional connectivity), and whether these associations had academic implications.
In a sample of around 100 overweight/obese children aged 8-11 years, we found that fitter children had bigger brains. Specifically, cardiorespiratory and motor fitness were related to total gray matter volume, without academic implications. Similarly, we also found that cardiorespiratory and motor fitness were independently associated with greater gray matter volume of numerous cortical and subcortical brain structures, coupled with better academic performance. When focused on cortical thickness and surface area, cardiorespiratory and motor fitness were also related to cortical thickness, but not surface area, and in turn to intelligence.

White matter tissue may be also modified by physical fitness. In this case, muscular strength seems to be the fitness component more susceptible and selective to influence white matter, but not gray matter indicators. Muscular strength was associated with global white matter volume, and with regional white matter volume and integrity. Indeed, regional white matter volume was also related with better academic performance. Lastly, in term of functional connectivity, cardiorespiratory and motor fitness, but not muscular strength, were independently related with better hippocampal functional connectivity, and in turn, to academic performance.
Thus, physical fitness components seem to selectively influence brain structure and function, coupled with academic implications in children with overweight/obesity. This presentation will guide future studies on fitness, exercise and brain health in childhood obesity.

**COGNITIVE EFFECTS OF EXERCISE IN CHILDREN BORN PRETERM: NEUROCOGNITIVE MECHANISMS OF MARTIAL ARTS**

LUDYGA, S., MÜCKE, M., GERBER, M., PÜHSE, U.
*UNIVERSITY OF BASEL*

Due to advances in medical care, mortality rates of babies born very preterm decreased over the last decades. However, babies that survive the preterm birth face severe neurodevelopmental disabilities and impairments in motor skills across different developmental stages. These problems are related to pronounced deficits in executive function that can be detected at the transition from childhood to adolescence. Structured exercise programs have been found to benefit executive function in term-born and typically developing individuals, with a tendency to induce greater benefits in children with worse performance on cognitive tasks. This indicates a potential of exercise to reduce executive function deficits in children born preterm, but a paucity of studies in this field question whether exercise-induced effects apply to this population.
Using case-control matching, we examined the roles of different aspects of physical fitness to preterm birth-related deficits in executive function and response inhibition in particular. Motor skills rather than aerobic fitness mediated the impairments in response inhibition in children born very preterm. On a neurocognitive level, this mediating effect was explained by motor skills influencing a cognitive control process that contributed to deficits in behavioral performance. Due to the indication that motor skills are a pathway by which response inhibition can be improved, we conducted randomized controlled trials to investigate the effects of a motor-demanding martial arts program on this cognitive function in children born preterm and peers born at term. Following 12 weeks of training, improvements in response inhibition were detected among both groups. Even though the magnitude of the gains were similar between children born preterm and peers born at term, the neurocognitive mechanisms differed. Martial arts training elicited benefits for response inhibition by reducing a specific cognitive control deficit associated with preterm birth. In contrast, children born at term improved this cognitive function by a change towards more effective conflict monitoring.
Our findings highlight aspects of physical fitness that promise improvements in executive function, when targeted by structured exercise. Both children born preterm and those born at term can expect beneficial effects for this cognitive domain after a period of martial arts training. However, the pathway by which martial arts benefit aspects of executive function differ between these groups. These findings broaden the understanding of mechanisms underlying exercise-induced effects in children with typical and atypical cognitive development.

## Invited symposia

### IS-AP10 Exploring the heterogeneity of human responses to exercise and physical inactivity

**INDIVIDUAL RESPONSE TO EXERCISE TRAINING (OR LACK THEREOF): SEEMINGLY OBVIOUS BUT SCIENTIFICALLY ELUSIVE**

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Interindividual variability in the relation between the levels of physical exercise and fitness seems obvious (“talent”, “trainability”) and the large variation in observed responses after experimental changes in exercise levels is in line with casual observation. However, it is important to keep in mind that observed variation does not necessarily reflect true difference between individuals. In fact, the only certain component of observed variation in training response is measurement error. A control group enables a plausible discrimination between measurement error (present in either group) and eventual training induced variation (present in the training group only). This is the consideration that is generally taken into account today. In contrast, it is frequently overlooked that training induced variation may be due to true differences between subjects and / or limited repeatability of individual responses. Importantly, the repeatability of training responses on the individual level is still unknown, presumably due to the challenges associated with replicated study designs when investigating long-term adaptive responses.
Taking other lines of evidence into account, the results of twin or family studies and animal breeding experiments let meaningful interindividual variation in training response seem highly plausible. On the other hand, the multitude of modifiable moderators affecting the response to physical exercise leads to suspect considerable within-subject variation. Finally, the difficulty of standardizing exercise “dose” (as compared to e.g., pharmaceutical interventions) must be considered when interpreting variability in responses.
This talk aims to provide an overview of what is known (or not) about interindividual variability in the response to changes in the level of physical exercise and raise some potentially interesting points.

**INDIVIDUAL VARIABILITY IN SKELETAL MUSCLE MASS AND FORCE LOSS AFTER BED REST**

FERNANDEZ-GONZALO, R.
*KAROLINSKA INSTITUTET*

Interindividual differences in physiological responses to an intervention have received great attention in the last decades. However, some approaches used to analyze individual variability do not account for the variability explained by technical and/or random errors, and thus not biological variability alone. To tackle these limitations, the inclusion of a control group is crucial. Alternatively, the use of cross-over designs can be very helpful, since they offer the advantage of controlling for genetic factors influencing the individual response.
A unique opportunity to address individual variability upon bed rest responses is the Planica bed rest program, where three studies were performed using identical pre- and post-bed rest tests under strictly controlled conditions and using a cross-over design.

This talk will describe the analysis of the individual responses in skeletal muscle outcomes after bed rest using data from these three studies with similar protocols (PlanHab; FemHab; LunHab). Subjects participated in three cross-over campaigns within each study: normoxic and hypoxic bed rest, and hypoxic ambulation (used as a control). Individual variability (SDIR) was investigated as √(SDExp2–SDCon2), where SDExp and SDCon are the standard deviations of the change score (i.e., post - pre) in the experimental (normoxic and hypoxic bed rest) and the control (hypoxic ambulation) groups. Significant SDIR was detected for knee extension torque, and thigh and calf muscle area. The individual variability reported here had a high degree of repeatability and it was partly driven by baseline values. The use of orthogonal partial least squares (OPLS) regression analysis is also presented to explore if changes in the investigated variables could predict calf muscle area alterations. This analysis indicated that 43% of the variance in calf muscle area could be attributed to changes in all the other variables.
In summary, this talk presents a validated methodology to report clinically relevant individual variability in muscle mass and force alterations after bed rest, as well as tools to examine the repeatability and potential moderators of interindividual responses. The data originating from this study may serve as one of the cornerstones to develop (bio)markers of the individual response, which would offer new tools to improve health management of astronauts and to optimize individual programs to counteract the negative effects of unloading both during space missions and here on Earth.
The information conveyed in this talk should be of interest and use to skeletal muscle physiologists with an interest in muscle atrophy, unloading, and inactivity. In addition, the methodological approach presented here could serve as an example of how to examine individual variability in physiological outcomes after an intervention and help to understand the limitations and possibilities of different methodological tools.

**INTER-INDIVIDUAL VARIATION IN ASTRONAUTS IN RESPONSE TO THE SPACEFLIGHT ENVIRONMENT AND THE ROLE OF LONG-TERM HEAD-DOWN BED REST STUDIES IN UNDERSTANDING IT**

SCOTT, J.

*FRANCE*

Exposure to the spaceflight environment results in profound multi-system physiological adaptations in which there appears to be substantial inter-individual variability (IV) between International Space Station (ISS) crewmembers. However, the routine performance of 'countermeasure' exercise on ISS renders it impossible to separate the effects of the spaceflight environment alone from those associated with exercise, whilst differences in exercise programs, spaceflight operations constraints, and environmental factors further complicate the interpretation of IV. In contrast, long-term head-down bed rest (HDBR) studies isolate, by means of a control group, the effects of mechanical unloading from those associated with countermeasure exercise interventions, as well as controlling many of the factors that may contribute to IV.
This presentation reviews the available evidence of IV in response to the spaceflight environment and discusses factors that may complicate its interpretation. Individual data from two, 60-d HDBR studies are presented, which demonstrate that, despite the highly standardized experimental conditions, marked quantitative differences still exist in the response of the cardiorespiratory and musculoskeletal systems between individuals. The statistical concept of "true" and "false" individual differences and its potential application to HDBR data is also discussed. It is concluded that it is currently not possible to evaluate IV in response to the ISS spaceflight environment and countermeasure exercise. However, with highly standardized experimental conditions and the presence of a control group, HDBR is suitable for the investigation of IV in the physiological responses to gravitational unloading and countermeasures. Such investigations may provide valuable insights into the potential role of IV in adaptations to the spaceflight environment and the effectiveness of current and future countermeasures.

## Oral presentations

### OP-PN35 Immobilisation and fatigue

**THE IMPACT OF BETA2-AGONIST INGESTION ON MUSCLE AMINO ACID KINETICS AND INSULIN SENSITIVITY DURING SHORT-TERM FOREARM IMMOBILIZATION IN HEALTHY, YOUNG VOLUNTEERS**

DIRKS, M.L., JAMESON, T.S.O., ANDREWS, R.C., DUNLOP, M.V., ABDELRAHMAN, D.R., MURTON, A.J., WALL, B.T., STEPHENS, F.B.

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INTRODUCTION: Short-term muscle disuse, e.g. during recovery from (sports) injury or surgery, leads to negative muscle amino acid balance and consequently muscle atrophy. Although the underlying mechanisms remain to be elucidated, disuse is accompanied by the rapid development of anabolic resistance (AR, i.e. blunted muscle protein synthesis (MPS) following protein intake) and insulin resistance (IR, i.e. impaired insulin-stimulated glucose uptake). Short-acting beta2-agonists cause hypertrophy by increasing MPS and reducing muscle protein breakdown (MPB), and stimulate muscle glucose uptake. The aim of this work was to determine the impact of salbutamol ingestion on muscle amino acid kinetics and insulin sensitivity during short-term disuse. Twenty healthy individuals (age 23±1, BMI 24.0±0.6 kg·m-2) underwent 2 days of forearm cast immobilization. During immobilization, participants orally ingested placebo (PLA; n=9, 5M/4F) or salbutamol (SAL; 4 mg Ventolin; n=11, 6M/5F) four times daily, and a fully-controlled eucaloric diet (1.2 g·kg-1·day-1 protein (~10-15en%), 50-55en% carbohydrates, 30-35en% fat). Before and after immobilization, whole-body glucose disposal rate (GDR), forearm glucose uptake (FGU, i.e. direct measure of muscle insulin sensitivity), and amino acid kinetics were measured under fasted and hyperinsulinaemic-hyperaminoacidaemic-euglycaemic clamp conditions (50 mU·m2·min-1 Actrapid; 1.38 mL·kg-1·h-1 10% Primene) using arteriovenous forearm balance and intravenous L-[ring-2H5]phenylalanine (phe) infusion. During clamps GDR was unchanged in PLA, but increased 18±9% in SAL (P<0.05). In contrast, immobilization decreased insulin-stimulated FGU by 34±19% (from 52±5 to 29±7 umol·min-1; P<0.05), with no difference between groups. Both forearm phe net balance (NB) and rate of disappearance (Rd, i.e. proxy for muscle amino acid uptake) increased during clamps (P<0.05; NB and Rd from -20±4 to 19±6 and from 19±4 to 46±7 umol·min–1·100 mL forearm volume–1, respectively; all clamps) but were not affected by immobilization or treatment. Phe rate of appearance (Ra, i.e. proxy for muscle amino acid release) increased over twofold during fasting and clamps following immobilization in PLA (clamp: from 13±5 to 33±7 umol·min–1·100 mL forearm

volume–1; P=0.062), an effect completely suppressed in SAL (clamp: from 29±8 to 31±6 umol·min–1·100 mL forearm volume–1; P>0.05). Salbutamol enhances insulin-stimulated whole-body glucose disposal but not in inactive muscle, suggesting that this is mediated by contraction. In contrast to previous work, immobilisation did not significantly reduce forearm amino acid uptake, perhaps due to potent stimulation by insulin and amino acids. However, salbutamol inhibited the efflux of amino acids from muscle, suggesting inhibition of MPB and/or stimulation of MPS, and reversal of anabolic resistance. Further research is required to determine the intracellular mechanisms involved and whether salbutamol prevents muscle disuse atrophy.

**METHODS: RESULTS: CONCLUSION: DOES HUMAN SKELETAL MUSCLE POSSESS A NEGATIVE MEMORY OF MUSCLE WASTING?**

TURNER, D.

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INTRODUCTION: Immobilization (IMM) evokes a significant loss of skeletal muscle (SkM) size and function. Research has demonstrated an epigenetic memory of SkM strength and hypertrophy, where these parameters are further enhanced when strength training is reencountered. Despite this evidence of a positive memory, it is still currently unknown if a negative memory of muscle wasting exists. The present study therefore aimed to determine whether SkM is compromised to a greater extent after repeated atrophy.
METHODS: Young healthy males and females (25.6±4.8 yrs, BMI 25.9±5.8) underwent 2 weeks of unilateral limb IMM (30-degrees knee flexion) twice. Each IMM period were interspersed by 7 weeks of recovery. Before and after each IMM period, leg lean mass (DXA), cross-sectional area (CSA, B-mode ultrasound) of the vastus lateralis (VL) and rectus femoris (RF) together with isometric knee extension torque (dynamometry) across 3 knee flexion angles (90-, 60- and 30-degrees) were assessed. SkM biopsies were obtained for future analyses of DNA methylation and gene transcription. Paired t-tests enabled detection of significant changes ($p<0.05$) after IMM (n=6). All data are presented as mean ± SD.
RESULTS: IMM induced a 3.1 ± 2.9% reduction of leg lean mass in the IMM leg (9.70 ± 2.85 vs. 9.41 ± 2.75 kg, p=0.06) and a 2.2 ± 1.8% increase in the non-IMM leg (9.71 ± 3 vs. 9.88 ± 2.91 kg, p=0.05). Across the 2 participants analyzed thus far, repeated immobilization (RIM) also led to a reduction in the IMM limb (5.5 ± 2%, 10.29 ± 4.59 vs. 9.78 ± 4.54 kg) with no difference in the non-IMM limb (-0.1 ± 0.5%, 10.22 ± 5 vs. 10.20 ± 4.94 kg). VL CSA decreased by 10.4 ± 5% after IMM (n = 6, 24.02 ± 5.37 vs. 21.47 ± 4.73 cm2, p=0.01) with no change in RF CSA (0.1 ± 3.6%, 5.87 ± 1.11 vs. 5.86 ± 1.09 cm2, p=0.95). For the only participant analyzed thus far, VL CSA decreased to a similar extent after IMM (13.5) and RIM (13.7%). For RF however, CSA increased (2.3%, 6.72 vs. 6.87 cm2) after IMM and decreased after RIM (4.6%, 7.14 vs. 6.81 cm2). Knee extension torque reduced by 18.1 ± 11.3% (241 ± 75 vs. 198 ± 69 N, p=0.01), 7.8 ± 12.7% (240 ± 80 vs. 216 ± 64, p=0.16), 2.3 ± 17.9% (147 ± 48 vs. 142 ± 52, p=0.82) at 90-, 60-, 30-degrees, respectively (n=6). When relativized to recovery, RIM also induced a similar reduction in muscle strength at 90- (24.37 ± 2.8%, 252 ± 50 vs. 191 ± 45 N), 60- (18.8 ± 14.6%, 241 ± 102 vs. 203 ± 118 N) and 30-degrees (26 ± 11.6%, 137 ± 52 vs. 104 ± 54 N, n=2).
CONCLUSION: Overall, SkM is significantly compromised after IMM-induced atrophy. To date however, it is still currently unknown if there is a greater loss of SkM after RIM. Furthermore, studies on the molecular mechanisms underpinning SkM wasting are scarce. Future research should employ unbiased genome-wide analysis to determine the transcriptional and epigenetic response of repeated atrophy.

**BRAIN OXYGENATION DURING COGNITIVE PROCESSING IS ALTERED WITH 60 DAYS BEDRIDDEN PHYSICAL INACTIVITY**

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INTRODUCTION: Regular physical activity elicits central angiogenesis and neurogenesis and may, thus, support cognitive performance and brain health. Training interventions have shown to decrease neuronal activity (decreased hemodynamic response) during executive cognitive processing in prefrontal areas, which is suggested to reflect more efficient information processing (Voelcker-Rehage, Godde, & Staudinger, 2011). Studies investigating adverse effects of physical inactivity are scarce due to ethical reasons and mainly include injured individuals or observational data. Investigating the effects of inactivity on healthy subjects, however, would provide important information about the timely onset of degradation processes. 60-day bedrest is hypothesized to impair information processing compensated by increased neuronal activity (=higher oxygenated (O2Hb) and lower deoxygenated hemoglobin (HHb) concentrations assessed by functional near-infrared spectroscopy (fNIRS)).
METHODS: 24 participants (aged 33.3 ± 8.9 years, 8 females) spent 60 days in strict bedrest (group BED). fNIRS was used to monitor hemodynamic changes within the prefrontal cortex at rest and during attentional auditory and visual cognitive tasks on day -2 before, 3, 50 during, and +2 and +13 after bedrest. A control group (CTRL, n= 9, aged 32.5 ± 10.0 years, 3 females) completed the same test battery without bedrest. ANOVA for repeated measures (Bonferroni corrected) with the factors time, group and their interaction were calculated for O2Hb and HHb, as well as reaction time (RT) and accuracy (ACC) of the cognitive tests.
RESULTS: RT revealed a main effect of time ($p< .001$). BED and CTRL groups tend to differ in their progressions (time*group p= .045) and only CTRLs showed a significant decrease on day +13 compared to -2 (p= .014). ACC did not change over time, between groups or conditions. For O2Hb, the time*group interaction ($p< .001$) indicated higher relative prefrontal O2Hb concentration during attentional processing on day 50 of bedrest compared to day -2 (p= .001) and to day +13 after bedrest (p= .033) within the BED group and compared to day 50 of the CTRL group (p= .026). No difference was observed for HHb.
CONCLUSION: Attentional task performance was slightly affected during 60 days of bedrest reflected by increased O2Hb concentration (higher neuronal/oxygen demand). The adverse effects of physical inactivity were recovered on hemodynamic level two days after bedrest, but remained on behavioral level even thirteen days after bedrest. This may indicate that hemodynamic alterations are not the cause but consequence of cognitive impairments.
References:
1. Voelcker-Rehage, C., Godde, B., & Staudinger, U. (2011). Cardiovascular and Coordination Training Differentially Improve Cognitive Performance and Neural Processing in Older Adults. Frontiers in Human Neuroscience, 5. doi:10.3389/fnhum.2011.00026.

### FATIGUE INDUCED BY A SIMULATED COMPETITION IN ELITE WORLD-CLASS FENCERS

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**NANTES UNIVERSITÉ, LABORATORY MOVEMENT - INTERACTIONS - PERFORMANCE.*

INTRODUCTION: Fencing is an open-skilled, asymmetric combat sport characterized by high-intensity bouts and requires high levels of coordination, power, and accuracy. However, the performance-specific fatigue of fencing remains to be elucidated1. In the present study, we evaluated the neuromuscular and mental aspects of fatigue induced by a competition in elite world-class athletes.
METHODS: Changes in countermovement jump height, knee extensors maximal isometric force, rate of force development (RFD), voluntary activation and contractile response to muscular electrical stimulation were measured in 12 male world-class fencers (epee n = 6 ; foil n = 6). Measurements were performed before and after the first match, and after a 5-matches simulated competition. Perceived fatigue and effort were evaluated with 10-cm visual analog scales (VAS), and the perceived workload was assessed with the NASA-TLX scale.
RESULTS: Jump height did not change significantly after one or five matches (P = 0.108). Maximal force, RFD and voluntary activation were not significantly different after match 1 but significantly decreased after match 5 compared with baseline (-13 ± 12%, P < 0.001; -9 ± 19%, P < 0.025; -15 ± 16%; P = 0.003, respectively). Finally, contractile responses did not change significantly along the simulated competition (P = 0.337). Perceived fatigue increased from baseline (3.9 ± 2.5 cm) after match 1 (5.6 ± 2.0 cm, P = 0.026) and match 5 (7.3 ± 2.1 cm, P < 0.001), and was greater following match 5 compared to match 1 (P = 0.001). Similar outcome after match 1 and match 5 were also found for perception of effort (6.6 ± 1.8 cm vs. 6.8 ± 1.6 cm, P = 1.000) from the VAS scale, and perceived mental (75 ± 13 vs. 70 ± 20, P = 0.259) and physical demand (68 ± 13 vs. 76 ± 14, P = 0.158) from the NASA-TLX.
CONCLUSION: In elite world-class fencers, there was no evidence of neuromuscular alterations after a single match. The observable impairments at the end of the competition were moderate regarding maximal force and RFD. Those changes were mainly due to impairments in voluntary activation. The moderate neuromuscular impairments suggest that elite world-class fencers can cope well with the physical demand of a 5-matches simulated competition. However, feelings of tiredness and lack of energy (perception of fatigue) increased along the five matches and was high at the end of the simulated competition. The perceived physical and mental demand of the match, along the perception of effort, remained constantly elevated throughout the competition. These results suggest that elite fencing is characterized by an important mental demand that could lead to the induction of mental fatigue overtime.
1. Turner AN, Kilduff LP, Marshall GJG, et al (2017) Competition Intensity and Fatigue in Elite Fencing. J Strength Cond Res 31:3128–3136.

### EFFECT OF A SUSTAINED COGNITIVE ACTIVITY ON COGNITIVE PERFORMANCE FATIGUE, PERCEIVED FATIGUE AND PREFRONTAL CORTEX ACTIVATION

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INTRODUCTION: Sustained cognitive activities (SCA) can lead to the phenomenon of fatigue and have been shown to impair endurance performance and motor control during different tasks. In general, cognitive task-induced state fatigue can be defined as psychophysiological condition that is characterized by a decrease in a cognitive performance measure and/or an increased perception of fatigue. However, the temporal development and possible dynamics of cognitive performance fatigue and perceived fatigue during a SCA were rarely studied. To better understand the effect of a SCA on the development of state fatigue, perceived fatigue, its potential determinants, cognitive performance and prefrontal cortex activation were investigated over time.
METHODS: In a randomized, counterbalanced cross-over design, 30 subjects (female: 15; age: 23 ± 2.9 years; BMI: 20.5 ± 3.1 kg*m-2) completed a SCA task (60 min digital Stroop task) and a control task (60 min watching a neutral video). In both sessions, activation of the prefrontal cortex was measured with functional near-infrared spectroscopy (fNIRS). To record the development of perceived fatigue and other possible contributors (e.g., affective valence, stress, perceived mental effort, arousal, boredom, motivation) during the SCA, visual analogue scales were used to quantify these aspects in regular time intervals (1, 15, 30, 45, 59 min). Reaction time and accuracy recorded during the Stroop task were used as cognitive performance measures. Data were analysed with repeated measures ANOVAs.
RESULTS: Significant interactions were observed for perceived fatigue (VAS mental fatigue) ($p = .000$; $\eta p2 = .186$), affective valence ($p = .000$; $\eta p2 = .215$), stress ($p = .015$; $\eta p2 = .100$) as well as prefrontal cortex activation ($p = .044$; $\eta p2 = .133$). Main effects of condition were shown for perceived fatigue, perceived mental effort and stress ($p \leq .018$; $\eta p2 \geq .179$). Time effects were found for perceived fatigue, perceived mental effort, affective valence, stress, motivation and boredom ($p \leq .000$; $\eta p2 \geq .109$). Furthermore, a significant main effect of time was found for the cognitive performance measure reaction time ($p = .000$; $\eta p2 = .211$) during the Stroop task.
CONCLUSION: Changes in perceived fatigue, its potential determinants affective valence and stress, and prefrontal cortex activation indicated a clear discrimination between conditions. Increased activation of the prefrontal cortex during the Stroop task, compared to the control condition, together with improvements in reaction time with constant accuracy during the Stroop task may suggest a compensatory mechanism that contributed to maintain cognitive performance over time. The changes in perceived fatigue and its potential determinants could be assumed to be a premature protective signal against expected cognitive performance fatigue.

## Oral presentations

### OP-MH22 Vascular function

### EFFECT OF DIFFERENT MODES OF EXERCISE ON VASCULAR FUNCTION OF RECESSIVE FEMALE UNIVERSITY STUDENTS WITH FAMILY HISTORY OF HYPERTENSION

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INTRODUCTION: Due to sedentary behavior, physical inactivity and high caloric diet and other unhealthy lifestyle habits, atherosclerotic cardiovascular disease (ASCVD) has become the main disease threatening the health of women and the leading cause of death of women in China. Sedentary lifestyle and insufficient exercise are life pattern of many university students, especially in females, which result in overweight and obesity and other health problems. This paper probes into characteristics of changes in vascular function among female univer-

sity students with family history of hypertension after different modes of exercise with same energy expenditure, instruct them to do exercise scientifically and prevent hypertension and ASCVD.
METHODS: Forty-five young women (20.6±1.7yrs) with family history of hypertension (without training experience) participated in the study that was approved by IRB at Beijing Sport University. All of them were overweight (China cutoff point body mass index≥24kg/m2). They were evenly randomized to control (CT) group, high-intensity interval exercise (HE) group and moderate-intensity continuous exercise (ME) group. The exercise began after two hours of the meal. The ME group did exercise 40 min at the intensity of 65%-75%HRmax. The HE group performed an interval running session consisting of 4×4 min bouts (running at the intensity of 85%-95%HRmax 4 min, interspersed by 3-min rest). The energy expenditure was similar between those two groups. The pulse wave velocity (PWV) and ankle brachial index were determined at the time points of pre-exercise, immediately after exercise, then every 5 minutes till 40 minutes.
RESULTS: (1) Immediately after exercise, the HE group demonstrated significantly decreased level of PWV (867.00±84.33 vs 972.50±93.05cm/s, P<0.01). During recovery period, from 5 to 40 min, the level of PWV in HE group increased gradually. 40 min after exercise, participants in HE group still had a significant lower PWV level compared with the baseline (4.4%, P<0.01). (2) Participants in the ME group had a significant reduction in the PWV level (12.3%, P<0.01) immediately after exercise. 40 min after exercise, PWV level in ME group returned to the baseline. (3) During recovery period, compared with CT group, participants in ME and HE groups had significant lower PWV level from 5 min to 25 min (P<0.05). There were no significant differences in PWV level between ME group and HE group neither immediately after exercise nor during recovery period.
CONCLUSION: Both moderate-intensity continuous exercise and high-intensity interval exercise could reduce arterial stiffness and ameliorate vascular elasticity of overweight young women with family history of hypertension, which were beneficial to prevent hypertension and ASCVD in early life. It was suggested that high-intensity interval exercise may result in a greater stimulus for vascular adaptations when compared to moderate-intensity continuous exercise.

**PRELIMINARY RESULTS OF THE PHYSICAL ACTIVITY AND CAROTID ATHEROSCLEROTIC PLAQUE HEMORRHAGE (PACAPH) PROJECT**

MURA, M., DEHINA-KHENNICHE, L., WEISS-GAYET, M., JOSSET, L., RIVOIRE, E., THOMAS, A., ARSICOT, M., DELLA-SCHIAVA, N., MILLON, A., PIALOUX, V.

*UNIVERSITÉ CLAUDE BERNARD LYON1*

INTRODUCTION: Carotid atherosclerotic plaque instability is one of the major causes of ischemic strokes. Instable plaques are hemorrhagic and contain large content of infiltrated monocytes (MC). In recent cross-sectional studies, our team demonstrated that atherosclerotic patients practicing moderate physical activity (PA) have less intraplaque hemorrhage and less pro-inflammatory circulating MC than non-active ones.
The objective of this study is to determine the effect of an individualized home-based PA intervention on carotid atherosclerotic plaque instability.
METHODS: The PACAPh study is a longitudinal, interventional, monocentric, randomized, controlled study. 80 asymptomatic patients will be recruited with carotid stenosis >50%, without indication of surgery or intercurrent inflammatory diseases. Patients are randomized 1:1 either in the control or in the PA group. The control group follows its usual care. Patients of the PA group receive a connected wristlet for daily step count, and a PA instructor call them twice a month to set new daily step goals, in order to increase the daily step count. In both groups, fitness, MC subsets and kinetic of blood clot formation are assessed.
RESULTS: 52 patients were included (72.1±1.4y/o). To date, 37 patients completed the protocol. PA group increases their VO2 plateau from 13.0±0.8 to 15.8±1.0 mL/min/kg while the control group remains stable (13.6±1.1 to 13.9±1.1 mL/min/kg). Maximal strength of quadriceps is unchanged in both groups. Quality of life slightly improves in the PA group (EQ-5D-5L), and sedentary declines in the PA group.
CONCLUSION: Fitness results suggest that the PA intervention increases the active behavior of patients while limiting sedentary behavior. With addition inclusion, we should be able to analyze the effects of this PA intervention on biological markers, such as MC subsets, kinetic of blood clot formation or blood rheology.

**ACTIVE STRETCHING TRAINING IN PATIENTS WITH CHRONIC VENOUS INSUFFICIENCY: A PILOT RANDOMIZED CONTROLLED TRIAL.**

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*UNIVERSITY OF FERRARA <1> <2> <3>*

INTRODUCTION: Chronic venous insufficiency (CVI) is the most common vascular pathology which affect up to 50% of the general population in the industrialized counties [1]. The progression of CVI depend on different risk factors: genetic background, female sex, hormone, obesity and sedentary lifestyle [2]. Musculoskeletal disorders are often associated with more severe clinical stages of CVI, especially foot static disorder [3] affecting body posture. The aim of the study was to investigate the effect of active stretching (AS) training on venous function and quality of life in patients with CVI. The secondary objective was to evaluate the changes in postural outcomes.
METHODS: A prospective two-arm pilot randomized controlled trial was conducted. Of a total of 25 eligible patients, 5 were excluded, while 20 were included and randomly assigned to AS training, performed twice a week for 3 months (0/10 M/F; mean age 62.9±9 y), or to a control group (C) (2/8 M/F; mean age 54.5±15.5 y) who did not receive any exercise indication.
At baseline and after 3 months leg volume, air plethysmography (APG), quality of life (QoL) with disease specific validated questionnaire (VVSymQ), ankle range of motion (ROM), postural deformities using the optoelectronic body posture machine were recorded.
RESULTS: At the end of the training in the AS group a significant leg volume reduction was detected (from 2340±239mL to 2239±237mL (4.3%); p<.0001), whereas in the C group no significant volume changes was found. Among APG parameters, the ejection fraction rate (EF%) increased significantly from 49.3±9.3% to 61.1±14.5%, p<.005. A moderate-strong correlation between EF% and ankle ROM variation was found (R2=0.6790; p<.003). In AS group a significant improvement in venous symptomatology was measured, the VVSymQ total score decreased from 11.1±2.7 to 3.7±0.8, p<.0001; while in the C group no significant changes were recorded. Finally, the postural outcomes related to lower back and pelvis such as pelvic tilt, pelvis torsion, and lordotic angle significantly improved only in the AS training group (p<.04, p<.01, p<.01 respectively).
CONCLUSION: The proposed AS training impacts on venous function improving APG parameters related to musculoskeletal pump efficiency. In addition, the amelioration of postural outcomes confirms the AS action on the lower back and pelvis misalignments. This pilot study

paves the way for future investigations in this field, opening a further possibility in the management of CVI patient by means of appropriate exercise programs.

1. Beebe-Dimmer JL, et al. The epidemiology of chronic venous insufficiency and varicose veins. Ann Epidemiol. 2005; 15:175-84.
2. Erdal ES, et. al. Evaluation of physical activity level and exercise capacity in patients with varicose veins and chronic venous insufficiency. Phlebology. 2021;36:636-643.
3. Uhl JF, et al. Static foot disorders: a major risk factor for chronic venous disease? Phlebology. 2012; 27:13-8.

### EFFECTS OF ANTIHYPERTENSIVE MEDICATION ON THE BLOOD PRESSURE RESPONSES TO AEROBIC EXERCISE IN HYPERTENSIVE INDIVIDUALS

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INTRODUCTION: Hypertension is the most important risk factor for death and cardiovascular disease, affecting more than 1.1 billion people worldwide and leading to 9.4 million deaths every year. Endurance aerobic training, is effective at lowering resting systolic blood pressure (SBP) by 2–8 mmHg depending on the initial hypertension level. Especially during exercise, SBP rises above resting levels, as cardiac output increases to meet the oxygen and nutrient demands from contracting muscles. Individuals with hypertension at rest, show an exaggerated SBP response to submaximal and maximal exercise in comparison to normotensive individuals. The hypertension during exercise is concerning since those hypertension peaks could further damage the already eroded vasculature of hypertensive middle-aged individuals. In fact, a recent metanalysis reveals that hypertension during moderate exercise intensity is independently associated with higher risk for cardiovascular events and mortality.
Many individuals with diagnosed resting hypertension are successfully treated with antihypertensive medication (AHM). However, the ability of AHM to reduce hypertensives responses during exercise has been recently questioned. The objective of this study was to investigate if the systolic blood pressure (SBP) response to a maximal graded exercise test (GXT) is influenced by antihypertensive medication (AHM).
METHODS: Thirty-one hypertensive individuals with metabolic syndrome under AHM treatment targeting the renin-angiotensin-aldosterone system (RAAS) were recruited. By using a randomized, double-blind, placebo-controlled, crossover design, participants completed two trials: 1) AHM trial in which participants were tested under their habitual antihypertensive medication treatment and, 2) placebo trial (PLAC) in which participants were analyzed after 72-hours of AHM withdrawal and substituted by placebo. In each trial, plasma renin activity (PRA), aldosterone concentration and SBP responses at rest and during GXT were measured. A two-factor ANOVA was used to determine statistically significant differences between trials (i.e., medication and intensity as factors).
RESULTS: There was an interaction between medication and intensity on SBP responses (P=0.049). Bonferroni post-hoc analysis revealed that AHM reduced SBP at resting conditions (128±11 vs 134±12 mmHg, P=0.001). However, medication did not affect SBP at any of the incremental exercise intensities, ranging from 40 to 100% of the peak power output, resulting in similar peak SBP in AHM and PLAC trials (211±25 vs 206±25 mmHg respectively, P=0.088). An adequate RAAS blockade is suggested by the increase in PRA (P<0.001) and the decrease in aldosterone to renin ratio (P=0.007) observed in AHM in comparison to PLAC.
CONCLUSION: The present data suggest antihypertensive medication is effective inhibiting the RAAS activity and lowering resting SBP. However, AHM seems to be not effective lowering SBP during incremental aerobic exercise until exhaustion.

### PHYSICAL ACTIVITY, GENETIC PREDISPOSITION FOR CARDIOVASCULAR DISEASE, AND ALL-CAUSE MORTALITY: THE FINNISH TWIN COHORT

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INTRODUCTION: Current paradigm in the field of exercise science is that physical activity (PA) reduces the risk of premature death (1). To complement the evidence-base, more research is called to assess the role of PA in participants with different underlying attributes, such as genetic predispositions (2). We assessed if PA mitigates the risk of all-cause mortality despite genetic liability for CVD.
METHODS: All-cause mortality was followed for 19.7±8.1 years among 5,344 participants (mean age at baseline 48.9±9.6 years, 55% women) from the older Finnish Twin Cohort. Genetic predisposition for coronary heart disease (CHD), high systolic (SBP) and diastolic blood pressure (DBP) were assessed with polygenic risk scores (PRSs). PA during leisure-time was assessed longitudinally with a structured questionnaire in 1975, 1981 and 1990 and quantified into a mean value of metabolic equivalent hours per day (meanMET h · day-1). Cox proportional hazards model was used to estimate associations between PRSs, PA and all-cause mortality, adjusted for family relatedness, ten principal components of ancestry, age, sex, body mass index (BMI), smoking, binge drinking, fruit, and vegetable consumption.
RESULTS: During the follow-up 1,314 (25%) participants died. In models adjusted for family relatedness, ancestry, age, sex, and BMI, one standard deviation increase in CVD PRSs was associated with 8–12% higher risk of all-cause mortality: CHD (Hazard Ratio 1.11, 95% Confidence Interval 1.04–1.17), SBP (1.08, 1.03–1.14), DBP (1.12, 1.07–1.19). When meanMET was added to the model, statistically significant main effects with 4% lower risk of mortality were observed despite the genetic liability for CVD. However, the associations were attenuated and non-significant after further adjustments for other lifestyle factors.
CONCLUSION: We examined among the first studies the associations between PA during adulthood and mortality in adults with known genetic predisposition for CVD. Genetic predisposition for CVD and lifestyle factors showed independent main effects with all-cause mortality. The favorable associations observed between PA, genetic risk for CVD, and all-cause mortality were attenuated when other lifestyle factors were also considered. The clustering of healthy lifestyles might partially explain the frequently observed favorable associations between PA and mortality. These findings provide information for research-based health policy making and suggest that promoting overall healthy lifestyles might mitigate the risk of all-cause mortality despite the genetic liability for CVD.
References:
1) Bull FC, Al-Ansari SS, Biddle S, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54(24):1451-1462. doi:10.1136/bjsports-2020-102955
2) 2018 Physical Activity Guidelines Advisory Committee. 2018 Physical Activity Guidelines Advisory Committee Scientific Report.; 2018. doi:10.1111/j.1753-4887.2008.00136.x

## OP-AP08 Plyometric Training

### COMPARISON OF COMPLEX TRAINING WITH TWO DIFFERENT ORGANIZATIONS ON LOWER LIMB NEUROMUSCULAR PERFORMANCES

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INTRODUCTION: Complex training combines high-load strength exercises with plyometric ones to improve explosive performance (1). These two exercises can be either alternated set by set (contrast loading; CL) or performed separately by blocks, with all sets of high-load exercises preceding plyometric ones (block training; BT). It has often been suggested that the heavy exercise in CL may have an acute potentiating effect on the following plyometric exercise and hence further increases the explosive performance after a training program (2). The objective of this study was to determine whether the use of different load organizations influenced neuromuscular performance?
METHODS: Forty-seven young men (age range: 23.6 ± 2.8 years) involved in explosive sports were assigned to either a control group (CON, n = 13), CL group (n = 17) or BT group (n = 17). The training program lasted 8 weeks (2 sessions/week) with all training variables (volume, intensity, rest) being identical between the two training groups. The strength exercises consisted of a 6-s maximal isometric half-squat and calf exercises, and the plyometric exercises of different jump types (vertical and horizontal jumps performed in bipodal and unipodal conditions and from different heights). The number of sets per training session was increased progressively during the training program from 6 to 10 sets. Before and after the training or control period, maximal height in squat jump (SJ), drop jump (DJ, 40 cm height) and its associated reactivity index (jump height/contact time) were assessed, as well as the maximal isometric force (MVC) and one repetition maximum (1RM) for the half-squat exercise.
RESULTS: Before training, none of the variables differed between groups. After training, both training groups showed an increase in SJ height (CL: +13.5%, BT: +16.2%, $p < 0.001$), 1RM (CL: +13.9%, BT: +11.2%, $p<0.01$), and MVC (CL: +4.8%, $p = 0.05$, BT: +11.1%, $p<0.001$), without significant changes in the CON group. The BT group experienced a greater increase in MVC than the CL group ($p<0.05$), and only the BT group showed an increase in DJ height (+13%, $p<0.05$) and reactivity index (+10%, $p<0.05$).
CONCLUSION: Our results confirm that CL and BT are effective for improving isometric and dynamic strength and jump performances (3). The lesser efficacy of CL could reflect a greater accumulation of fatigue which have counteracted the potentiating effect of the maximal isometric contraction on the following jump exercise (4), although the effect of fatigue in CL and BT remains a matter of debate (5). In conclusion, the present results indicate that both training organization improved explosive performance with a trend towards a greater efficacy for the BT organization.
REFERENCES
1. Bauer & al. J Sports Sci Med. 22:838-851, 2019.
2. Ebben. J Sports Sci Med. 1:42-46, 2002.
3. Kobal & al. J Strength Cond Res. 31:1468-1476, 2017.
4. Cormier & al. J Strength Cond Res. 34:1461-1479, 2020.
5. Knicker & al. Sports Med. 41:307-328, 2011.

### THE INFLUENCE OF PLYOMETRIC TRAINING ON COLLEGIATE DANCERS

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INTRODUCTION: Plyometric training is an effective method for improving jumping and leaping ability. Whether it can improve the performance of collegiate dancers, who perform a considerable amount of jumping and leaping in their normal training, is unknown. Therefore, the purpose of this study was to examine whether plyometric training can influence dancers' jumping ability, compared to activities normally performed in dance training.
METHODS: This six-week training study included 14 collegiate dancers (age: 21.1 ± 2.4 yr). Nine participants followed a plyometric training program, while five completed a volume-matched dance training program, with common propulsive dance maneuvers selected to resemble the plyometric exercises that would be performed in the plyometric training group. Each group trained twice per week for the duration of the study. Changes in the squat jump, countermovement jump, and broad jump were used as outcome measures. The first three weeks of training were a series of beginner-level jumps (80 touches per session) and the final three weeks progressed to intermediate-level jumps (100 touches per session). Data were assessed using a two-tailed T test, and the alpha level was set to .05.
RESULTS: Plyometric training resulted in significantly greater improvements in broad jump (25.7 ± 6.1 cm) compared to dance training (4.5 ± 4.3 cm) ($p=.03$). No significant differences were observed between plyometric training and dance training in the countermovement jump ($p=.56$), or the squat jump ($p=.22$).
CONCLUSION: These findings suggest that replacing some portion of traditional dance training with a volume-matched plyometric program may result in improvements in broad jumping for collegiate dancers, but not vertical jumping. Collegiate dancers seeking to improve their ability to leap horizontally may benefit from incorporating plyometric exercise.

### A 4-WEEK BLOCK OF HIGH-DENSITY BODYWEIGHT EXERCISES WITH WHOLE-BODY ELECTROMYOSTIMULATION DOES NOT IMPROVE JUMP AND STRENGTH PERFORMANCE: A TWO-ARMED RCT

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INTRODUCTION: The combination of whole-body electromyostimulation (WB-EMS) training and jumping exercises both conducted twice weekly over the duration of 8-14 weeks has been found to increase maximal strength in lower extremities, sprinting and jumping performance [1, 2]. In elite sports, however, the mesocycles of training are often organized according to block periodization. Further, since EMS cannot improve the coordinative aspect of sport-specific movements, the functional transfer into a sport-specific context may be more pronounced when performing dynamic rather than static exercises with superimposed EMS. Thus, this randomized controlled trial aimed at

elucidating whether a 4-week block of either high-density static or dynamic WB-EMS followed by a 4-week block of realization consisting of plyometric exercises is suitable to increase maximal strength and jumping performance in young and physically active adults.
METHODS: Twenty-six trained adults (13 female, 20.8 ± 2.2 years, 69.5 ± 9.5kg, 9.7 ± 6.1h of training/w) were randomly assigned to either a static (STA) or volume-, load- and work-to-rest-ratio-matched dynamic training group (DYN). Before (PRE), after 4 weeks (thrice weekly) of WB-EMS training (MID) and a subsequent 4-week block (twice weekly) of plyometric training (POST), maximal voluntary contraction (MVC) during leg extension (LE), leg curl (LC) and leg press (LP) and jumping performance (SJ, Squat Jump; CMJ, counter-movement-jump; DJ, drop-jump) were assessed. Further, mean perceived effort (RPE) was additionally rated for each session.
RESULTS: Neither rANOVA nor pairwise comparison resulted in significant effects for MVC, SJ and CMJ. The reactive strength index of DJ was significantly higher in STA compared with DYN at MID (162.2 ± 26.4 vs. 123.1 ± 26.5 cm・s-1, p = 0.002, SMD = 1.48) and POST (166.1 ± 28.0 vs. 136.2 ± 31.7 cm・s-1, p = 0.02, SMD = 1.00). Further, DYN rated the perceived effort significantly higher than STA (6.76 ± 0.32 vs. 6.33 ± 0.47 a.u.,, p = 0.013, SMD = 1.06).
CONCLUSION: A high-density block of dynamic or static bodyweight training with complementary WB-EMS is not suitable for increasing maximal strength and jumping performance in young and physically active adults. Therefore, a lower training volume with higher training intensity over a longer training period may induce higher adaptations.
References:
[1] A. Filipovic, M. Grau, H. Kleinöder, P. Zimmer, W. Hollmann, W. Bloch, Effects of a Whole-Body Electrostimulation Program on Strength, Sprinting, Jumping, and Kicking Capacity in Elite Soccer Players., Journal of Sports Science & Medicine. 15 (2016) 639–648.
[2] F. Micke, H. Kleinöder, U. Dörmann, N. Wirtz, L. Donath, Effects of an Eight-Week Superimposed Submaximal Dynamic Whole-Body Electromyostimulation Training on Strength and Power Parameters of the Leg Muscles: A Randomized Controlled Intervention Study, Frontiers in Physiology. 9 (2018) 1719. https://doi.org/10.3389/fphys.2018.01719.

## EFFECT OF INTER-REPETITION REST DURATION ON PERFORMANCE DURING 50 MAXIMAL REPEATED COUNTERMOVEMENT JUMPS

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INTRODUCTION: To be effective, the plyometric exercises must be performed with fast movement velocity, but also with sufficient volume without too much fatigue. To achieve this balance, manipulating inter-repetition rest duration might be effective in delaying fatigue onset and allowing for a greater training volume. Therefore, the aim of the present study is to examine the effects of various inter-repetition rest durations on repetitive countermovement jump (CMJ) performance.
METHODS: Nine physically active men (27.1 ± 3.20 yrs, 1.79 ± 0.06 m, 84.0 ± 10.19 kg) participated in this study. Five visits, separated by at least 48 h, consisted of standardized warm-up and a set of 50 maximal CMJs without arm swing performed continuously (R0c; whereby the end of one jump immediately transitioned into the next jump) or intermittently with 0 (R0; where they landed, stood upright, and then began the next countermovement), 4 (R4), 8 (R8), and 12 (R12) seconds of inter-repetition rest. The start of the rest period was defined as a moment when a subject returned to the upright standing position. The subjects held a wooden dowel in the high bar back squat position, and two linear position transducers (GymAware PowerTool, Kinetic Performance, Australia) were used to measure jump height (JH) and time to peak concentric velocity (TTPV). The strings of the linear position transducers were attached to each end of the wooden dowel, and the average of values recorded by two devices was used for analysis for each variable. The subjects were instructed to use self-selected countermovement depth and to perform all jumps with the intention to jump as high as possible. The results were grouped into 5 groupings of 10 repetitions (G1-G5). Two-way repeated measures ANOVA and Post-Hoc pairwise comparisons were used to compare the mean values of each repetition groupings in IBM SPSS Statistics for Windows, v. 22 (IBM Corp., Armonk, NY, USA).
RESULTS: There were significant main effects ($p<0.05$) for condition and groups of repetitions in addition to a condition*repetitions interaction for JH and TTPV. JH decreased and TTPV increased throughout R0. Similar results were seen in R0c, however, TTPV was not different between G1 and G2, as well as between G3 and G4. JH was significantly decreased in G3, G4, and G5 compared to G1 in R4, as well as in G3 compared to G1 in R12.
CONCLUSION: Rest period manipulation significantly influenced the fatigue onset in repeated CMJs, measured as change of JH and TTPV. Significant decreases of performance occurred in the first 20 jumps in R0 and R0c conditions. On the other hand, increase of rest duration in R4 delayed significant decreases in performance. Furthermore, no decrease of performance was seen throughout the 50 jumps in the R8 condition, meaning that 8-seconds is likely enough to enable high-volume jump training without decreases in performance.

## EFFECTS OF PLYOMETRIC TRAINING IN SOCCER PLAYER'S KICKING PERFORMANCE: A META-ANALYSIS

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INTRODUCTION: Kicking ability is a fundamental skill in the sport of soccer, notably when attempting to score goals. Increased probabilities of winning are related to high standards of kicking performance. Assessing kicking performance and recognizing factors that influence this component of play is critical to the success of soccer games. A great deal of research examines the effects of plyometric training (PT) on soccer kicking performance. Nonetheless, available studies produced inconsistent results, and the literature has not yet been systematically reviewed. Therefore, the impacts of PT on kicking performance remain unclear. This meta-analysis aimed to determine the pooled effect size of PT on kicking performance in soccer players depending upon the related factors (i.e., age, gender, skill level, and duration of intervention).
METHODS: This meta-analysis was carried out according to the PRISMA guidelines. Searches for this study were conducted in four electronic databases: Web of Science, PubMed, Medline, and Scopus. Peer-reviewed studies must have included when they met all of the following criteria: 1) participants were healthy soccer players; 2) the PT intervention was utilized in the experimental group; 3) the regular soccer training program was applied in the control group; 4) the outcome was kicking performance, including kicking speed or kicking distance; 5) the paper was in English.
RESULTS: A total of seventeen studies yielding 18 effect sizes with n = 568 participants were finally included in the meta-analysis. A random-effects model was used to calculate Hedge's g with 95% confidence intervals, which showed that PT had a large-sized positive effect on soccer kicking performance (g = 0.974, 95% CI [0.607, 1.340], $p < 0.001$). Subgroup analyses were performed (i.e., age, gender, skill level, intervention duration), demonstrating no significant differences. In concrete terms, when assessing kicking performance between the

groups (over 18 years of age vs. under 18, male vs. female, elite vs. non-elite), no difference was observed between the groups (p = 0.153-0.827). Similarly, the over-7-week PT intervention has the same effect on kicking performance as the under-7-week one (p = 0.726).
CONCLUSION: The study demonstrates that PT is an effective method to improve soccer players' kicking performance, which plays a crucial role in the overall success of the games. As for the soccer players, coaches, and strength and conditioning professionals, the PT includes a certain value in practice. Therefore, besides well-known training methods like power training in the weight room, PT could be incorporated into the overall strength and conditioning programs for soccer players to reach high standards of kicking performance.

## Oral presentations

### OP-PN39 Physiology III

#### REBOUND CEREBRAL HAEMODYNAMICS DURING SPRINT-BASED EXERCISE

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INTRODUCTION: Exercise-induced increases in blood flow is thought to induce beneficial adaptive responses in the cerebrovasculature. Compared to the sustained blood flow elevations observed with continuous, moderate intensity exercise, interval-based approaches exhibit more complex patterns in flow. Short, supramaximal-intensity exercise (e.g. 30-second sprints) suppresses middle cerebral artery velocity (MCAv) during the bout, but is followed by a subsequent elevation at the onset of recovery. These changes are closely linked to exercise-induced hyperventilation driving hypocapnia at high intensities. This study aimed to examine the role that exercise intensity plays in this post-interval bout rebound response. It was hypothesised that higher intensities would elicit the greatest rebound in early sprint bouts, while lower intensity efforts would induce more consistent responses across multiple bouts.
METHODS: Eight physically active participants (5 female) completed four separate sprint-interval sessions at 80%, 120%, 160% and 200% of maximal power output (Wmax), in a randomised order. The exercise protocol involved 4 x 30-s sprint bouts, interspersed with 4.5-minutes of active recovery at 50 W. MCAv was assessed by transcranial doppler, alongside measures of breath-by-breath end-tidal carbon dioxide (PETCO2). Data were exported and passed through automated feature selection to detect the minimum point during each bout and the maximum point during rebound (first 1-minute of active recovery). All data were analysed using linear mixed effects modelling.
RESULTS: MCAv values within the 80% Wmax visit (97.7 ± 32.3 cm/s) were significantly higher than those in visits at any other intensity (120%: 96.0 ± 33.5 cm/s; 160%: 90.7 ± 30.0 cm/s; 200%: 83.8 ± 27.9 cm/s; all $p < 0.01$), while MCAv in 200% Wmax visits was significantly lower than in all other visits ($p \leq 0.03$). Across the four bouts, regardless of intensity and minimum/maximum point, MCAv was significantly greater for bout 1 (102.0 ± 31.8 cm/s) than in any other bout (Bout 2: 91.4 ± 31.8 cm/s; Bout 3: 88.0 ± 29.6 cm/s; Bout 4: 85.7 ± 29.8 cm/s; all $p < 0.01$). While not significant, rebound responses (maximum – minimum point) were seen to increase across repeated bouts at 80% (Δ39.2 cm/s in bout 1 vs. Δ44.1 cm/s in bout 4). Whereas at 200% the opposite trend was seen, with a decline in rebound magnitude from bout 1 (Δ52.3 cm/s) to bout 4 (Δ38.8 cm/s). Across all intensities and bouts PETCO2 responses were seen to mirror those in MCAv.
CONCLUSION: Acute sprint bouts across a range of intensities and for multiple bouts induce MCAv rebound responses. The amplitude and pattern of these responses over repeated efforts appears to feature an intensity-dependent component, with submaximal intensity sprint efforts showing a more sustained elevation during the bouts and for the rebound response post bouts. These findings indicate that submaximal intensities should be incorporated into interval-based exercise interventions to maximise adaptive stimuli.

#### EFFECTS OF SPRINT INTERVAL TRAINING, CONTINUOUS TRAINING AND BLOOD FLOW RESTRICTION IN ACTIVE YOUNG MEN

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INTRODUCTION: To examine the effects of sprint interval training (SIT), continuous training (CT) and continuous training combined with blood flow restriction (BFR) (CT+B), with equal estimated energy expenditure between CT and CT+B, on body composition, aerobic and anaerobic performance.
METHODS: 45 young healthy active men (age: 19.70±1.01 yr, height: 178.36±5.67 cm, body mass: 71.23±8.47 kg) volunteered to participate in this study. Prior to training participants were familiarized to training procedures and undertook baseline test, including weight, body fat percentage, 2000m rowing performance (duration, maximal oxygen uptake and maximal heart rate) and Wingate test (maximal anaerobic power and average anaerobic power) were measured in baseline test. On the basis of baseline test, all subjects were matched into one of four groups (control, SIT, CT or CT+B). Participants in three training groups completed 12 supervised rowing sessions over 4-weeks period, sessions were separated by a minimum of 48 hours. The SIT group (n=12)performed 20s all out sprints with 160s (1:8 work-rest ratio) of low cadence， nine bouts per session. CT and CT+B groups performed continuous rowing at an intensity of 25% of peak power output either without (CT, n=12) or combined with BFR (CT+B, n=12). In CT+B group, and cuffs were applied as high up as possible on the proximal portion of each thigh and were inflated for 20 s to a pressure of 100% arterial occlusion pressure, nine bouts per session as same as SIT. The control group did not participate in additional training sessions. Subjects were encouraged to maintain their physical activity and diet patterns throughout the programs. Post-training measures were identical with the baseline test.
RESULTS: The body fat percentage of SIT (-1.03±1.28%, P=0.012), CT (-1.06±0.68%, P＜0.001) and CT+B (-0.90±1.15%, P=0.02) were significantly decreased after intervention; the 2000m time-consuming in SIT group (-0.31±0.19min， $P < 0.001$), CT group (-0.36±0.29 min, P = 0.001) and CT+B group (-0.40±0.20 min, $P < 0.001$) were significantly reduced; maximal oxygen uptake of the SIT (5.02±3.73 ml/kg/min, P = 0.03) and CT+B (1.88±4.63 ml/kg/min, P = 0.017) groups were significantly increased; maximal anaerobic power in the SIT group (48.42±37.74W, P = 0.001) and the CT+B group (38.17±39.09W, P = 0.001) increased significantly; average anaerobic power in CT group (42.25±44.50W, P = 0.007) and CT+B group (39.33±29.18W, $P < 0.001$) increased significantly after intervention; and there was no significant difference between groups after intervention among above indicators ($P>0.05$).
CONCLUSION: 4-week SIT, CT, and CT+B interventions can equivalently improve body composition and endurance performance in active young men; however, SIT and CT+B are more effective in improving cardiorespiratory fitness than CT. Continuous training combined with intermittent blood flow restriction can be used as an alternative to improving cardiorespiratory fitness and body composition.

### SUSTAINED SLEEP RESTRICTION REDUCES RESISTANCE EXERCISE PERFORMANCE BUT NOT MARKERS OF MUSCLE PROTEIN METABOLISM IN RESISTANCE-TRAINED FEMALES

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INTRODUCTION: Female athletes sleep less and report more sleep problems than males (1). Resistance exercise is an important component of athletic training programs yet inadequate sleep reduces muscle strength in males (2). The implications for females are unknown. This study investigated the effect of sustained sleep restriction on repeated resistance exercise performance, anabolic and catabolic hormone levels, molecular markers of skeletal muscle protein synthesis and degradation and perceived fatigue and training stress in females.
METHODS: Ten healthy, resistance-trained, eumenorrheic females aged 18-35 years underwent nine nights of sleep restriction (SR; 5-h time in bed) and normal sleep (NS; > 7-h time in bed), in a randomised, cross-over fashion with a minimum 6-week washout. Participants completed resistance exercise sessions on days 3, 5, 7 and 9 of each trial, with blood samples collected pre- and post-exercise to assess hormonal responses. Muscle biopsies were collected pre- and post-exercise on day 3 and 9 to assess circadian and muscle protein metabolism-related gene and protein content via PCR and Western blot, respectively. Exercise performance was assessed using volume-load, reactive strength index and mean concentric velocity with rating of perceived exertion recorded post-exercise. Participants completed awakening saliva sampling and the multi-component training distress scale daily.
RESULTS: Volume-load decreased (<1%, $p < 0.05$) with SR. Mean concentric velocity per set was slower during SR for lower body (up to 15%, $p < 0.05$), but not upper body, compound lifts. SR increased total training distress by 84% ($p < 0.005$) and session perceived exertion by 11% ($p < 0.005$). SR increased the salivary cortisol awakening response (by 42%, $p < 0.005$), yet had no impact on the plasma testosterone, cortisol and IGF-1 response to exercise. SR reduced pre-resistance exercise plasma sex-hormone binding globulin (by 18%, $p < 0.005$) and increased pre-resistance exercise free androgen index (by 35%, $p < 0.01$) on day 3 only. SR had a limited effect on the expression levels of the markers of protein synthesis, protein degradation and circadian-related gene and proteins in skeletal muscle.
CONCLUSION: Nine nights of sleep restriction reduced resistance exercise quality more than quantity and increased perceived effort and training distress at the same relative intensity of exercise. However sleep restriction did not impact the expression of the markers of muscle protein synthesis and degradation, which may be explained by the resistance-trained status of participants. Markers of exercise quality and internal load may be more sensitive than volume-load, to advise coaches of the negative effects of SR on resistance exercise. Further research is needed to demonstrate a protective effect of resistance exercise on skeletal muscle health with inadequate sleep.
1. Roberts et al. (2021) 2. Knowles et al. (2018)

### EFFECT OF INCREASED TRICEPS SURAE CONTRACTION VELOCITY ON WHOLE-BODY METABOLIC RATE AND MUSCLE ACTIVITY DURING CYCLIC PLANTARFLEXION CONTRACTIONS

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INTRODUCTION: Almost 100 years ago, Fenn (1923) demonstrated that the heat liberation of a muscle during concentric contraction was higher than during isometric contractions [1]. Fenn's results were the first of many that led to the general understanding that isometric muscle contractions are energetically cheaper than concentric muscle contractions. While researchers often use this knowledge to explain differences in whole-body metabolic rate during full-body exercises, the evidence is primarily based on single fiber studies. Here, we quantify the effect of increasing triceps surae concentric contraction velocity on whole-body metabolic rate and triceps surae muscle activity during cyclic contractions.
METHODS: Fourteen participants lay prone on a dynamometer and performed cyclic plantarflexion contractions at three different ankle angular velocities: 1) isometric with ankle angle at 10° plantarflexion (PF); 2) isokinetic at 30°/s with the ankle rotating from 5° PF to 15°PF and 3) isokinetic at 60°/s with the ankle rotating from 0° PF to 20° PF. During each condition participants generated torque during 1/3s to reach a target torque (25% of MVC) followed by 2/3s of rest. The conditions were randomized and cyclic contractions were sustained for 6 minutes in each condition. We collected whole-body metabolic rate, triceps surae and tibialis anterior muscle activations and in-vivo gastrocnemius medialis muscle fascicle kinematics.
RESULTS: As expected, increasing ankle angular velocity resulted in faster gastrocnemius medialis contraction velocities and more positive muscle mechanical work per cycle. While mean and peak plantar flexion torques per cycle were not different across ankle angular velocity conditions, net whole-body metabolic rate increased with increasing ankle angular velocity. Compared to the isometric condition, net metabolic rate was 50% and 113% higher in the 30°/s and 60°/s condition respectively. The increase in net whole-body metabolic rate should reflect an increased triceps surae muscle metabolic rate, which depends on muscle activity . Indeed, we found greater mean and peak triceps surae muscle activation with increasing ankle angular velocity. Interestingly, the increase in activation of gastrocnemius lateralis was most prominent (+100% at 60°/s vs. isometric) whereas the relative increase in soleus activation was smaller (+57% at 60°/s vs. isometric). The differences in relative increase may reflect the difference in muscle fiber type distribution with the soleus containing more slow twitch muscle fibers than the gastrocnemius lateralis [2].
CONCLUSION: We provide evidence that slower muscle contractions are metabolically cheaper at the whole-body level . In addition, our results indicate that when synergistic muscles contract faster we rely more on muscles with greater distributions of fast twitch fibers.
References
[1] Fenn (1923). J Physiol. 58(2-3):175-203.
[2] Johnson et al. (1973). J Neurol Sci. 18(1) :111-129.

### WHOLE BODY-ELECTROMYOSTIMULATION TRAINING INCREASED FGF21 IN PARKINSON PATIENTS

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INTRODUCTION: Parkinsons disease (PD) patients are unable or unwilling to adhere to traditional exercise programmes, due to physical and mental limitations. Therefore, it is needed to find a training methodology for them that provides an immediate feeling of well-being and enhances their motivation and perseverance. Whole Body-Electromyostimulation superimposed on voluntary movements is a time-

efficient and non-invasive training modality. The aim of this study was to find the most suitable and effective WB-EMS training methodology for this population.
METHODS: Twenty-five subjects (age 72.08 ± 6.07) were randomly assigned to three study arms: 20 min-Strength based WB-EMS training (85 Hz, with 4s on/4s off, 350 µs) (SG), 20 min-Endurance based WB-EMS training (7 Hz, 350 µs, continuous pulse duration) on a rowing machine (EG), and CG who did not carry out any training. For both the interventions the CE-certified medical EMS equipment Miha Bodytec, (Gersthofen, Germany) was used. Primary outcome variables included physical and cognitive performances, neurotrophic factors (BDNF, FGF21) and α-synuclein levels.
RESULTS: The RM-ANOVA showed significant improvements of both EG and SG in arm curl ($p = 0.003$) and sit to stand test ($p= 0.004$ and $p= 0.030$ respectively). The 6-minute walking test improved significantly ($p< 0.001$) better in the EG compared with the SG ($p= 0.004$) and in Tinetti balance and gait test EG showed higher balance and walking ability than in pre-intervention ($p< 0.001$) and better than SG ($p= 0.002$). With regard to cognitive performances, results showed improvements in general cognitive function (MMSE) both in EG ($p= 0.002$) and in SG ($p= 0.010$). Regarding the perception of fatigue (PFS-16), EG reported a lower fatigue than SG ($p= 0.013$) and CON ($p< 0.001$); in addition, the CON reported a higher perception of fatigue than pre-intervention ($p= 0.032$). The main result was that, after EG training, higher serum levels of FGF-21 ($p= 0.023$) and lower serum levels of α-synuclein were observed ($p= 0.037$). The FGF plays a crucial role in the survival of neurons as well as in neuroinflammation and mitochondrial dysfunctions caused by abnormal aggregation of α-synuclein [Liu,2021].
CONCLUSION: FGF21, in fact, reduces the accumulation of α-synuclein, reducing its toxicity and the loss of dopaminergic neurons. WB-EMS training resulted an effective and well-tolerated training without adverse events or side effects for Parkinsons patients [Fiorilli,2021]. Endurance training combined with WB-EMS was more effective than strength training in improving physical and cognitive performances, and the level of FGF21.

## Oral presentations

### OP-AP20 Cycling II

#### RELATIONSHIPS BETWEEN FUNDAMENTAL TRAINING VARIABLES AND ENDURANCE PERFORMANCE IMPROVEMENT IN RECREATIONAL MALE CYCLISTS

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INTRODUCTION: The question of how to optimize training regimens to maximize endurance performance has attracted much attention in recent years. Our current knowledge mainly comes from retrospective analyses of the training undertaken by elite endurance athletes, suggesting that high total training volumes (VOL) and high proportions of low-intensity training (LIT, typically ≥ 75%) are key to success [1 ]. The importance of training at moderate (MIT) and high intensities (HIT) has also been highlighted [1 ]. However, it is not clear whether training characteristics shown to be effective in elite athletes can also be considered best practices for recreational athletes [2]. The few studies addressing this problem to date were either cross-sectional, or if longitudinal, their sample sizes were typically small and the training period short.
METHODS: We analyzed powermeter data from a randomly selected sample of n = 69 recreational male cyclists (Mage = 42.9 ± 11.64 y, MCP = 3.90 ± 0.64 W/kg, MVOL = 24.85 ± 12.22 h/month) available from a public repository. Inclusion criteria were availability of power output data over a period of at least 24 months, interruptions of training of no longer than 4 months, and a minimum of 50 realized training sessions. Performance- and training-related data for each individual were quantified using the implementations of the Banister model and critical power (CP) in the Golden Cheetah software. The historical maximum of CP (CPmax) was defined as the reference point for later statistical analyses. Specifically, CPmax and its changes over a period of 12 months were used as dependent variables in several (partial) correlation and regression analyses.
RESULTS: Median (IQR) values of relative training intensity distribution were: LIT: 56.28% (50.98,62.92), MIT: 32.19% (26.36,35.84), HIT: 10.43% (8.37,14.16). Cross-sectional analyses of data from the time window of 12 months before CPmax revealed that VOL significantly predicted CPmax, $r = .39$, $p < .001$, as did the relative proportion of LIT, $r = .53$, $p < .001$ (corrected for VOL) and the ratio of LIT to MIT+HIT, $r = .52$, $p < .001$ (corrected for VOL). Longitudinal analysis revealed, however, that absolute yearly VOL was not associated with residualized CP change (corrected for CP baseline and age). Instead, we found that the percentage increase in yearly VOL (corrected for absolute VOL of the baseline year) was significantly correlated with residualized CP change, $r = .44$, $p = .004$. We will also present results of more complex regression models (relative weights analysis) aiming at ranking the predictors according to their statistical importance.
CONCLUSION: Our data indicate that best practice training recommendations derived from elite athletes do also hold true for ambitious recreational athletes. Specifically, the importance of high and progressively increasing VOL and high proportions of LIT became apparent.
[1 ] Seiler, Int J Sports Physiol Perform, 2010
[2] Vermeire et al., J Strength Cond Res, 2021

#### THE REPRODUCIBILITY OF PACING DURING 20-MIN TIME-TRIALS ON ZWIFT®

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INTRODUCTION: Although the reproducibility of performance (i.e., mean power output) during laboratory- and field-based cycling time-trials is well established [1], only few studies investigated the reproducibility of pacing [2, 3], especially in virtual environments [4]. The purpose of this study was to analyse the reproducibility of pacing (i.e., distribution of power output) during time-based 20-min cycling time-trials on the virtual-reality cycling software, Zwift®.
METHODS: Forty-four cyclists (11 women, 33 men; 37 ± 8 years old, 180 ± 8 cm, 80.1 ± 13.2 kg) were recruited and performed 3x 20-min time-trials on Zwift®. To determine the reproducibility of pacing, mean power output per 2-min time-intervals was normalised to overall mean power output during each time-trial. Typical errors (TE; which constitutes the variability of the measure) derived from log-

transformed data and changes in the mean normalised power outputs between time-trials 1-2 and 2-3 were calculated for each 2-min time-interval; two-way repeated-measures ANOVA ($P < 0.05$) was used to analyse differences between 2-min time-intervals.
RESULTS: We found higher variability (evidenced by higher TE) of normalised power output at the start and end of each time-trial (TE = 5.06% and 4.36% for intervals 0-2 min and 18-20 min, respectively), in comparison to the remaining time-intervals. There was a main effect of time ($F = 18.32$, $P < .001$, ES = .31) and mean normalised power output decreased from time-interval 2-4 min to 12-14 min (all $P < .047$) and increased during 18-20 min in comparison to all previous time-intervals (all $P < 0.001$), except from 0-2 min ($P = .359$). However, pacing was not different between time-trials ($F = 1.31$, $P = .249$, ES = .03).
CONCLUSION: Our findings indicate that pacing is consistent throughout repeated time-trials, although there might be higher variability—evidenced by the higher TE—at the start and end, in comparison to the middle parts. Our results are likely to be used in assisting coaches and athletes in their virtual training monitoring and the development of new remote-study designs by sports scientists. This is particularly important in the current COVID-19 pandemic, where cyclists might rely upon virtual training.
1. Currell K, Jeukendrup AE. Validity, reliability and sensitivity of measures of sporting performance. Sports Med 2008; 38: 297-316.
2. Stone MR, Thomas K, Wilkinson M et al. Consistency of perceptual and metabolic responses to a laboratory-based simulated 4,000-m cycling time trial. Eur J Appl Physiol 2011; 111: 1807-1813.
3. Thomas K, Stone MR, Thompson KG et al. Reproducibility of pacing strategy during simulated 20-km cycling time trials in well-trained cyclists. Eur J Appl Physiol 2012; 112: 223-229.
4. McIlroy B, Passfield L, Holmberg H-C et al. Virtual Training of Endurance Cycling–A Summary of Strengths, Weaknesses, Opportunities and Threats. Front Sports Act Living 2021; 3: 31.

## LOW INTENSITY TRAINING (LIT) IN CYCLISTS DURING PYRAMIDAL TRAINING: SHORTER, DAILY LIT SESSION SEEMS SUPERIOR FOR THRESHOLD POWER COMPARED TO LONGER 3-DAY LIT BLOCKS: A WORK-LOAD MATCHED RCT

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INTRODUCTION: Low-intensity training (LiT) is an essential training stimulus to improve performance and contributes to more than 80% of the weekly time- and session-related training volume in recreational and elite athletes. However, the density, distribution and duration of LiT sessions during a weekly training schedule still remains debatable. Thus, we aimed at elucidating whether shorter LIT training session on a daily basis result in superior threshold power compared to longer LIT training session within 3-day blocks.
METHODS: Twenty-one moderately trained cyclists (age = 33.9 ± 7.8 years, sex = 4 female, 17 male, 20 minute time trial performance = 3.7 ± 0.7 W/Kg, weight = 76.5 ± 13,9 Kg, training volume = 10.9 ± 2.27 h/week) were either assigned to the DenseLIT(DL)- or StretchLIT(SL)-group, using the minimization method (Strata: Gender, age, fitness level, training volume). DenseLIT accumulated 80% of their weekly LiT training volume in a three-day window with longer LIT sessions, whereas the Stretch-LIT group used a more weekly balanced approach with shorter daily LIT sessions. Both groups applied a pyramidal training intensity distribution (TID), and used two training mesocycles, each with three weeks of increasing training loads and one recovery (first cycle), or test week (last cycle). At the end of the eight-week intervention period, an incremental cycling (+50 W/5min.) test was conducted to assess submaximal performance surrogates at the lactate thresholds (iAT, P2, and P4) and peak performance.
RESULTS: rANOVA revealed significant time*mode interaction effect ($p \leq 0.05$; $\eta p2 \geq 0.18$) for iAT, P2 and P4. Subsequent pairwise post hoc testing revealed notably larger pre to post performance inprovements in StretchLiT (iAT (+30±28W; $p < 0.01$, SMD = 0.52), P2 (+37±33W; $p < 0.01$, SMD = 0.64) and P4 (+40±37W; $p < 0.01$, SMD = 0.58) compared to non-significant effects in DenseLIT (iAT (-5±21W; $p = 0.42$, SMD 0.01), P2 (+11±18W; $p = 0.07$, SMD = 0.17) and P4 (+12±25W; $p = 0.15$, SMD = 0.18). The training volume in both groups was workload matched (DenseLIT = 28191 ± 4165 Trimp vs. StretchLiT = 22474 ± 8983, $p = 0.25$).
CONCLUSION: StretchLiT show superior performance improvements in iAT, P2 and P4 performance with moderate effects , whereas DenseLIT display only trivial or no effects. Thereby, a continuous stretched out training regime seems to induce superior effects compared to a three-day dense LiT program in an eight-week intervention period of moderately trained cyclists.

## HIGH-INTENSITY INTERVAL TRAINING IN CYCLING: ACUTE RESPONSE AND CHRONIC ADAPTATIONS

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INTRODUCTION: High-Intensity Interval Training (HIIT) was highlighted as a safe intervention that allows for multiple health benefits across the lifespan [1]. Previous research indicated variables for characterizing HIIT protocols and categorized four types of HIIT: long intervals (LI, > 60 s), short intervals (SI, ≤ 60 s), repeated sprint training (RST) and sprint interval training (SIT) [2]. It is commonly assumed that the acute physiological response corresponds to the adaptational effect. While recent meta-analyses compared the chronic adaptations to LI and SIT [3], there are several promising HIIT protocols that deserve closer attention at both levels. Hence, this systematic review aims to compare the effects of various HIIT protocols on (1) the acute response and (2) chronic adaptions in cycling.
METHODS: PubMed and Web of Science were used to find studies in the timespan from 2013 until the date of the search (15th of February 2021). Inclusion criteria were the comparison of different HIIT protocols, cycling as exercise modality and participants with a mean maximal oxygen uptake ($\dot{V}O_2max$) ≥ 45 ml/min/kg. Risk of bias was assessed by using the PEDro scale. Results were summarized for the acute response (time ≥ 90% $\dot{V}O_2max$, lactate concentration, perceived exertion and power) and chronic adaptations (time trial performance, $\dot{V}O_2max$ and lactate threshold) while indicating the participants' performance levels.
RESULTS: A total of 31 studies (23 acute, 14 chronic, 6 both) with a mean PEDro score of 5.4 ± 0.9 and a total sample size of N = 544 were included. The majority of acute studies applied a crossover design, while longitudinal studies were exclusively group-based. The highest times ≥ 90% $\dot{V}O_2max$ were reported for intervals with varied work intensity and protocols that combined SI and LI. SI demonstrated a substantially higher acute response compared to LI while differences in chronic adaptations appeared to be rather small and tended to favor SI in highly-trained/professional athletes. When compared to SI and LI, SIT and RST demonstrated considerably lower improvements in aerobic endurance parameters, whereas anaerobic and sprint parameters were effectively improved.
CONCLUSION: The results indicate that HIIT protocols that are associated with a higher acute response may not necessarily lead to superior chronic adaptations. Whereas SI and LI seem to be equally effective for improving endurance performance, SIT and RST are more adequate for improving sprint performance. In accordance with previous research [3], the reported performance improvements decreased with increasing training status. Limitations arise from the design of longitudinal studies and the applied matching procedures. Future studies are

encouraged to perform crossover interventions and include measures of glycolytic capabilities to holistically examine the adaptational effect of various forms of HIIT.
1) Martland et al. (2020) J Sports Sci
2) Buchheit & Laursen (2013) Sports Med
3) Rosenblat et al. (2020-22) Sports Med

**LESS IS MORE—CYCLISTS-TRIATHLETE'S 30 MIN CYCLING TIME-TRIAL PERFORMANCE IS IMPAIRED WITH MULTIPLE FEEDBACK COMPARED TO A SINGLE FEEDBACK**

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Purpose: The purpose of this article was to (i) compare different modes of feedback (multiple vs. single) on 30 min cycling time-trial performance in non-cyclist's and cyclists-triathletes, and (ii) investigate cyclists-triathlete's information acquisition.
METHODS: 20 participants (10 non-cyclists, 10 cyclists-triathletes) performed two 30 min self-paced cycling time-trials (TT, ~5–7 days apart) with either a single feedback (elapsed time) or multiple feedback (power output, elapsed distance, elapsed time, cadence, speed, and heart rate). Cyclists-triathlete's information acquisition was also monitored during the multiple feedback trial via an eye tracker. Perceptual measurements of task motivation, ratings of perceived exertion (RPE) and affect were collected every 5 min. Performance variables (power output, cadence, distance, speed) and heart rate were recorded continuously.
Results: Cyclists-triathletes average power output was greater compared to non-cyclists with both multiple feedback (227.99 ± 42.02 W; 137.27 ± 27.63 W; $P < 0.05$) and single feedback (287.9 ± 60.07 W; 131.13 ± 25.53 W). Non-cyclist's performance did not differ between multiple and single feedback ($p > 0.05$). Whereas, cyclists-triathletes 30 min cycling time-trial performance was impaired with multiple feedback (227.99 ± 42.02 W) compared to single feedback (287.9 ± 60.07 W; $p < 0.05$), despite adopting and reporting a similar pacing strategy and perceptual responses ($p > 0.05$). Cyclists-triathlete's primary and secondary objects of regard were power (64.95 s) and elapsed time (64.46 s). However, total glance time during multiple feedback decreased from the first 5 min (75.67 s) to the last 5 min (22.34 s).
Conclusion: Cyclists-triathletes indoor 30 min cycling TT performance was impaired with multiple feedback compared to single feedback. Whereas non-cyclist's performance did not differ between multiple and single feedback. Cyclists-triathletes glanced at power and time which corresponds with the wireless sensor networks they use during training. However, total glance time during multiple feedback decreased over time, and therefore, overloading athletes with feedback may decrease performance in cyclists-triathletes.

## Oral presentations

### OP-BM15 Knee pain

**IS ONE ENOUGH? – EFFECT OF UNILATERAL AND BILATERAL STRENGTH TRAINING IN TOTAL KNEE ARTHROPLASTY REHABILITATION**

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INTRODUCTION: The loss of strength and flexibility is a frequent challenge in patients following total knee arthroplasty (TKA). Despite the lack of clear guidelines for the postoperative rehabilitation protocols, such protocols typically include bilateral strength training of the lower limbs. Training intensities are therefore calculated from the bilateral one repetition maximum. However, based on the theory of the bilateral deficit, a reduced bilateral force production compared to the summed unilateral force production from the same homologous muscles [1], this might underestimate the muscle's capacity [2]. Therefore, the aim of the study was to analyze the effects of unilateral compared to bilateral strength training following unilateral TKA on knee extensor strength and flexibility.
METHODS: Twenty-two patients were randomly assigned to a unilateral (UL: n=11, 6 males, 62.5+/-9.7 y, BMI: 32.4+/-7.3) or bilateral (BL: n=11, 4 males, 59.1+/-6.1 years, BMI: 29.8+/-3.9) inpatient rehabilitation training group. All patients participated in a 3-week routine physical therapy including flexibility, proprioception water aerobics, treadmill training, and ergocycle training. Additionally, depending on the training group assignment, patients performed unilateral (operated leg only) or bilateral leg press, knee extension, knee flexion, and calf raise exercises. Main outcome measures were isometric leg extension strength of the separate legs and maximum flexion of the operated knee before and after the training. Effects were tested by mixed multi factorial ANOVAs and post-hoc tests.
RESULTS: Both groups increased their isometric leg extension strength of the operated leg (from 17.5 +/- 6.3 to 21.9+/-6.4 kg) and the non-operated leg (from 21.2+/-5.0 to 24.9+/-5.4 kg). The increases were significantly greater ($p<0.05$) for the non-operated leg in the UL-group (+27.5% vs. +11.6%). Knee flexion increased in both groups (from 101.81+/-13.67° to 109.5+/-14.4°) with greater changes ($p<0.05$) in the UL-group (+10.7 vs. +4.5%).
CONCLUSION: Unilateral strength training following TKA led to similar strength benefits in the operated leg and even greater benefits in the strength in the non-operated leg and the flexibility of the operated knee compared to bilateral strength training. The greater intensity over the whole range of motion during unilateral strength training seems to provide a greater stimulus to increase flexibility than bilateral strength training without any negative effects during therapy. Hence, unilateral strength training in postoperative rehabilitation is a promising alternative to standard bilateral rehabilitation programs.
1. Steger, J. and Denoth, J, Das Bilaterale Defizit: Analysen anhand von Kraft-, EMG- und EEG-Messungen. Schweizerische Zeitschrift für Sportmedizin und Sporttraumatologie, 1996. 44(4): p.155-159.
2. Botton, C E et al., Neuromuscular Adaptations to Unilateral vs. Bilateral Strength Training in Women. J. Strength Cond. Res. 2015. 30(7): p.1924-1932.

### INFLAMMATORY MARKERS IN EARLY SYMPTOMATIC KNEE JOINT OSTEOARTHRITIS: A CASE-CONTROL-PILOT STUDY

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INTRODUCTION: Osteoarthritis (OA) is characterised by the failure of normal biological processes to repair following damage. This can be due to abnormalities in movable joint structures and manifests symptomatically as pain and reduction of physical function [1]. These can be caused by sports injury or post-traumatic osteoarthritis [2]. Traditionally, OA was considered a “wear and tear” disorder, however it is now recognised as an inflammatory condition, pre-seeded by molecular modifications [3]. Early diagnosis of OA is essential to optimising treatment and clinical outcomes. A recent set of clinical assessment criteria have been recommended for use in patients with early OA, with further research into biochemical markers being advocated [4]. The aim of our study was to evaluate select inflammatory markers in individuals with early knee OA (eKOA) and asymptomatic controls (matched for age, anthropometrics and physical function).
METHODS: Twenty six eKOAs were recruited (females, n = 13; age = 60.2 ± 5.4yrs, height = 1.73 ± 0.11m, body mass = 77.8±12.8kg, DXA-fat = 33.9 ± 8.5%). The inclusion criteria were as follows; pain for >1 year, Knee Injury and Osteoarthritis Outcome Score (KOOS) pain score of greater than 50 and Kellgren and Lawrence grade ≤ 2. Twenty-three asymptomatic individuals (females, n = 14; age = 59.9 ± 5.5yrs, height = 1.71 ± 0.09m, body mass = 72.6 ± 11.3kg, DXA-fat = 30.4 ± 8.2%) were recruited as a comparator group. The Timed Up and Go Test and the 6 Minute Walk Test were used to evaluate participant’s physical function. Participants’ blood was drawn into serum separator tubes, centrifuged and stored at -80oC. Serum levels of IL-1α, IL-1 β, IL-2, IL-4, IL-6, IL-8(CXCL8), IL-10, hsCRP and TNF-α were quantified using a multiplex assay quantified on a V-plex®Sector Imager 2400 (Meso Scale Discovery, Rockville, MD, USA).
RESULTS: Expectedly KOOS pain differed between the groups (mean = 99.2 ± 2.0 AU vs 69.2 ± 13.8 AU; $p < 0.001$). Only IL-6 was higher in eKOA ($p = 0.001$, $\eta p2 = 0.229$; by 0.197pg/mL, 34.5%). This difference had moderate discriminative accuracy (AUC = 0.751, 95% CI = 0.610-0.891, $p = 0.003$), an accurate positive rate of 84% (false positive rate = 64%) and a cut-off below 0.627pg/mL. Among eKOA, IL-6 did not correlate with KOOS pain ($p = 0.501$; $r = -0.151$).
CONCLUSION: Inflammation plays a pivotal role in the progression of KOA, however is sparsely investigated in eKOA, with little structural or functional defects. Our results illustrate that circulating IL-6 could be used as a potential biomarker of early knee OA. Future work should seek to verify this results in a larger sample and further investigate IL-6 related molecular pathways in eKOA.
References
1. Kraus et al., 2015, Osteoarthr. Cartil.; 2. Whittaker and Roos, 2019, Best. Pract. Res. Clin. Rheumatol.; 3. Mobasheri et al., 2017, Osteoarthr. Cartil.; 4. Emery et al., 2019, Nat. Rev. Rheumatol.

### WHOLE BODY VIBRATION FOR CHRONIC PATELLAR TENDINOPATHY: A RANDOMIZED EQUIVALENCE TRIAL.

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INTRODUCTION: Whole body vibration (WBV) triggers an anabolic response in various tissues, including tendons [1]. However, the clinical effectiveness of this exercise regime against tendinopathy remains unexplored. Therefore, in this waitlist-controlled equivalence trial, we tested the effectiveness of WBV as a treatment of patellar tendinopathy against conventional heavy slow resistance training (HSR).
METHODS: Thirty-nine patients were randomized to either 3 months of WBV training (n = 13), HSR training (n = 11), or a waitlist control (WLC) group (n = 15). In a partly cross-over design, 14 patients of the WLC group were redistributed to one of the two intervention groups (5 in WBV, 9 in HSR). Pre- and post-intervention testing included pain assessments (VAS), functional limitations (VISA-P), knee extension strength and tendon morphology, as well as tendon material and mechanical properties. Follow up measurements (VAS, VISA-P) were performed in the WBV and HSR groups six months after the intervention.
RESULTS: Comparisons with the WLC group revealed significant improvements in VISA-P and VAS scores after HSR (41%, $p = .003$ & 54%, $p = .005$) and WBV (22%, $p = .022$ & 56%, $p = .031$) training. These improvements continued until follow-up (HSR: 43% & 56%; WBV: 24% & 37%). Pre-post improvements in VAS scores were equivalent between WBV and HSR groups but inconclusive for the VISA-P score and all pre-test to follow up comparisons. The mid-tendon cross-sectional area was reduced after both WBV (-5.7%, $p = .004$) and HSR (-3.0%, $p = .006$) training, although the equivalence test was inconclusive.
CONCLUSION: Whole body vibration improved symptoms typically associated with patellar tendinopathy. This type of intervention is as effective as HSR against pain, although equivalence could not be confirmed for other variables. The beneficial responses to WBV treatment persisted for 6 months after the end of the intervention.
REFERENCES:
1 Rieder F, Wiesinger HP, Kösters A, Müller E, Seynnes OR. Whole-body vibration training induces hypertrophy of the human patellar tendon. Scand J Med Sci Sports. 2016;26(8):902-10.

### BIOMECHANICAL ANALYSIS OF THE PATTERNS OF FEMALE FUTSAL PLAYERS WITH AND WITHOUT KNEE PAIN. CROSS-SECTIONAL STUDY.

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INTRODUCTION: Knee injury incidence and especially anterior cruciate ligament (ACL) injuries in womens soccer is very high and higher than in mens soccer (1). The high sports casualty and recurrence rate justifies the need to work on injury prevention identifying and reversing the main biomechanical and neuromuscular risk factors (2,3). A cross-sectional study is proposed to identify the relationship between biomechanical risk patterns established by the bibliography (4).
METHODS: A sample of 16 female futsal players (23,94 ± 5,03 years) was selected. They were divided into three groups: ACL intervention (LCA), knee pain (KP) and no knee injury (NI). A 3D capture system of 12 infrared cameras (Qualisys A.B, Gotegorg, Sweden) was used. Visual3D software was then used to create an 8-segment biomechanical model for the calculation of biomechanical variables. A pressure platform system was used to detect the peak torque of the braking reaction force. Specific tests were performed. A contrast of variables between groups was performed using Students t-test and an analysis of the effect size using Cohens d. A linear regression model was constructed using ANOVA. A 95% confidence level was established.

RESULTS: Eight KP players, one with LCA, and another group of 8 NI players were analysed. The contrast between groups did not significant results, although relevant differences appeared when analysing the effect size. The KP group presented a biomechanical adjustment towards greater knee valgus (d=0.64), contralateral trunk displacement (d=0.86), contralateral pelvic drop (d=1.04), and greater plantar flexion at the moment of maximum impact on the force platform ($p<0.05$). Moreover, a regression model was defined which fixes the knee valgus variable in 99% ($p<0.01$) as a function of the variables trunk displacement, pelvis drop, hip rotation, knee rotation and ankle valgus.
CONCLUSION: The biomechanical pattern may be different between futsal players with knee pathology and players without injury, being knee valgus a conditioned variable and definable from other biomechanical variables.
REFERENCES
1. Ruiz-Pérez I, López-Valenciano A, Jiménez-Loaisa A, Elvira JLL, de Ste Croix M, Ayala F. Injury incidence, characteristics and burden among female sub-elite futsal players: a prospective study with three-year follow-up. PeerJ. 2019;7:7989.
2. Hewett TE, Myer GD, Ford KR, Heidt RS, Colosimo AJ, McLean SG, et al. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: A prospective study. Am J Sports Med. 2005;33(4):492–501.
4. Krosshaug T, Slauterbeck JR, Engebretsen L, Bahr R. Biomechanical analysis of anterior cruciate ligament injury mechanisms: Three-dimensional motion reconstruction from video sequences. Scand J Med Sci Sports. 2007;17(5):508–19.

# Oral presentations

## OP-SH08 Teacher Education

### INITIAL TEACHER EDUCATION - A PHYSICAL EDUCATION PRESERVICE TEACHERS PERCEPTION

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Introduction
This study explores physical education preservice teachers' (PSTs) perceptions of initial teacher education (ITE) and its input to their professional life and teachers' identity, at the end of their teaching practicum. The aim was to explore PSTs' perceptions concerning different features of the teaching profession, investigate the value attributed to the teaching practicum, and examine PSTs' identity as teachers.
Methods
The sample was composed of 157 PSTs in the Master's in Teaching PE, who just completed their teaching practicum. Data was collected using the 'Questionnaire for student teachers' (Ezer et al.,2010) . The close-ended questions determined perceptions concerning five features of the teaching profession and ITE, such as agents of training, components of teacher education, roles of teachers, motivation for teaching, and conceptions of teaching and learning. The statements regarding motivation for teaching were associated with subcategories of self-efficacy, commitment to the practice of teaching, intrinsic and extrinsic motivation. The statements in conceptions of teaching and learning were associated with subcategories of traditional and constructivist approaches to teaching and to learning. The open-ended questions described significant changes during the teaching practicum and what made PSTs feel like teachers. Quantitative data was statistically analysed through SPSS 26, and qualitative data were analysed using thematic content analysis.
Results and Discussion
Findings revealed that PSTs consider the cooperating teacher the principal agent of training (1.55±1.14); the teaching practicum as the most important component of initial teacher education (1.57±1.18); it is the teachers' role to deliver universal values (2.34±1.43); motivation for teaching is the relationship established with children (5.52±.64); and the teaching profession requires lifelong learning and development (5.63±.66). The most valued statements regarding motivation for teaching were related to intrinsic motivation (5.15±.57). The PSTs showed a constructive approach to teaching (5.20±.48) and to learning (5.07±.56). Through their open-ended questions, the most significant change was their self confidence, and the teacher and pupil relationship made them feel like teachers. PSTs place the student at the centre of the teaching and learning process, which requires learning and lifelong development within the teaching profession. PSTs consider the cooperating teacher as the most important agent of training during ITE and, therefore, decisive in their professional identity formation.
Conclusion
The analysis of the results regarding perception of learning and teaching revealed a preference for a constructivist approach. The present findings allow us to improve ITE programs.
References
Ezer, H., Gilat, I., & Sagee, R. (2010). Perception of teacher education and professional identity among novice teachers.European Journal of Teacher Education,33(4), 391–404

### TEACHER EDUCATORS' PROFESSIONAL IDENTITY DEVELOPMENT: AN EXPLORATORY STUDY WITH UNIVERSITY-BASED PHYSICAL EDUCATION TEACHER EDUCATORS

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Introduction
Gee (2000-2001, p.99) defines identity as, 'being recognized [by oneself and others] as a certain «kind of person», in a given time and context'. Research literature over the last two decades highlights the importance of identity in teaching practice and teacher professional learning (Beauchamp & Thomas, 2009; Beijaard et al, 2004; Day et al., 2006; Rodgers & Scott, 2008). Teacher educators (school and university-based) are an occupational group experiencing increased scrutiny by international policy makers and researchers (Tryggvason, 2012; White, 2018). However, limited related literature falls within the development of a professional identity for university-based teacher educators (Izadinia, 2014; Pereira et al., 2015; Yamin-Ali, 2017), rendering it difficult to identify and define them. Thus, addressing university-based teacher educators' complex work in current higher education contexts requires identifying the issues influencing their professional

identity development (Hinostroza-Paredes, 2021; Mannes, 2020). Taking Gee's (2000-2001) discursive notion of identity - constructed through language and talk, this study addresses this lack of consideration by exploring who university-based teacher educators are.
Methods
Ten individuals supervising school placements from Portuguese Physical Education Teacher Education Programme at a private university took part in semi-structured interviews. An inductive qualitative analysis was undertaken for data analysis. An informed consent form seeking approval to use the data collected to inform the study was completed by the participants. Pseudonyms were assigned to ensure anonymity and confidentiality.
Results
There were two overarching themes: Issues of teaching identity, including experience, participation, interaction, reflection, and performance; and Constraints in the work context, namely personal, institutional, and social.
Discussion
The findings revealed that, a university-based teacher educator is someone whose identity is developed from, (i) previous professional experiences and roles; (ii) one's active participation in the school placements' syllabus; (iii) informal interactions with the faculty-tutors peers; (iv) research and reflexion of one's practices; and (v) the performance of the role itself. The constraints in developing a professional identity were: (i) responsibility in preparing effective teachers for the future; (ii) workload and conciliating other professional roles; (iii) lack of recognition by the stakeholders; (iv) professional instability; (v) preservice teachers' lack of commitment and assessment; (vi) balancing educational experiences in cooperating schools; (vii) lack of time to establish meaningful pedagogical relationships; and (viii) management of conflicts. Recommendations were offered for a continuing development of teacher educators' professional identity.

### TEACHING SKILLS OF EXPERIENCED ELEMENTARY SCHOOL TEACHER IN PHYSICAL EDUCATION CLASSES—FOCUSED ON INVOLVEMENTS WITH STUDENTS IN CLASSES AND ACTIVATION WITH VERBAL COMMUNICATION OF STUDENTS—

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INTRODUCTION: Teachers teaching skills have been identified through many previous studies. Furthermore, teachers' teaching skills in physical education classes have been examined by systematic observation instrumentation. Recently, it is required verbal and non-verbal communication with others through physical activities in physical education classes. It suggested the importance of active learning with communication in the government curriculum guidelines (Ministry of education, 2015). Therefore, teachers' teaching skills are essential for the acceleration of group work using verbal communication in physical education classes. However, teachers' teaching skills in physical education classes have been investigated mostly by quantitative research using observation methods and the student evaluation in physical education classes. The purpose of the study was to examine the teaching skills of experienced teachers in physical education classes.
Methods
we investigated involvement with children of experienced elementary school teachers in physical education classes. Participants were four experienced elementary school teachers and 5th and 6th graders (81boys and 90 girls) who always take their physical education classes. In the approach, we analyzed the contents of experienced teachers' speeches and the content of descriptions on students' cards. Each text data was analyzed through text mining (NVivo). Additionally, the communication date was measured by Hitachi Business Microscope to confirm group communication conditions by teacher's involvement. The Business Microscope described their communication networking figures.
Results and Discussion
Resultantly, it was suggested there were common characteristics of experienced teachers from the contents of teacher speeches in classes, student cards, and communication networks. From the experienced teacher's speeches, there were various and many questions for students. Nakajima (2017) showed that experienced teacher has asked about tasks and encouraging explanation instead of presenting the answer. Therefore, it would be predicted experienced teachers involve students in various questions and attempt to encourage thinking to learn tasks. In addition, there were more specific descriptions that related to learning tasks from students' cards after classes. Umeno (1997) indicates students could be motivated to learn tasks by doing questions from the teacher constantly. Similarly, students' awareness of learning tasks would be presented in the descriptions by constant questions from an experienced teacher. Moreover, it was shown that the group communication among the experienced teachers was active. Due to this result, experienced teachers could be promoted collaborative learning in each learning group.
1) Ministry of education, 2015
2) Nakajima T., Hokkaido journal of physical education, health and sport sciences, 2015
3) Umeno K., Japanese journal of sport education studies, 1997

### OPPORTUNITIES OR CONSTRAINTS THROUGH PHYSICAL EDUCATION AND SPORTS PAST EXPERIENCES.

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Schools and Physical Education (PE) have been recognized as important environments for promoting a physically active lifestyle (Pate et al., 2006). Literature supports that through the experiences, teachers develop stable emotional characteristics, which contribute to structure their values (Haynes et al., 2016). The study analyses teachers experiences in PE and how these experiences relate to the value they attribute to PE and sports and whether they are facilitators or obstacles promoting active lifestyles.
Methods
A mix method study was adopted. A questionnaire (Carreiro da Costa & Marques, 2011) about the experience in PE, perceptions about PE status was applied to 297 teachers (58 male). From this sample, 24 teachers were selected for 3 focus groups depending on their experiences in PE (good, bad experiences or both). MaxQda was used for the inductive qualitative data analysis.
Discussion
Teachers who have had good experiences in PE in school value the role of PE and sports. They refer the teacher, the curriculum, and a high self-perception of competence as the factors that have contributed to building positive experiences. Teachers who have had bad experiences do not value the importance of PE or sports. The teachers, curriculum, specific equipment, traumatic experiences, and a low level of self-competence are explanatory factors of negative attitudes towards PE.

Conclusions
These results support the importance of the earliest good experiences in PE to generate attitudes that value and support PE and sports value. They have demonstrated that PE and sport are still peripheral core subjects in schools. It is crucial that PE teachers and sports coaches, in addition to their work, should function in the school, with subject teachers, parents, and the community, promoting the role and importance of school and PE in promoting active lifestyles.
References
Carreiro da Costa, F., & Marques, A. (2011). Promoting active and healthy lifestyles at school: views of students, teachers, and parents in PortugaL. In I. K. H. K. G. (Eds). (Ed.), Contemporary issues in Physical Education: an international perspective (pp. 249-268). Mainhead: Meyer & Meyer.
Haynes, J., Miller, J., & Varea, V. (2016). Preservice Generalist Teachers Enlightened Approach to Teaching Physical Education through Teacher Biography. Australian Journal of Teacher Education, 41, 21-38. https://doi.org/10.14221/ajte.2016v41n3.2
Pate, R., Davis, M., Robinson, T., Stone, E., McKenzie, T., & Young, J. (2006). A Leadership Role for Schools: A Scientific Statement From the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Physical Activity Committee) in Collaboration With the Councils on Cardiovascular Disease in the Young and Cardiovascular Nursing. Circulation 114, 1214–1224.
https://doi.org/https://doi.org/10.1161/CIRCULATIONAHA.106.177052

## 13:15 - 14:15

## Conventional Print Poster

### CP-MH02 COVID-19: Aerobic fitness and physical activity

#### EXERCISE INTOLERANCE POST-COVID-19 – IS IT ALL DECONDITIONING? A REVIEW

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INTRODUCTION: Exercise intolerance is a chief complaint of patients with post-COVID-19 symptoms and is concomitant with low cardiorespiratory fitness.[1-3] There is a growing body of literature investigating potential underlying mechanisms of this complaint.[2,3] Due to the variety of studies, it is however difficult for researchers and clinicians to capture the big picture. We thus aimed to perform a narrative review on the contribution of the pulmonary system, cardiovascular system, as well as the periphery to low cardiorespiratory fitness post-COVID-19.
METHODS: We systematically searched the databases Medline, EMBASE, and L.OVE Coronavirus Disease by Epistemonikos through January 2022. After deduplication and screening, we ended up with 32 relevant studies examining adult patients post-COVID-19 using cardiopulmonary exercise testing.
RESULTS: The prevalence of restrictive lung disease seemed to decrease with recovery time. Already in the first months after the active phase of COVID-19, traditional spirometry parameters (forced expiratory volume in 1s, forced vital capacity, the ratio between the two) were within the normal range in most patients. However, median diffusive lung capacity using carbon monoxide was low even up to one year post-COVID-19 (1 to 5 months, n = 12: 76 [74, 79] % of pred.; >5 months, n = 6: 86 [78, 87] % of pred.). Chronotropic incompetence and small stroke volume are cardiovascular parameters that may contribute to low cardiorespiratory fitness, especially during the first months post-COVID-19. Yet, the available evidence is inconsistent.
CONCLUSION: The absence of major pulmonary and cardiac limitations points toward the periphery including vasculature and musculature as a central component of low cardiorespiratory fitness. Contrary to the conclusions of many studies, deconditioning is not the sole mechanism of low cardiorespiratory fitness post-COVID-19. Hence, cardiopulmonary exercise testing with measures of all three organ systems seems of major importance to identify relevant organ limitations in patients post-COVID-19.
References: 1. Gebhard CE, Sütsch C, Bengs S, Deforth M, Buehler KP, Hamouda N, Meisel A, Schuepbach RA, Zinkernagel AS, Brugger SD, Acevedo C, Patriki D, Wiggli B, Beer JH, Friedl A, Twerenbold R, Kuster GM, Pargger H, Tschudin-Sutter S, … Gebhard C. Sex- and Gender-specific Risk Factors of Post-COVID-19 Syndrome: A Population-based Cohort Study in Switzerland. medRxiv. 2021:2021.06.30.21259757.
2. Motiejunaite J, Balagny P, Arnoult F, Mangin L, Bancal C, Vidal-Petiot E, Flamant M, Jondeau G, Cohen-Solal A, dOrtho MP and Frija-Masson J. Hyperventilation as one of the mechanisms of persistent dyspnoea in SARS-CoV-2 survivors. Eur Respir J. 2021; 58(2):2101578.
3. Vannini L, Quijada-Fumero A, Martín MPR, Pina NC and Afonso JSH. Cardiopulmonary exercise test with stress echocardiography in COVID-19 survivors at 6 months follow-up. Eur J Intern Med. 2021;94:101-104.

#### REDUCED AEROBIC EXERCISE CAPACITY AND PULMONARY DIFFUSING CAPACITY AFTER HOSPITALISATION FOR COVID-19

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INTRODUCTION: A large proportion of patients suffer from persistent and invalidating symptoms after recovery from coronavirus disease 2019 (COVID-19), which among other things may both be due to changes in lung function and in aerobic capacity. function.
METHODS: 28 patients admitted to hospitals were recruited for this investigator-blinded randomized study with a 12-week HIIT intervention. Patients will be block-randomised to either supervised HIIT exercise group or standard care (control group). This study is currently ongoing, and therefore these data will be evaluated based on baseline data. Patients underwent a standardized assessment including measurements of lung function and a maximal oxygen consumption test (VO2max). Expected lung function values was calculated based on summary equations according to height, age and sex. Normal standards for aerobic work capacity (VO2max (ml/min/kg)) in men and women with special reference to age was used to compare COVID-19 patients to healthy subjects.
RESULTS: 28 patients (58.1 ± 10.4 years; 64.3% male) who have been admitted to the hospital (median hospitalization stay: 6.5 days) completed baseline and were included in this analysis. Abnormalities were noted in diffusing capacity % predicted (81.6 + 19.2) and in total

lung capacity (88.5 + 15.7). The mean peak oxygen uptake was 22.8 ± 7.6 ml/min/kg. 24/28 (85.7%) COVID-19 patients showed to have lower exercise capacity than the general population, which is associated with higher all-cause mortality and cardiovascular events.
CONCLUSION: Reduced diffusing capacity was the most common abnormality of lung function followed by restrictive ventilatory defects and the patients showed lower exercise capacity compared to the general population. The findings indicate the need for a rehabilitation strategy for COVID-19 patients.

**IMPACT OF THE MRNA COVID-19 VACCINATION ON AEROBIC EXERCISE CAPACITY IN YOUNG ACTIVE HEALTHY SUBJECTS.**

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*FACULTY OF MOTOR SCIENCES, ULB*

INTRODUCTION: A clear understanding of the COVID-19 vaccination side-effects in the general population, including young heathy adults, is still emerging. For athletes, previous studies reported 21% of myalgia in younger individuals after the first dose of the Pfizer/BioNTech vaccine which increased to 37% after the second dose [1]. However, a clear understanding of the COVID-19 vaccination effects on aerobic exercise performance would be of interest for adequate training adaptation in athletes.
1. Polack FP et al. N Engl J Med. 2020
METHODS: 18 healthy and active subjects (age: 18-35 years) referred to the Laboratory on 3 occasions: before (baseline) and 7 to 21 days after the first and the second dose of nucleic acid anti-COVID19 vaccines (Pfizer/BioNTech or Moderna). After a clinical examination, all subjects underwent an eight minutes submaximal (below the first ventilatory threshold (VT1)) steady-state exercise test on a cyclo-ergometer with concomitant gas exchange, cardiac output (Q), heart rate (HR) and stroke volume (SV) measurements (inert gas rebreathing technique, Innocor). After HR recovered to resting levels, a classical cyclo-ergometric incremental cardio-pulmonary exercise test (CPET) was performed until exhaustion. Oxygen consumption (VO2) and CO2 output (VCO2), ventilation (VE), electrocardiogram, blood pressure (BP) and finger pulsed oximetry (SpO2) were measured continuously during CPET.
RESULTS: During the steady-state submaximal exercise, at identical VO2 and Q, HR was increased and SV was decreased in the post-vaccination period as compared to baseline (respectively, HR:112±17 beat/min vs 104±21 beat/min, $p<0.05$ and SV: 117±36 ml vs 130±36 ml, $p=0.01$). This positive chronotropic effect was more pronounced after the second dose than after the first dose of vaccine ($p<0.05$). However, no alteration of CPET parameters were observed after vaccination with identical maximal VO2, VE, HR respiratory exchange ratio, O2pulse, BP, SpO2, VE/VO2, VE/VCO2 but also identical VT1 levels (all pNS).
CONCLUSION: Although no altered aerobic exercise capacity and performance are observed after the first and the second dose of mRNA vaccine in young heathy volunteers, an exacerbated chronotropic response during submaximal steady-state endurance exercise was observed. This is of importance for HR based training intensity titration to avoid under-training after vaccination. However, further investigations are needed to clarify the clinical relevance of this observation.

**THE IMPACT OF ONLINE-BASED GROUP RESISTANCE TRAINING ON PHYSICAL HEALTH AND EXECUTIVE FUNCTION IN OLDER INDIVIDUALS DURING COVID-19 PANDEMIC**

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*RITSUMEIKAN UNIVERSITY*

INTRODUCTION: The coronavirus disease 2019 (COVID-19) has spread worldwide, influencing lifestyle behavior. A decrease in physical activity has led to a decrease in physical and psychological health such as muscle mass and cognition in older individuals, therefore, the development of exercise at home was necessary. Resistance exercise is shown to be an effective method to increase muscle mass and muscular strength. In addition, resistance exercise promotes cognitive function in older individuals (Cassilhas et al., Med Sci Sports Exerc, 2007). However, little is known about the online-based resistance exercise on body composition and executive function. The aim of this study was to investigate the effects of online-based group resistance training using an elastic band on physical health and executive function in older individuals during the COVID-19 pandemic.
METHODS: Forty-one Japanese older subjects (age, 69 ± 1 years) were recruited for this study and randomly allocated to the exercise group (EX; n = 21) and control group (CON; n = 20). EX group participated in the online-based group training program through the video conference application (Zoom) connected by the 10.2-inch tablet three times per week for 12 weeks. This program consisted of 14 exercises using the elastic band for exercising the whole body. Before and after the intervention, dual-energy x-ray absorptiometry was used to measure the fat-free mass and fat mass. The isometric knee extensor and flexor torques were measured using a BIODEX dynamometer. In addition, the executive function was assessed by the Digit Span Backward test as working memory, Stroop test as inhibition, Trail Making test as cognitive flexibility, and Rey-Osterrieth complex figure as long-term episodic memory.
RESULTS: No significant differences were observed for the fat-free mass, fat mass, and knee extensor/flexor torques. The percent change from baseline in knee extensor torque was higher in EX group than in CON group ($P < 0.05$) while no significant change was observed in both groups. Regarding to executive function, EX group significantly improved the number of correct answers and longest level of sequence of two correct answers out of three trials in the Digit Span Backward test ($P < 0.05$ for both). In addition, EX group significantly improved the number of correct answers in the Color-Word version of Stroop test ($P < 0.05$) while no significant interaction was observed by repeated two-way analysis of variance. No significant change was observed in all executive function tests of the CON group.
CONCLUSION: The results of this study reveal that the online-based resistance training improved several executive functions meanwhile no improvement in body composition and muscular strength. These findings suggest that implementation of online-based training has a positive benefit for the executive function in elderly people during stay-at-home requests like COVID-19 restriction.

**THE EFFECTS OF EXERCISE THERAPY MODERATED BY SEX IN REHABILITATION OF COVID-19**

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INTRODUCTION: Pulmonary rehabilitation serves as a key component in the recovery of COVID-19 and standardized exercise therapy programs in pulmonary rehabilitation have been shown to significantly improve physical performance and lung function parameters in post-acute COVID-19 patients. However, it has not been investigated if these positive effects are equally beneficial for both sexes, especially considering a more severe physical impact of COVID-19 in men when compared to women. Therefore, the purpose of this study was to analyze outcomes of a pulmonary rehabilitation program with respect to sex differences, in order to identify sex-specific pulmonary rehabilitation requirements.

METHODS: Data of 233 patients (40.4% females) were analyzed before and after a three-week standardized pulmonary rehabilitation program. Patients were admitted to rehabilitation due to post-acute COVID-19 illness and staged using the COVID-19 Severity Scale by Huang et al. (2021). Lung function parameters were assessed as part of the clinical routine using spirometry (ICmax, maximal inspiratory capacity) and body plethysmography (FVC, forced vital capacity; FEV1, forced expiratory volume in the first second) and functional exercise capacity was measured by the Six-Minute Walk Test (6MWT). For the comparison of lung function and walking parameters by sex, Welch-ANOVA was used, as results of Levenes test suggested significant heteroscedasticity ($p < 0.05$). When comparing post-treatment 6MWT, FEV1 and FCV to corresponding reference values, paired t-tests were used.
RESULTS: At post-rehabilitation, ICmax, FVC, FEV1 and 6MWT has been improved in both sexes. Females showed a significantly smaller improvement in FEV1 and ICmax ($F = 5.86$, $\omega 2 = .02$; $p < 0.05$) than males. There was no statistically significant difference in FVC and 6MWT performance improvements between men and women. After the rehabilitation stay, females made greater progress towards reference values of 6MWT ($T(231) = -3.04$; $p < 0.01$) and FEV1 ($T(231) = 2.83$; $p < 0.01$) than males.
CONCLUSION: Sex differences in the improvement of lung function parameters seem to exist when completing a three-week pulmonary rehabilitation program and should be considered when personalizing standardized exercise therapies in pulmonary rehabilitation.

## Conventional Print Poster

### CP-AP10 Physical performance in team sports

#### THE DEVELOPMENT AND VALIDATION OF A SKINFOLD-THICKNESS PREDICTION EQUATION IN HIGH LEVEL FUTSAL ATHLETES

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INTRODUCTION: Specific and practical approaches to estimate fat mass (FM) in athletes are warranted, especially regarding team sports athletes, i.e. futsal players. Assessing skinfold (SKF) thickness and body girth is a simple field technique to evaluate FM, especially when performed by an ISAK (The International Society for the Advancement of Kinanthropometry) certified practitioner. The aim of this study was to develop and cross-validate an anthropometric equation for FM estimation in a sample of male futsal players using ISAK SKF and body girth as variables vs. the dual X-ray absorptiometry (DXA) fat mass (%) output.
METHODS: Using a cross-sectional design, a total of seventy-nine young (18-37 y) professional and semi-professional futsal male players were recruited.
Players were assessed for weight (kg), height (cm), ISAK SKF (mm) and girths (cm) by a certified level 1 ISAK-accredited anthropometrist. The FM (%) output used as criterion was obtained by DXA according to standard procedures. Stepwise regression analysis was performed to evaluate the prediction errors regarding FM and a mathematical model was developed accordingly. Validation procedures for the developed models were performed according to the PRESS method.
RESULTS: Predictive variables included 3 SKF, 1 girth, and age. The resulting model for futsal athletes presented was:
FM (%) = -4.712 + 0.200 * ΣSKF + 0.171 * Waist + 0.025 * age
[where ΣSKF is the sum of triceps, abdominal and thigh SKF in mm, Waist is circumference in cm, and age in years].
The accuracy for the developed model was observed by the high coefficient of determination ($r2 \geq 0.81$).
The validation procedure was performed including the regression parameters, correlation concordance coefficient (CCC), and agreement analyses between the FM estimated from the new developed model and the reference method (DXA). No differences between methods were observed with a high correlation being reported ($r2 \geq 0.80$). The precision and accuracy of the methods was 0.906 and 0.997, respectively, with a CCC of 0.9037 (moderate strength of agreement). From the Bland Altman analysis, no trend was observed between the mean and the difference of the methods.
CONCLUSION: The high costs and the lack of portability of the DXA equipment precludes its use in most clinical/field settings. Using an easy to perform, safe and reliable method according to the ISAK protocols, our findings deliver a new valid and accurate model for FM (%) estimation in professional and semi-professional futsal players.

#### EFFECTS OF REPEATED-SPRINT TRAINING UNDER HYPOXIC ENVIRONMENT ON TEAM-SPORT-SPECIFIC SPRINTING ABILITY

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INTRODUCTION: The purposes of this study were to examine the acute and delayed effects of repeated-sprint training volume on the improvement of the sprinting ability.
METHODS: This was single-blind, randomized control trial. Participants were randomly assigned into four groups for 4-w (RSH4) and 2-w (RSH2) repeated-sprint training under hypoxia; or under normoxia by 4 w (RSN4) and by 2 w (RSN2). Each training session was consisted of 3 sets of 5x5-s sprints at 20% maximum breaking load interspersed with passive recovery at exercise:recovery ratio of 1:5, 2 training sessions/week. In experimental groups (RSH4 & RSH2), the normobaric hypoxia was set at the FIO2 of 13.5%, simulating altitude of 3500 m approximately. In control groups (RSN4 & RSN2), training conducted under normoxic environment. Identical sprinting tests were conducted before (pre, baseline), immediately after (post, acute effect), and 4 w after (4-w-post, residual effect) the intervention. Data collection of 9-12 participants in RSH4, RSH2, and RSN2 were completed and analysed temperately for COVID pandemic.
RESULTS: The characteristics of 32 Participants were with age 20.5 ± 1.7 y, body height 174.9 ± 5.1 cm, body mass 70.9 ± 8.2 kg, and VO2max 56.8 ± 6.5 ml.kg-1.min-1. There was a significant time ($F = 11.85$, $p < 0.001$, $\eta 2 = 0.49$) effect on the distance covered in Yo-Yo test, with pre (1172.5 ± 365.3 m) were significantly lower than that of post (1300.6 ± 410.5 m, $p < 0.001$) and 4-w-post (1286.5 ± 440.9 m, $p = 0.033$) level. Peak velocity of anaerobic test showed a significant time effect ($F = 5.63$, $p = 0.009$, $\eta 2 = 0.29$), with pre (4.75 ± 0.27 m.s-1) were significantly lower than that of post (4.86 ± 0.23 m.s-1, $p = 0.037$) and 4-w-post (4.89 ± 0.23 m.s-1, $p = 0.044$) level. Peak power of anaerobic test showed a significant time effect ($F = 4.12$, $p = 0.027$, $\eta 2 = 0.23$), with pre (1024.5 ± 123.0 w) were significantly lower than that of post (1065.1 ± 150.0 w, $p = 0.026$) and 4-w-post (1071.2 ± 123.6 w, $p = 0.018$) level. Mean power of anaerobic test showed a signifi-

cant time effect (F = 6.76, p = 0.004, η2 = 0.33), with pre (669.8 ± 70.1 w) were significantly lower than that of post (693.5 ± 86.4 w, p = 0.047) and 4-w-post (704.9 ± 67.3 w, p = 0.001) level. Fatigue index of anaerobic test showed a significant time effect (F = 4.63, p = 0.019, η2 = 0.26), with pre (70.4 ± 8.4 %) were significantly higher than that of post (65.9 ± 7.2 %, p = 0.014) and 4-w-post (65.3 ± 8.5 %, p = 0.005) level. Total work of IEP test showed a significant time effect (F = 8.21, p = 0.002, η2 = 0.38), with pre (273.7 ± 26.1 w) were significantly lower than that of post (283.2 ± 24.9 w, p = 0.002) level. No other significant effects were founded.
CONCLUSION: There were effects of repeated-sprint training on the improvements of sprinting ability, delaying until 4 w after training. The specific sprinting abilities affected by training were sprinting when simulated team-sport intermittent exercise, as well as aerobic and anaerobic ability of sprinting.

### EVOLUTION OF THE PHYSICAL CHARACTERISTICS OF THE FRENCH WOMENS RUGBY SEVEN AND UNION: A TEN-YEAR LONGITUDINAL ANALYSIS

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INTRODUCTION: Rugby union and rugby sevens are demanding and intermittent team sports with collisions, high intensity runs interspaced with periods of low intensity activity. While the physical characteristics development of elite male rugby union and rugby seven players have been widely described, much less is known about female international players. This present study aims to assess physical changes over time of women's rugby union players (backs and forwards) and women's seven players.
METHODS: Anthropometric and physical performance of French rugby union and seven women players were monitored at least two times per years by the French Rugby Federation. The best performance of each French international player over a two-year period was identified. Finally, a total of six hundred and thirty-one samples was obtained. Anthropometric data (height, mass and fat mass), physical performance (10, 20 and 50m sprint, maximal aerobic speed, counter movement Jump test, maximal bench press and rowing repetition) were monitored.
RESULTS: Specific evolution of anthropometric characteristics and physical performances was observed within rugby union positions and rugby seven.
Rugby union forwards improved their sprint ability (10m, 20m and 50m) regularly from 2009 to 2020 ($p<0.01$) while body weight, body fat, and age did not change over the years. Height, maximal aerobic speed, counter movement jump, maximal bench press and rowing repetition increased over the years ($p=<0.01$).
Rugby union backs have improved their sprint ability (10m, 20m, 50m), maximal aerobic sped, counter movement jump, maximal rowing repetition increased over the years ($p=<0.01$). The anthropometric characteristics evolved and the players become taller and increased their weight ($p<0.05$).
Seven players improved their explosivity (10m, $p<0.05$), maximal aerobic speed, maximal bench press and rowing repetition increased over the years while the speed over 20m and 50m, and the counter movement jump performances remained unchanged. The anthropometric characteristics evolved and the players become taller and lighter ($p<0.05$).
CONCLUSION: These results highlight the evolution of the woman rugby player profile over the last decade. It suggests that the coaches should adapt the references values used to identify or developed talent over the years.

### MATCH PHYSICAL DEMANDS DIFFERENCES BETWEEN STARTERS VS NON-STARTERS (SUBSTITUTES) IN SPANISH PROFESSIONAL SOCCER LEAGUE

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INTRODUCTION: A substitution is when a player is brought on to the pitch during a match in exchange for an existing player, during a stoppage in play. The soccer player who has been substituted takes no further part in a match. Research has showed that total distance, high-intensity running distance covered and the number of sprints were greater for non-starter compared to starter players (Lorenzo-Martínez et al., 2020; Padrón-Cabo et al., 2018). The aim of this study was to investigate the match physical demands differences between players who completed the entire match, players who were replaced (i.e., starters, ≥75 minutes played) and those that were substituted into (i.e., non-starter) soccer matches.
METHODS: The sample included the team match observations of all the matches played over four consecutive seasons (from 2015/16 to 2018/19) in the first (Liga Santander; n = 2,950) Spanish soccer leagues. Match physical demands data were obtained using an optical tracking system called ChyronHego® (TRACAB, New York, US). Relative total distance (TD/min.) and distance covered > 24 km·h-1 per minute (VHIRD/min.) were analyzed. The players were divided into three different groups: players who completed the entire match, players who were replaced, and substitute players. Linear Mixed Models (LMM) were applied to analyze the differences in match physical demands (i.e., distances covered) between players that started and those that were substituted. In addition, the effect of age and playing position soccer players were considering.
RESULTS: Results showed that TD covered per minute was greater in substitutes players (114.79 m/min.) than players who completed the entire match (111 m/min.) and players who were replaced (113.59 m/min.). Also, distance covered at more than 24 km·h-1 was greater in substitutes players (12.91 m/min.) than players who completed the entire match (3.11 m/min.) and players who were replaced (4.34 m/min.). In addition, there was a significant difference between playing position and age soccer players.
CONCLUSION: The present study showed that significant physical performance differences during soccer matches in Spanish LaLiga exist between starters and non-starters soccer players.

### ACUTE PHYSIOLOGICAL RESPONSE TO 5V5 FOOTBALL IN FEMALE FOOTBALL PLAYERS

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INTRODUCTION: Physiological response to various football formats has been investigated intensively and are well understood in male football players, whereas investigations in female football playersare sparse. Studies in female football players have indicated that anaerobic energy turnover in female football players are lower than in male players (Krustrup et al., 2005; 2021). This study therefore aims at describing the acute physiological response to 5v5 football in female football players.

METHODS: 10 well-trained female football players (height: 169±5 cm, weight: 67.0±8.0 kg, fat% 24.8±7.6%) participated in 5v5 indoor football match organized as 4x12 min periods on an indoor 40x20 m wooden floor pitch. Heart rate was monitored during the session (Polar Team Pro) and blood lactate was evaluated prior to the match and after the 2nd and the 4th period. Muscle biopsies were collected from m. vastus lateralis at rest and at the end of the 4th period. Data are presented as means ± SD. Data were analyzed using t-test and one-way ANOVA with repeated measures. A significance level of 0.05 was chosen.
RESULTS: Average and peak heart rate were 166±14 and 189±11 bpm during the match. Average heart rate was higher during the first 12 min period than the following three periods (172±13, 165±16, 163±15, 163±14 bpm, P<0.05). Time spent with heart rate higher than 90% of maximal heart rate was 28±27%.
Blood lactate increased from 1.8±0.4 mmol/L prior to the match to 2.7±1.2 and 3.1±1.6 mmol/L after the 2nd and 4th period (P<0.05) with no difference between after the 2nd and 4th period.
Muscle lactate was 4.8±2.3 mmol/kg dw pre-match and increased to 8.8±3.9 mmol/kg dw after the match. No change was observed in muscle ATP (21.7±1.6 vs. 21.0±2.4 mmol/kg dw; P>0.4), whereas PCr was 73.0±8.3 mmol/kg dw pre-match and decreased to 57.0±12.6 mmol/kg dw after the match (p<0.05). Muscle glycogen was 343±73 mmol/kg dw pre-match and was lowered to 265±70 mmol/kg dw. after the match (p<0.05).
CONCLUSION: Heart rate was high during 5v5 with periods with near maximal intensity during indoor 5v5 football for female football players. Anaerobic energy turnover was, however, modest indicated by moderate drops in muscle glycogen and PCr and small increases in muscle and blood lactate and are similar to that observed in male footballers (Panduro et al., 2022, In review).

**ACTIVITY PROFILE AND PHYSICAL PERFORMANCE OF MATCH PLAY IN KORBALL PLAYERS: A PILOT STUDY**

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INTRODUCTION: Korfball is a non-Olympic team game played by hand within a rectangular field of play whereby two mixed teams try to shoot a ball into the korf (basket) of the opposite team. The sport's main characteristics encompass all-around skills, cooperative play, controlled physical contact, gender equality, players' right to protected ball possession and scoring from 360° around the korf (IKF, 2020). The best korfball players must perform both attacking and defending, about 72 times during a match, for about 24 minutes. The average match score in the Korfball League is 24 goals and a team needs 85 - 120 chances to create them (Crum, 2021). Previous investigations of movement profile were performed in netball, floorball, or the other non-Olympic sports but no similar studies exist in korfball. Therefore, this study aims to quantify match demands and the player load of all playing positions in korfball on elite level players.
METHODS: Twenty-two participants were elite korfball players from the Polish National Team (n=11, 24 ± 4.1 years, 167 ± 3.6 cm, 61.3 +8.7 kg for female, n = 11, 26.8 ± 6.2 years, 187.5 ± 3.4 cm, 88.5 +9.1 kg for men) who were investigated for a total of 3 completed matches. All athletes wore a Catapult Vector 7 unit containing a 10Hz LPS tag and 100Hz inertial 124 sensors (tri-axial accelerometer, gyroscope and magnetometer) connected wirelessly to the ClearSky LPS (Catapult Sports, Melbourne, Australia). The male players were divided into two subgroups of position to analyze the results: rebounder (MR) (n=5) and mixed (MM) (n=6). The following speed categories were used: walking (0 to 6 km / h), low intensity running (LIR; 6.1 to 12 km / h), medium intensity running (MIR; 12.1 to 15.4 km / h), high intensity running (HIR; 15.5-28.5 km / h) and sprint (>18.4 km/h). All values are presented as mean ± standard deviation (SD) with 95% confidence intervals.
RESULTS: The mean total distance covered in three full matches no differed substantially between gender in mixed positions (2149 ± 296 m for female, 2483 ± 233 m for MM and 2239 ± 220 m for MR). Running profiles characterized the match demands for typical korfball were identified regardless of sex (sprint and HIR <2%, MIR~16%, LIR ~40 %, walking ~42%). Nevertheless, mean change-of-directions jumps and acceleration/deceleration profile were different in each subgroups.
CONCLUSION: The results of these studies identify a descriptive movement match-profile that characterizes the motor demands for korf-ball players. The coeducational nature of korfball seems to differentiate the requirements for players according to the gender and role on the court.

**CHANGES IN THE ENERGY METABOLISM OF PLAYERS DURING A SOCCER GAME**

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INTRODUCTION: Energy metabolism required for exercise can be broadly classified into aerobic (endurance) and anaerobic (including muscle strength) energy metabolism, which are important factors in a soccer competition. However, exercise characteristics, such as the interval time in a soccer game, are complicated, and the ratio of aerobic and anaerobic energy metabolism is believed to greatly vary among individuals or players' positions in soccer. Moreover, quantifying the anaerobic energy metabolism is difficult in the game by measuring the running speed using global positioning system (GPS). Therefore, this study aimed to identify aerobic and anaerobic energy metabolism of each player using laboratory tests and evaluated physical activity and fatigue (accumulated anaerobic energy consumption) in each player using a GPS device during the course of the game.
METHODS: This study was conducted on 17 soccer players (mean age, 16.5 ± 0.6 years) from the women's youth professional soccer team in Japan (Chifure AS Elfen Saitama). In the laboratory tests, the anaerobic thresholds of each athlete were evaluated to identify their aerobic and anaerobic metabolic characteristics. During the treadmill exercise tolerance test, the individual ventilatory threshold and the required oxygen uptake (O2 demand) at each running speed were determined using a respiratory metabolism device (ARCO-2000N, manufactured by Arco System) (1, 2). Additionally, the running speed of each player in the soccer game was continuously measured using a GPS device to quantify the anaerobic energy metabolism during the game using respiratory data.
RESULTS: The ratio of anaerobic energy to the total energy consumed during the game was calculated for each player, which ranged from 20% to 40%. Furthermore, the ratio of aerobic to anaerobic energy metabolism varied among individuals, and this variation was partly due to the player's positions during the soccer game.
CONCLUSION: Changes in anaerobic energy metabolism during the game were visualised within an individual, which indicated that the sprint ability (the ability to recover from fatigue) can be evaluated during the game. Moreover, different characteristics of energy metabolism in soccer and player positions were presented, suggesting that this analysis may help evaluate the individual physical characteristics required for each position in soccer as well as the training effect in games.

## Conventional Print Poster

### CP-BM07 Biomechanics of jumping and squatting

#### EFFECT OF SURFACE ENVIRONMENT ON FRONT SQUAT OF CROSSFIT ATHLETES

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INTRODUCTION: The CrossFIT is the one of popular fitness program consisting mainly of a mix of aerobic exercise, bodyweight exercise and Olympic weightlifting (1). Korean CrossFit gyms(Boxes) are inevitably very sensitive to soundproofing since they are located in collective buildings. Thus floor of the boxes in Korea is made of thickened and softened and it is unstable. As such, it is thought that the unstable ground environment of the Korean box can increase the risk of injury for CrossFit athletes (2 & 3). Therefore, the purpose of this study was to verify the effect of surface environment on Front Squat which is the most frequently used in CrossFit exercise.
METHODS: Ten CrossFit athletes who have more than 5 years athletic career and had no experience of musculoskeletal injuries on lower extremities in the last six months(age: 32.30±3.05 yrs., height: 173.70±5.12 cm, body mass: 82.40±6.31 kg, 1RM: 160±13.80 kg) participated in this study. All subjects were asked to perform front squat with 80% of 1 RM on hard surface(HS) and soft surface(SS). To investigate kinematics and kinetics differences between HM and SS, a three-dimensional motion analysis was performed using eight infrared cameras(sampling rate: 100 Hz) and seven channel of EMG(sampling rate: 1,000 Hz). A paired t-test was conducted to verify the differences and statistical significance set as $\alpha$=.05.
RESULTS: From the results of this study, no significant differences between SS and HS were found during ascending phase of front squat. Ankle joint range of motion in horizontal plane revealed greater in SS than that of HS during descending phase indicating increased possibility injury factors in SS (4) ($p<.05$). Also significantly greater quadriceps muscle activation was found in HS than that of SS during descending phase ($p<.05$). For the muscle activation ration (Gluteus maximus /Quadricepts), higher the ration was found in SS than that of HS during decending phase indicating Gluteus maximus is dominant in SS ($p<.05$).
CONCLUSION: The findings of this study suggests that performing front squat on SS may increase the risk of lower body injury. Therefore, new open boxes in Korea need to use hard surface with less risk of injury if it is possible.
REFERENCES:
1) Hines, Expatriates Magazine, 2013
2) Pohl et al., Gait & Posture, 2020
3) Behm et al., The Journal of Strength & Conditioning Research, 2002
4) LaStayo et al., Journal of Orthopaedic & Sports Physical Therapy, 2003

#### THE COMBINATION OF PLYOMETRIC TRAINING WITH OTHER TRAINING METHODOLOGIES TO IMPROVE THE VERTICAL JUMP

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INTRODUCTION: vertical jumping (VJ) performance is determined by a complex interaction among several factors including maximal force capacity, rate of force development, muscle coordination, and stretch shortening cycle(1). Enhancement of vertical jump performance is a common goal since the capacity to jump higher than an opponent may be advantageous in team competitions and in many individual sports (2). Various training methods have been applied to improve VJ performance. Such methods include plyometric (PL) training, resistance training, weight lifting (WL) training, and electrical stimulation etc. (3;4;5;6). Because of the multifaceted nature of VJ performance, a single training method approach may not be as effective as combining training methods to provide variation in stimulus and to increase the overall training adaptation (7). Therefore, the objective of this meta-analysis was to investigate the effects of a plyometric training program combined with other methodologies on vertical jump performance.
METHODS: After an electronic database search (PubMed and WoS), a total of 36 articles were included in the meta-analysis and were reviewed to analyze the impact of Plyometrics combined with other methodologies on vertical jump performance. Studies were included if they met the following criteria: 1) Studies with experimental groups performing a combination of training methods (e.g., plyometric combined strength). 2) Inclusion of control group. 3) At least one measure related to physical fitness (e.g., vertical jump tasks) before and after the training intervention. 4) Study design: multi-arm trials.
RESULTS: twenty-nine studies provided data for CMJ performance, involving 40 experimental and 33 control groups (pooled n = 933). Results showed a moderate effect of trained participants on CMJ performance (ES = 0.63; 95% CI = 0.49 to 0.77; $p < 0.001$; $I2 = 9.2\%$; Egger's test p = 0.133; Figure X) when compared to controls. Sixteen studies provided data for SJ, involving 20 exp. and 16 control groups (pooled n = 430). Results showed a moderate effect of trained participants on SJ (ES = 0.77; 95% CI = 0.45 to 1.10; $p < 0.001$; $I2 = 60.0\%$; Egger's test p = 0.797; Figure X) when compared to controls. Eight studies provided data for countermovement jump with arms performance, involving 9 exp. and 8 control groups (pooled n = 282). Results showed a moderate effect of trained participants on CMJA performance (ES = 1.01; 95% CI = 0.31 to 1.70; p = 0.005; $I2 = 85.8\%$; Figure X) when compared to controls. Five studies provided data for DJ performance, involving 9 exp. and 7 conTROL groups (pooled n = 237). Results showed a small effect of trained participants on DJ performance (ES= 0.46; 95% CI = 0.114 to 0.77; p = 0.005; $I2 = 26.3\%$; Figure X) when compared to controls.
CONCLUSION: Combining several elements into one training session seems to be an interesting idea in training modality. This meta-analysis showed that combined strength training programme was useful to increase jumping.

#### VALIDITY OF TIME OF FLIGHT DURING SINGLE-LEG JUMPS MEASURED WITH SMARTPHONE ACCELEROMETERS COMPARED TO FORCE PLATFORMS

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INTRODUCTION: Single leg jump height has recently been shown to be more effective than hop distance in the identification of deficit in lower limb muscle strength after anterior cruciate ligament reconstruction (1). However, not all clinics have access to specialised equip-

ment such as force platforms and contact mats, which are needed to estimate jump height (2). A possible alternative may be to measure the time of flight using the accelerometers embedded in smartphones. In this study we aimed to determine whether smartphone accelerometers provide a valid measure of time of flight during single leg jump when compared to a force platform.
METHODS: Twenty healthy participants (8 females, 27±4 years old, 173±1 cm, 72±1 kg) without current pain or recent lower limb injuries performed 5 single-leg jumps. Participants stood on their dominant leg, jumped as high as possible, landed on the same leg, and stabilized as quickly as possible. A force platform was used to collect ground reaction forces at 250 Hz. Body acceleration was collected using a smartphone that the participants held firmly on their chest in landscape mode, so that the X-axis of the smartphone accelerometer was mostly aligned with the gravity vector. Smartphone data were collected at 100 Hz using the MATLAB Mobile app. Vertical ground reaction forces and smartphone acceleration were exported and analysed in Microsoft Excel. For the force platform data, the start and end of each jump were identified as the time instant when the ground reaction force reached 50% of the participant's body weight. Similarly, in the acceleration data the start and end of each jump were identified when the acceleration reached 50% of the gravitational acceleration. The time of flight was calculated as the difference between the end and start of each jump and averaged across the 5 repetitions. Validity between the two systems was calculated using Intraclass Correlation Coefficient. The presence of a systematic bias was assessed using a paired T-test.
RESULTS: Time of flight measured with smartphones was approximately 20 ms longer than the time of flight measured with a force platform (305±46 vs 327±49 ms, $p<0.001$). Intraclass correlation coefficient demonstrated excellent validity (ICC = 0.988, CI: 0.969-0.995).
CONCLUSION: Our results provide preliminary evidence that the time of flight measured with smartphone accelerometers is highly valid when compared to the time of flight estimated from a force platform. The systematic bias implies that measures obtained using the two systems cannot be directly compared, and the use of different thresholds may reduce this bias. The wide availability of smartphones, the use of a free app, and the ease-of-use of the software for data analysis are promising factors for the implementation of this objective measure of motor performance in practice.

## POST-ACTIVATION POTENTIATION WITH SHORT HIGH INTENSITY ENDURANCE TRAINING AND PLYOMETRIC TO IMPROVE JUMPING PERFORMANCE

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INTRODUCTION: The ability to exert muscle power is critical for successful results in sports [1]. Exercises (e.g., sprint or heavy load exercises) performed in the warm-up have shown improvements in the subsequent performance [2]. The phenomenon of acute performance enhancement is called post-activation potentiation (PAP) and it increases acutely muscle power and performance [3]. The purpose of this study was to analyze the effects of high- vs low- intensity cycling exercises combined with plyometrics on vertical jump performance.
METHODS: Twenty-four physically active men participated were randomly divided into two groups and one control group (CON). One group performed short high intensity cycling efforts [5 x 10s ("all-out")/50s rest] (IT) and the other group performed low intensity continuous effort [5 min (75% of HRmax)] (CT). Both experimental groups performed 3 sets of 10 plyometric jumps with 1 min rest between sets after the cycling efforts. CON performed both days a warm-up activity of 13 minutes of low intensity cycling at 60% of HRmax. Before the warm-up, a countermovement jump (CMJ) (baseline) was performed in a platform Kistler Quattro-Jump (Kistler, Switzerland). Finally, after the warm-up, a CMJ was measured at 1, 3, 6 and 9 min rest.
RESULTS: CMJ showed differences regarding the time of measurement ($F = 39.103$, $p \leq 0.001$, partial $\eta 2 = 0.488$) and time x condition effects ($F = 17.536$, $p \leq 0.05$, partial $\eta 2 = 0.155$). CMJ height improved by 7.11, 7.23, 10.19 and 11.21% in IT and by 11.72, 15.08, 14.97 and 13.77% in TC at 1, 3, 6 and 9 min respectively compared to baseline.
Mean power showed differences regarding the time of measurement ($F = 9.585$, $p \leq 0.001$, partial $\eta 2 = 0.197$), but not with time x condition effect. Power increased by 5.18% in IT at 6min and by 7.92, 8.18 and 7.01% in CT at 1, 3 and 6 min compared to baseline.
CONCLUSION: The results suggest that IT is the most effective warm-up method for induce optimal PAP at 7 – 10min [3]. IT delays more time to produce potentiation than CT, maybe due to two causes. The principal cause, IT produces greater neuromuscular fatigue and requires more recovery time to optimal PAP effect. The other reason, CT causes less fatigue and PAP effect is shown after the end of the conditioning activity, being reduced after 7 min.

## COMPARISON OF KINEMATIC DATA OF JUMPING MOTION USING MARKER-BASED AND MARKERLESS MOTION CAPTURE

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INTRODUCTION: Three-dimensional motion analyze are a widely used method in the field of biomechanics. The standard method for 3D motion analyze is an optical marker-based motion capture system. The reliability of kinematic data obtained using marker-based motion capture has been questioned due to its sensitivity to marker placement and soft tissue artefact. Markerless motion capture systems are free from these errors associated with marker-based systems and may be able to measure kinematics more reliably. Theia3D markerless motion capture system (Theia Markerless Inc, Kingston, ON, Canada) has shown similar patterns and high reliability of lower limb joint angles in gait. However, its reliability in large joint motions such as skiing has not been confirmed. The purpose of this study was to compare the lower limb joint angles and center of mass (COM) positions measured by Theia 3D markerless and marker-based motion capture systems.
METHODS: Nine healthy adult males (mean age 21.6 ± 1.2 years, height 172.7 ± 6.8 cm, weight 65.6 ± 3.1 kg) participated in this study. They performed a side box jump (box height 300 mm, 795 mm between boxes), a ski mogul training exercise. The motion was recorded simultaneously using ten video cameras (RX0-II, Sony) for Theia 3D and 12 infrared optical motion capture cameras for marker-base motion capture (MAC3D, motion analysis Co.). Video data were processed using Theia 3D software, marker-based data were processed using marker-based capture software, and both sets of data were compared. The analysis was performed during the period of ground contact with the right-side platform. Grounding and release were defined as maximal plantar flexion of the right ankle joint just before grounding and release, and were time-normalized. Mean joint angles of each of the three right lower limb joints (hip, knee, and ankle joints) and COM were calculated. We used Pearsons product rate correlation coefficient for relative reliability, and Bland-Altman analysis for absolute reliability for both systems.
RESULTS: The relative reliability of the lower limb joint angles ranged from r = 0.59 to 0.99. The absolute reliability was 2.4 ± 0.6 ° on average for the 95% confidence interval of the minimum detectable change (MDC95). The relative reliability of COM was r = 0.97 to 0.99. The

average MDC95 was 0.82 ± 0.3 cm. Similar to comparisons in gait, the two systems produced very similar measurements in side-box jumps, with small differences in measurements and similar waveform patterns.
CONCLUSION: The results suggest that it is possible to measure not only walking but also jumping, landing, and other sports movements, as well as in the field, which were previously difficult to perform. Since this study was conducted on males in their 20s, results may differ depending on age, gender, health status, and clothing. Theia 3D was suggested to reduce the limitations of applied movements such as jumping and landing, as well as the measurement environment.

### ASYMMETRIC LOADING STRATEGIES DURING SQUATS FOLLOWING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: A LONGITUDINAL INVESTIGATION THROUGHOUT REHABILITATION WITH CURVE ANALYSES

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INTRODUCTION: Kinetic loading asymmetries during bilateral squats have been reported following anterior cruciate ligament reconstruction (ACLR). Evidence is however limited to discrete value data extracted at specific knee angles from cross-sectional studies where side-to-side strategies are presented only at group level. It is therefore unclear whether loading asymmetries occur throughout the entire squat, whether they change during rehabilitation and how they are distributed between sides.
METHODS: Bilateral bodyweight squats were performed by 24 individuals (13 females) post-ACLR on three occasions: 1) Early rehab - 2.9 (1.1) months; 2) Mid-rehab - 8.8 (3.1) months; 3) Return to sport (RTS) - 13.1 (3.6) months; and 29 asymptomatic controls (22 females) on one occasion. Motion capture and two force plates were used to calculate time-normalized curves of vertical ground reaction forces and hip, knee, and ankle moments. Outcomes were compared between sides and groups, and over time, using functional t-tests with p-values adjusted by the interval-wise testing procedure. Individual knee loading strategies, i.e., under-/overloading of the ACLR side, were classified when asymmetry in favour of the respective side exceeded the 95% pointwise confidence interval of controls during at least 50% of the squat.
RESULTS: At Early rehab, ACLR had significantly greater (adjusted $P < .05$) asymmetry in knee flexion moment than controls during the time-normalized interval of 15-100% of the eccentric phase and the entire concentric phase, as well as ankle flexion moment during 56-65% of the concentric phase. At Mid-rehab, ACLR had significantly greater asymmetry than controls for knee flexion moment during 41-72% of the eccentric phase and for ankle flexion moment during 56-69% of the concentric phase. No significant between-group differences were found at RTS. At RTS compared with Early rehab, ACLR significantly reduced asymmetry for hip (21-46%, eccentric phase), knee (27-58%, concentric phase), and ankle flexion moment (21-57%, eccentric phase). Individual asymmetry strategies for knee flexion moment at Early rehab were mainly due to individuals underloading the ACLR side (46%) rather than overloading (4%). At RTS, however, more individuals overloaded (25%) than underloaded (17%) the ACLR side.
CONCLUSION: Curve analyses revealed significant kinetic loading asymmetries throughout bilateral bodyweight squats for our ACLR group compared with controls at Early rehab and Mid-rehab, but not at RTS. Significant reductions in hip, knee and ankle flexion moment asymmetry from Early rehab to RTS showed modifications during rehabilitation. An expected underloading strategy was evident for almost half of the ACLR participants at Early rehab, but an overloading strategy was the main reason for knee flexion moment asymmetry at RTS. Loading asymmetries during bilateral tasks should thus not be assumed due to underloading of the ACLR side, but may depend on an overloading strategy, particularly late in rehabilitation.

### A COMPARISON OF MEAN AND PEAK POWER BETWEEN THE PUSH PRESS, PUSH JERK AND SPLIT JERK WEIGHTLIFTING DERIVATIVES

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INTRODUCTION: Weightlifting overhead pressing derivatives such as the push press (PP), push jerk (PJ) and split jerk (SJ) are used by practitioners to enhance the athletes ability to generate high power outputs (1). The PP, PJ, and SJ involve the dip and thrust phases. It is during the thrust phase where the highest power outputs have been recorded (2,3). However, to the authors knowledge, the differences in peak and mean power between these exercises have not been compared to date.
METHODS: Twelve well-trained participants (9 males and 3 females, weightlifting experience: 2.1 ± 1.1 yrs; 1RM PP: 75.5 ± 19.7 kg; 1RM PJ: 84.8 ± 19.7 kg; 1RM SJ: 92.9 ± 20.1 kg) performed a testing session to obtain the mean and peak power of the three exercises. Participants randomly performed one set of three repetitions of each exercise. A load of 75% 1RM of each exercise was selected as previously referred as the load at which the power outputs are maximized during weightlifting overhead pressing derivatives (2,3). Force-time data was recorded using a force platform (AMTI) interfaced with a laptop and data were collected in Qualisys Track Manager Software. Data were analysed using a customised Excel spreadsheet to obtain the kinetics and phase duration and displacement of the center of mass (COM). The mechanical power achieved by displacing system mass was calculated as the product of the force and velocity of the COM, as previously described elsewhere (4). Repeated measures ANOVAs with Bonferroni post-hoc corrections were performed to compare the peak and mean power outputs between exercises. Statical significance was set at $p<0.05$.
RESULTS: There were significant differences for the peak ($p=0.012$) and mean ($p=0.006$) power between the PP (2930.1 ± 778.7, 1816.7 ± 484.9 W), PJ (3139.1 ± 744.5, 1917.5 ± 483.5 W) and SJ (3265.35 ± 779.3, 2004.3 ± 478.7 W). Results from Bonferroni revealed that there were significant differences in the peak power between the PP and SJ ($p=0.013$, ES = 0.43). In contrast, there were no significant differences between the PP and PJ ($p=0.062$, ES=0.27) and between the PJ and SJ ($p=0.206$, ES=0.17). Similarly, there were significant differences in the mean power between the PP and SJ ($p=0.005$, ES = 0.39). In contrast, there were no significant differences between the PP and PJ ($p=0.111$, ES=0.21) and between the PJ and SJ ($p=0.068$, ES=0.18).
CONCLUSION: The exercise at which the peak and mean power outputs are optimized is the SJ, followed by the PJ and PP, although there were no significant differences between the PJ and SJ. Practitioners may consider implementing the SJ exercise to enhance the athletes ability to generate high power outputs.
REFERENCES:
1) Soriano et al. (2019)
2) Lake et al. (2014)
3) Flores et al. (2017)
4) Soriano et al. (2020)

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## KINEMATICS AND KINETICS OF LEFT AND RIGHT LEGS DURING LANDING OF GRAND JETÉ PERFORMED BY PROFESSIONAL BALLET DANCERS

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INTRODUCTION: Ballet dancers are required to use the same technique on both sides of the body, though humans have each characteristic movement as seen in dominant foot manner. It is supposed that there are characteristics of movement control unique to ballet dancers. Although a difference between left and right ground reaction forces was observed in ballet students' landing of a grand jeté, a basic ballet jump (1), there have been few kinematic and kinematic studies between left and right professional ballet dancers' ones. The purpose of this study was to compare kinematics and kinetics of those left and right grand jeté landings performed by professional ballet dancers.
METHODS: Fifteen female professional ballet dancers (age: 26.5±3.2 years, height: 160.5±3.8 cm, weight: 47.1±3.4 kg, their ballet experience: 22.1±3.4 years) were recruited to participate in this study. A questionnaire survey was circulated and replied before the experiment. Subjects were instructed to perform three times grand jeté plays for each leg at maximum effort, of which each highest jump in both legs was analyzed.
Using the data obtained in the experiment, we calculated the jump height and maximum ground reaction force (Max Fz), the angle of flexion and extension of the three lower limb joints at Max Fz, the angle of external and internal hip rotation, the moment of flexion and extension of the three lower limb joints at Max Fz and the max moment of extension of each joint to evaluate the performance of the grand jeté. The time required from IC (initial ground contact) to Max Fz and IC to maximum extension moment of each joint were individually calculated. Unpaired t-test was performed using the above-calculated data assuming equal variances with $\alpha = 0.05$ Variables of left and right legs were compared.
RESULTS: The questionnaire showed that all subjects usually used the right grand jeté, and 86% of them, which indicated that they were good at the right grand jeté. However, t-tests for each analyzed item showed no statistically significant differences in the angles and moments of the three lower limb joints at Max Fz or the max moment of each joint at their landing in the left and right grand jeté.
CONCLUSION: The results of this study have suggested that professional ballet dancers have more or less strong and weak points on their grand jeté plays depending on the dominant foot manner and also their total amount of practices. However, from viewpoints of kinematics and kinetics it was confirmed that the left and right grand jeté landings were coincident. This could be attributed to their daily training effect as professional ballet dancers of which enhancement may reduce bilateral difference.
REFERENCE:
1) Cara et al, 37th International Society of Biomechanics in Sport Conference, 2019

## ACUTE EFFECTS OF DIFFERENT FULL SQUAT SET CONFIGURATIONS ON VERTICAL JUMP PERFORMANCE, VELOCITY LOSS AND SKIN TEMPERATURE

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INTRODUCTION: The post-activation performance enhancement (PAPE) refers to an acute increase of maximal voluntary strength, power or speed following a conditioning activity (CA) (1). The set configuration and intensity directly determine the acute velocity loss (VL), metabolic, and hormonal (2). Therefore, implementing velocity-based training might help to monitor CA intensity and the incurred fatigue (3). Although most literature suggest an increased muscle temperature as the main mechanism underlying PAPE (4), no studies have measured skin temperature (Tsk) during PAPE protocols, which is a noninvasive method used as a surrogate of muscle temperature (5). Therefore, the aims of the current study were (I) to evaluate the acute effects of different full squat set configurations on countermovement jump height (CMJ), VL and Tsk, and (II) to determine whether the VL or the changes in Tsk incurred during the CA may modulate the change in CMJ height.
METHODS: Sixteen resistance-trained men randomly performed 4 squat protocols at maximal intended velocity with the 60% of the one repetition maximum (sets × repetitions [intra-set rest]): TR (2×6 [0-s]), CL2 (2×6 [30-s every 2 repetitions]), CL1 (1×12; [36-s between each repetition], and control (CO; no training). CMJ height was assessed before and 2, 4 and 8 minutes after the squat protocols. Tsk was continuously measured during the protocols.
RESULTS: Unexpectedly, a significant main effect of time ($F = 20.61$, $p<0.001$) was observed due to the comparable reduction of CMJ height after 8 min compared to baseline for the 4 protocols: TR (-3.4 ± 4.2%), CL2 (-5.3 ± 4.9%), CL1 (-5.4 ± 2.9%), and CO (-4.2 ± 3.6%). As expected, the VL was higher for the squat protocols with lower intra-set rest ($F = 20.54$, $p<0.001$: TR > CL2 > CL1) as well as the mean Tsk tended to decrease after the protocols. The VL and the change in Tsk were not associated with the change in CMJ height ($p>0.05$).
CONCLUSION: The four experimental protocols showed a comparable decrement in the CMJ height. CL sets configuration significantly mitigated the VL, while the mean Tsk tended to acutely decrease after all the protocols. The change in CMJ height was not modulated by the VL or the changes in Tsk, which seems not to provide further insights into the acute change in CMJ height. Relative loads of 60% 1RM performed at maximal intended velocity would not be recommended to promote PAPE during the final phase of the warm-up in this population.
REFERENCES
1. Boullosa et al.. Int J Sports Physiol Perform, 2020.
2. Piqueras-Sanchiz et al., J Strength Cond Res, 2021.
3. Pareja-Blanco et al., Scand J Med Sci Sport, 2017.
4. Blazevich et al., Front Physiol, 2019.
5. da Silva et al., Physiol Meas, 2018.

## Conventional Print Poster

### CP-SH01 Coaching and leadership

#### A CASE STUDY EXPLORING IF A BEHAVIOUR CHANGE INTERVENTION CAN INCREASE ADHERENCE TO ATHLETE MONITORING

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INTRODUCTION: Athlete monitoring is used to inform training programming, to optimise performance and to minimise the risk of athlete maladaptation. This is particularly important in elite sport where the high training loads and limited recovery periods increase the risk of negative performance and health outcomes. Poor athlete buy-in to monitoring has been recognised as a significant barrier to athlete monitoring system (AMS) implementation (1). However, the application of any systematic approach to combat poor buy-in to monitoring is notably absent from research. This study therefore aims to assess if a behavioural change intervention can remedy poor AMS adherence (2).
METHODS: The participants included three coaches (43.6 ± 10.0 years) and eight age-group national team athletes (20.1 ± 2.0 years) that had been using an AMS for one year. Initially, coaching staff attended a facilitated workshop where a behaviour change intervention was collectively planned. The intervention was then implemented and adherence to the AMS measured over 6 months. Subsequently, the participants attended one-to-one semi-structured interviews where they discussed their views on the AMS.
RESULTS: Seven target behaviours were identified in the workshop: 1) Increase athlete knowledge of monitoring value; 2) Increase coach's knowledge of monitoring value; 3) Conduct weekly case conferences which form part of athlete feedback; 4) Improve and increase feedback to athletes; 5) Upload and rate technical videos in AMS; 6) Put in place consequences for non-adherence; 7) Increase reminders to improve adherence. The main themes from the interviews were: Changes During the Intervention; AMS Attitudes; and Leadership. A decrease in adherence was observed during the intervention from a weekly average of 62% in the first week to 22% in the final week.
CONCLUSION: Despite the interventions, a decrease in adherence over the intervention period was demonstrated. This was likely caused by organisational changes within the sport where two out of the three coaching staff announced their resignations, and subsequently not all behaviour change interventions were implemented. This led to a reduced emphasis on completing the AMS and palpable frustration from both the coaching team and athletes. Despite this, the coaches reported improved athlete awareness in the purpose of monitoring. Overall, the intervention allowed practical behavioural targets to be discerned, but the time-consuming nature of its approach prevented it from being easily modified in the fast-paced setting of elite sport. Practitioners may instead want to consider a more agile approach to implementing behaviour change interventions, for example supporting key interactions such as the coach-athlete dyad.
1. Neupert et al. (2019) INTJ SPORT PHYSIOL 14(1):99-104.
2. Michie et al. (2011) IMPLEMENT SCI 6(1):42.

#### ELITE TEAM SPORT ATHLETES' PERCEPTIONS AND EXPERIENCES OF DESTRUCTIVE COACH LEADERSHIP BEHAVIOR

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INTRODUCTION: Research on coach leadership in sport has traditionally been aimed at positive aspects of coach leadership styles and behavior. Ineffective coach leadership has primarily been linked to the absence of constructive leader behavior, often labeled in the concept of laissez-faire leadership resulting in unsatisfactory performance and losses for both athletes and teams. Less research has focused on identifying behaviors that the coaches shouldn't do; destructive behaviors that may undermine the immediate and long-term effect of their otherwise effective and constructive behaviors. The purpose of this study therefore was to explore elite team sport athletes' perceptions and experiences of destructive coach leadership behavior.
METHODS: Eight (4 females, 4 males, age range 20 to 37 yrs.) former and current World Class and international elite soccer and handball players participated in individual online semi structured interviews. Question examples from the interview guide included: "Can you describe coach behavior you have experienced as a player that you would label as 'destructive'?", "What effect did that type of behavior have on you?" "On other players? on the team?" The interviews were transcribed verbatim, pseudo-anonymized and analyzed using thematic analysis.
RESULTS: The athletes' experiences of destructive behavior were categorized in two overarching themes 'active' and 'passive' behaviors that then contained subcategories. Active behaviors were related to the actions a coach performs in a situation, and passive behaviors were ones where the coach omitted or failed to act in a situation where action was expected from or needed by the athletes. The active destructive behaviors consisted of five subcategories: Abusive & Aggressive behavior, Condescending behaviors, Negative Criticism, Autocratic Decisions, and Punishment behavior. Passive destructive behavior consisted of two categories Rejection and Ignoring. In addition, one subcategory was labeled as 'incompetent sport coaching behavior' that contained both active and passive behaviors, but this was not deemed to be intentionally destructive behavior.
CONCLUSION: This study parallels leadership studies in organizational contexts and confirms anecdotical stories that indicate that destructive coach leadership behavior is prevalent in sport. The sample in this study were elite athletes and it may well be that destructive leadership is more common and tolerated at this level than in sub-elite and recreational sports. However, this study highlights the importance to further investigate the "dark side" of leadership in sport and we recommend more research on destructive coach leadership behavior in other contexts such as individual sports, different sporting levels, and in different age groups.

#### COACHING AT CHAMPIONSHIP – NATIONAL ATHLETIC COACHES EXPERIENCES AND PRACTICE HOW TO HANDLE CHALLENGES CONCERNING GOAL SETTING STRATEGIES

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Coaching at Championship – National Athletic coaches experiences and practice how to handle challenges concerning goal setting strategies

Background: A decisive factor in performance environments is the coachs ability to set different types of goals in collaboration with his/her athletes (i.e., outcome, performance and process goals).
This is especially important at major championships. Consequently, this study was conducted during the European Championships in Athletics among Swedish national team coaches (n=20).
Aim: To study how coaches experience and practice goal setting strategies at Championship
METHODS: Data was collected during the championship using a questionnaire with a mix of fixed and open-ended questions.
Results: The perceived pressure of participating at a championship is in itself very high. Therefore a majority of the coaches (60 %) used a process-oriented goal setting strategy, which according to the coaches provided a safer environment for the athletes compared to setting outcome goals.
“As a coach you have to know what kind of goal setting approach that suits every individual athlete…this athlete, as a I coach now, acts far more differently than previous athletes Ive had at any Championships before "
Most coaches set outcome goals when preparing for the championship, however in this study only a minor group of coaches (20 %) used outcome goals as a strategy during the Championship.
"We always work with outcome goals because thats what competition is all about,...."
However, as seen in our results, and in line with earlier research, coaches tend to focus more on process and performance compared to outcome goals when being at a championship.
Discussion/Conclusion: According to the coaches in our study, it is important to constantly be permissive and reflective, to consciously affirm the athlete no matter what happens. There are great improvements to be added by learning and reflecting on the experience of being at an international championship, rather than only appreciating the performance outcome.
Athletes are looking forward to compete and therefore they are also ready to work with outcome goals and performance goals. Hence, in our result coaches expressed that a sustainable development benefits from having process-oriented goals as “their main track”. Further the coaches emphasized the importance of working with a process-oriented goal setting in close collaboration and involvement with the athletes.

**SUSTAINABLE LEADERSHIP**

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Introduction
There is a declining proportion of children and youth in Sweden who are involved in sport associations, but there are also difficulties for youngsters to participate as leaders in associations. And so, the work of engaging more young people as leaders must be intensified by generating new knowledge and skills about sustainable leadership-roles for youth.
Methods
From the ethnographic approach which enables studying the social world in its ‘natural state’ and involves observations, data will be collected by planning, developing, and implementing workshops where young leaders together with experienced leaders from sport-clubs and associations are invited to share their experiences. In parallel, conduct semi-structured interviews with the participants that will be documented and analysed. The results from the interviews and workshops will form the basis for an intervention with some selected associations where sustainable leadership-roles will be tried, studied, and analysed.
Results
Preliminary results show that young people tell us that they are rarely asked to lead in an association, some underline that they themselves cannot influence what happens during various activities. Furthermore, associations do not make use of their experiences and knowledge and have poor follow-ups after completed leadership trainings for youth. Hence, there is a need for collaboration between different actors in society such as the Academy, the municipality, sport associations and the private sector; a kind of relationship exchange where each experience can create new interactions based on interpretations of each others conceptual worlds, with the goal of generating new knowledge that is practically useful and theoretically interesting, with a common learning process as the core.
Discussion
A starting point for this interactive research project with the aim to create change is collaboration. This approach which usually is described as part of the action research family has the purpose to identify a problem and develop solutions through a set of processes that are initiated. Also, since this study involves collaboration with different groups, there is a need for new ways and approaches to communicate and report findings to be able to include all participants.
References
Bradbury, H. (ed) (2015). The Sage handbook of action research. London: Sage
Coffey, A. (2018) Doing ethnography. London: Sage
Svensson, L., Ellström, P.-E., & Brulin, G. (2007). Introduction – on interactive research. International Journal of Action Research, 3(3), 233-249

**COMMUNITIES AS POWERFUL AGENTS OF CHANGE: A STUDY ABOUT MEDIATIZATION AND KNOWLEDGE EXCHANGE IN EQUESTRIAN SPORT.**

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The field of sport has frequently been referred to as an example of how media has become powerful agents of change (Hepp, 2012; Schultz, 2004). However, equestrian sports and media seem to have a rather complex relationship and equestrianism is traditionally underrepresented in media in comparison to sports like men’s football and Ice hockey (Andersson & Radovic, 2011; Andersson, 2003; Dashper, 2017; Eriksson & Norblad, 2009). In parallel, Information and Communications Technologies (ICTs) are proven to be highly important assets when it comes to exchanging ideas, knowledge and information about horses and riding (Broms et el., 2021; Byström, 2015; Dashper, 2017). Previously, institutions such as the military, riding schools, educational institutions and the equestrian federation has been the main providers of knowledge in equestrian sports (Moore-Colyer & Simpson 2004; Hedenborg 2009; Thorell & Hedenborg 2015). However, several studies show that equestrians today, to some extent, use ICTs and more specifically social media to obtain and exchange information and knowledge (Bolwell et al.,16 2013; Byström, 2015; Hii et al., 2013; Lofgren et al., 2015). Professionals in the equine industry are worried about the issues surrounding knowledge exchange through social media. The lack of coverage in traditional media and the fre-

quent use of ICTs among the equestrian community questions the idea of media as powerful agents of change in (all) sports. Is it perhaps rather the lack of visibility in traditional media in combination with the possibilities offered through ICTs that are the drivers of change in equestrian sports? And what are the consequences of this? The aim of this study is to investigate in what way experts in equestrian sports (veterinarians, coaches and teachers) are affected by the increasing use of ICTs as platforms for knowledge and analyze what this means for the developments in the sport. The material includes nine interviews with equestrian professionals (three veterinarians, three coaches and three riding school-teachers) as well as netnographic observations and is analyzed with support from mediatization and affordance theory (cf. Nagny and Neff, 2019; Hepp, 2012). Results show that it is more appropriate to use the term communities as powerful agents of change rather than media as powerful agents of change in sports that are traditionally underrepresented in media. Further, this study highlights the importance of increased understanding of how audiences in sports use social media and what this means for the development in the specific sports context.

### THE CONFLICTS OF GREENER GRASS: THE REGULATION OF ARTIFICIAL TURF IN SWEDEN

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Introduction
Artificial turf is a popular substitute for natural grass and is widely used for playgrounds, landscaping and sport surfaces. Artificial turf has increased in popularity over the past decade, with the development of surfaces designed specifically for soccer. The use of these surfaces has increased the availability of playing hours and allowed for matches and training to take place in climatic conditions where natural grass is not easy to upkeep. However, from a sustainability viewpoint, artificial turf has been increasingly criticized for being dangerous to both people and the environment. As these surfaces are used extensively, from regular youth team training to elite professional matches, the environmental and health priorities must be evaluated alongside the geographical requirements, the risk of injury, the regulation of the game itself and a more effective exploitation of playing surfaces. Research on the policy terrain surrounding artificial turf from the perspectives of different stakeholders combined with the perception of players is not well-developed, as the focus is usually on purely technical or medical aspects or on strictly environmental and health-related perspectives.
Method
The focus of this study is on the sustainability of artificial turf in relation to soccer and is based on semi-structured interviews with a number of different actors such as municipalities, companies and sports associations, a qualitative survey of soccer players, and the analysis of different policy documents and reports. The data has been analyzed with a thematic analysis using the software NVivo.
Results
This investigation uncovers the issues that are related to the procurement, use, maintenance, and disposal of artificial turf in Sweden. They shed light on the different constraints that the actors who work with artificial turf encounter when the policy terrain is so complex.
Conclusion
The data, as well as previous research suggests a tendency for soccer to take priority over other sport and outdoor activities. There is also an indication that information and knowledge about the technical attributes and materials used in artificial turf pitches has a great influence on the decisions taken by the actors. Despite the encountered constraints, the study participants mentioned a number of efforts to improve the sustainability of artificial turf throughout the different phases of its lifecycle, from acquisition to disposal. Some recommendations are made based on the results relating to information flow, knowledge about materials and better handling of several kinds of policies in order to support the efforts that are already are in place for municipalities and other actors working with artificial turf.

### RESEARCH ON THE DEVELOPMENT STRATEGY OF ACADEMIC EXCHANGE OF THE CHINESE SPORT SCIENCE SOCIETY

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Introduction
This study uses SWOP-PEST and SWOT-AHP models to analyze the development of academic exchanges at home and abroad of the Chinese Society of Sports Sciences from the perspective of management, so as to achieve the purpose of exploring the optimal development strategy of academic exchanges of the Society. Under the global background of the COVID-19 pandemic, it provides a strategic reference for academic exchanges between sports academic organizations at home and abroad.
Methodology
This study mainly uses SWOT-PEST, SWOT-AHP, Delphi Method and mathematical statistics.
Results and discussions
The analysis of the AHP model shows that the size ranking of the total strength (absolute value) between the four groups of SWOT: Opportunity O Group (2.4019) > Advantage S Group (0.8849) > Disadvantages W Group (0.3953) > Challenge Group T (0.2757), which determines the development of academic exchanges of the Society. The exhibition strategy should be the main, and the WO strategy should also be taken into account.
SO strategy: Accelerate the establishment of the "four links" strategic system, that is, to realize policy communication between the society and the government, economic integration with social enterprises, communication with the hearts and minds of the people, and technical communication with sister associations.
WO strategy: seize opportunities to effectively promote the reform of "de-administration"; actively strive for opportunities for government purchase services and transfer of government functions; dynamically introduce and absorb diversified forms of communication; informatization construction and vocational training of the workforce go hand in hand.
Recommendations:
(1) Establish and improve a quality evaluation system for academic activities that conforms to its own characteristics;(2) Appropriately add the "academic gunpowder flavor" to the exchange activities in the form of pilot;(3) Establish a systematic results management platform for academic exchange activities.

## CP-AP02 Sport performance

### USE OF A STATISTICAL MODEL TO FOLLOW THE EVOLUTION OF THE PROBABILITY OF VICTORY OF PARA TABLE TENNIS MATCHES.

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*INSEP*

INTRODUCTION: Para-table tennis is an opposition sport where the mind and self-confidence have a predominant role. The purpose of this study is to estimate the probability of winning a para-table tennis match and to calculate the evolution of this probability at the end of each set.
METHODS: We have collected all the para table tennis matches since 2016, i.e. 26 535 mens and womens confrontations of all impairment categories. For each match, we have the exact score, the international ranking of opponents, their impairment category and the results of previous confrontations. Five ordinal logistic regression models were used to estimate the probability of final result, before the start of the match, then after each set until the end.
RESULTS: Some indicators did not significantly enrich the prediction model such as the impairment category ($p = 0.13$), the tournament phase ($p = 0.42$). The main indicators retained are the international ranking of opponents ($p<0.01$) and the results of previous matches ($p<0.01$). Before the beginning of the match, based mainly on the rankings and previous confrontations, 81% of the results are correctly predicted, including 40% with the correct scores. After the first set, 83% correct predictions including 51% with correct scores. At the end of the 4th sets, the model has a success rate of 66% with great importance given to the result of the 4th set.
CONCLUSION: The models used have shown very good predictive performance and are statistically robust. The study brings real added value in the prediction when the opponents have a similar level. The results of this study can be used by the staff for mental preparation before a Para-table tennis match to study the different possible scenarios.
Key words : paralympics ; para table tennis ; logistic regression ; performance ; score

### TYPES AND SEVERITY OF PHYSICAL IMPAIRMENTS OF PARA-KARATE ATHLETES

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INTRODUCTION: Para-karate is applying to be added to the Paralympic Games scheduled to be held in 2028. Research on the classification of para-athletes is common in other para martial arts sports [1,2], however, there is limited research on the classification of para-karate athletes. This study aimed to provide details on the impairments and disabilities of the para-karate players. The secondary objective was to investigate the relationship between the level of impairment and the athletes rankings.
METHODS: The data of 197 para-karate athletes (65 females and 132 males), who had been classified over the past six years (World Para Karate Championships 2012 Bremen, 2016 Linz, 2018 Madrid, 2021), were analysed. Descriptive information (counts and percentages) was calculated for each variable. Spearman rho correlation between the athletes standing in the WKF ranking and the extra score (level of impairment) was calculated.
RESULTS: The K20 class was the most popular, and 84 (43%) of the classified athletes belonged to this class (35% female / 65% male athletes), followed by the K10 sports class, 58 athletes (27%, 30% female / 70% male athletes), and K30 sport class, 55 athletes (30%, 35% female / 65% male athletes). In K30 sport class, an accident or a disease was the most frequent cause (73%) of impairment, and 27% of all impairments/disabilities occurred during 0–5 years of age. In K20 sport class, 44% of the athletes had Down syndrome. There was a weak but significant correlation ($r_s = 0.3$, $p = .00$) between the ranking and the level of disability / extra score.
CONCLUSION: Continued data collection that provides insights into the impairment profiles of para-karate athletes is needed to improve the current classification system to enhance safety and fairness in Para Karate competition.
References:
[1] I. Vivaracho, Y. Vanlandewijck, and D. van Biesen, “Initial steps towards evidenced-based classification for Taekwondo poomsae athletes with intellectual impairments: a pilot study,” European Journal of Adapted Physical Activity, vol. 11, no. 2, pp. 1–14, 2019, doi: 10.5507/euj.2018.006.
[2] K. J. Krabben, R. H. J. C. Ravensbergen, H. Nakamoto, and D. L. Mann, “The development of evidence-based classification of vision impairment in Judo: A Delphi study,” Frontiers in Psychology, vol. 10, no. FEB, 2019, doi: 10.3389/fpsyg.2019.00098.

### MATCH CHARACTERISTICS OF “RASPALL”, A MODALITY OF “PILOTA VALENCIANA”, A TRADITIONAL SPANISH HANDBALL SPORT

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*PILOTA 3.0 2020 S.L.*

INTRODUCTION: Pilota Valenciana is a sport integrated by different modalities of handball. It is typically played in Spain, in the Valencian Community. Raspall is one of these modalities of Pilota Valenciana (see official regulations of the Pilota Valenciana Federation [1] for further information on the specific rules of this modality). To win a raspall match a player must sum five games, each of them composed of four points (15, 30, Val, and Joc). [1] Previous research analyzed certain parameters of this sport [2,3] and highlighted the need for further research on the specific structural features of this sport modality. [3] Therefore, the aim of this study was to present the main structural features of raspall.
METHODS: Ten elite raspall singles matches involving 12 different players were recorded by one researcher or extracted from television broadcasts. The games took place during the year 2019. The matches were analyzed by one researcher using Longomatch software in which all actions were recorded on an electronic sheet. A second researcher confirmed the validity of the data extracted. Raw data were transferred to an Excel database to be cured. The variables selected were grouped in duration, punctuation, rest time duration, and hits. IBM Statistical Package for Social Sciences was used to perform descriptive analyses. Values are presented as mean ± standard deviation [95% confidence interval].

RESULTS: A total of 68 games and 399 points were analyzed. The duration of playing and non-playing activities during elite raspall games follow an intermittent activity pattern. Means for the variables analyzed were 1) match duration: 3389.47 ± 1316.61 seconds, 95%CI [2447.63-4331.32]; 2) game duration: 418.37 ± 246.97 seconds, 95%CI [358.59-478.15]; 3) point duration: 35.52 ± 37.91, 95%CI [31.79-39.25]; 4) games per match: 6.80 ± 1.62 [5.64-7.96]; 5) points per match: 39.90 ± 13.24, 95%CI [30.43-49.37]; 6) points per game: 5.87 ± 2.23, 95%CI [5.33-6.41]; 7) rest time between games: 93.78 ± 25.81 seconds, 95%CI [86.93-100.63]; 8) rest time between points: 43.06 ± 19.18 seconds, 95%CI [40.99-45.14]; 9) hits per match: 460.50 ± 168.69, 95%CI [339.83-581.17]; 10) hits per game: 67.72 ± 39.61, 95%CI [58.13-77.31]; 11) hits per point: 11.54 ± 10.07, 95%CI [10.55-12.53].
CONCLUSION: This study presents the structural features of raspall. The findings presented can be of interest to coaches, athletes, and strength and conditioning specialists to further understand the sport and design training programs based on the specific structure of this sport modality. Future scientific evidence analyzing the specific characteristics of raspall is required.
REFERENCES:
1. Pilota Valenciana Federation. Game rules. (2021)
2. González G. The development of the research about Valencian Handball: Bibliographical guide and information sources. Apunts Educación Física y Deportes. 2010;99(1):5–15.
3. Soler S. A descriptive study about a game of Pilota Valenciana in raspall modality. (2004)

### PERFORMANCE IN LONG JUMP: A QUESTION OF BIRTHDATE IN FEMALE ATHLETES?

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INTRODUCTION: Relative age effects (RAEs) bias sport participation, talent development (TD) and selection (TID) programs in youth sport. Most of RAEs studies showed results in cross-sectional samples, longitudinal studies are sparse. This study adds knowledge by providing data showing longitudinal RAEs for female long jump athletes.
METHODS: Out of 161'852 competition's results of 16'168 athletes, 18'368 results of 4141 athletes were extracted in order to include at least 3 results per season and at least 3 seasons of participation. Athletes were included from U8 to U23 in the timespan between 2010 to the 2019. Athletes were separated by one year age groups (AG) and birth quarters (Q). Odds ratios (OR) with 95% confidence intervals (95%CI) were used to quantify RAEs and ANOVA (one-way and repeated measures) to compare performance differences.
RESULTS: Significant RAEs with large effect were found for U8 (OR=3.52 (95%CI 2.63, 4.72)) and U9 (OR=3.01 (95%CI 2.45, 3.69)). Medium effect was shown for U10 to U12 and small effect for U13 to U18. No significant RAEs were found for U19 to U23. Mean long jump performances for AG were significantly shorter for Q4 than Q1 for U8 to U16. Performance differences were ranging from 7.41% in U8 to 3.44% in U16 with a mean difference of 5.82 ± 1.89%. Q4 performances were equally to Q1 between U17 and U19 and higher from U20 to U23 (not significant). Regarding the whole pathway, Q4 athletes showed a relevant higher performance development of 13.8 % compared to Q1. The 100 best athletes for each AG, showed even higher RAEs, i.e. OR= 15.24 (95%CI 4.49, 51.7) at U10, however a similar performance evolution.
CONCLUSION: Female athletes of different birth quarters are differently affected by the consequences of RAEs on their sport participation and TD pathway. RAEs bias performance outcomes till the age of 16 and distort participation, TD and TID decisions. In other words, RAEs induce inappropriate learning environments, a waste of talent, waste of resources and drop-outs before athletes can realize their full potential. Future research should analyse RAEs in other sports using a longitudinal approach.

### DEVELOPMENT OF A BADMINTON RECEIVING SKILLS ANALYSIS SYSTEM -EXTRACTION OF THE POSSIBLE RESPONSE AREA BASED ON SHOT ATTRIBUTES, COURSE, AND SHOT COMBINATION-

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INTRODUCTION: In sports training, it is important to set the level of difficulty according to the level of the players [1]. Therefore, a system that can change the level of difficulty according to the players level is needed.
We herein focused on the smash receive of badminton and developed a system to enable the receiver to practice receiving in virtual reality (VR) [2]. In this study, the system was redeveloped to visualize and analyze the area where a receiver can respond by individual players based on shot attributes, course, and shot combination.
METHODS: First, we developed a VR system for badminton receiving motion that can acquire variables necessary to estimate the receiving skills of each individual, such as the time it takes for the shuttle to fall, the time difference from one ball before, the coordinates of the falling point, and the left-right and front-back difference between the falling points from one ball before. Next, experiments using the VR system were conducted and the subjects' receiving data were acquired under various conditions of smashes. The subjects were an experienced badminton player and an inexperienced player. The number of balls that the experienced player received was 911 and the inexperienced player received was 800. Finally, a model was built to define and estimate the area where a receiver can respond. Using a random forest algorithm, we calculated the probability of a receiver being able to receive based on shot attributes, course, and shot combination in each of the 143 regions of the court and identified the possible response area for each individual.
RESULTS: Using the test data, we evaluated the expected calibration error (ECE) score. The ECE score was 0.065 for the experienced player and 0.082 for the inexperienced player. Both scores are sufficiently small showing that this model is effective in estimating player level.
We analyzed the effect of shot combination by classifying the shots launched from the drop time and drop point. The results showed that both inexperienced and experienced players had a lower return rate on the smash following a drop. However, there was no significant difference in the return rate for the drop following a smash. Thus, by focusing on the return rate, the possibility was shown to analyze the players ability to respond to the shots and their combinations.
CONCLUSION: This research enabled us to quantitatively evaluate the shot attributes, course, and shot combination that each player has difficulty receiving. In addition, by using our VR system, we can reproduce the poor shots and realize effective receiver training. In the future, we plan to verify the effectiveness of the training system based on the results of this research.
[1] M. Csikszentmihalyi, "Finding flow", Basic Books, 1997
[2] Kai I et. al., "The development of an immersive three-dimensional virtual reality system for identifying hand–eye coordination in badminton", The 2020 IEEE International Conference on Systems, Man, and Cybernetics, TuAT9.5, 2020

**MATCH CHARACTERISTICS OF "ESCALA I CORDA", A MODALITY OF "PILOTA VALENCIANA", A TRADITIONAL SPANISH HANDBALL SPORT**

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INTRODUCTION: Escala i corda is the most practiced Pilota's Valenciana modality [1], which is a traditional handball sport played in Valencian Community, Spain (see official regulations [2] for further information on the specific rules). To win a escala i corda singles match a player must sum nine games, which in turn are each composed of four points (15, 30, Val, and Joc). [2] Previous research has described how to play [1] or analyzed certain parameters of team's modality [3,4] and highlighted the need for further research on the specific structural features of this sport modality. [4] Therefore, the aim of this study was to present the main structural features of escala i corda.
METHODS: 11 elite escala i corda singles matches involving 14 different players were recorded by one researcher or extracted from television broadcasts. The games took place during the year 2019. The matches were analyzed by one researcher using Longomatch software in which all actions were recorded on an electronic sheet. A second researcher confirmed the validity of the data extracted. Raw data were transferred to an Excel database to be cured. The variables selected were grouped in duration, punctuation, rest duration, and hits. IBM Statistical Package for Social Sciences was used to perform descriptive analyses. Values are presented as mean ± standard deviation [95% confidence interval].
RESULTS: A total of 159 games and 991 points were analyzed. The duration of playing and non-playing activities during elite raspall games follow an intermittent activity pattern. Means for the variables analyzed were 1) match duration: 4505.51 ± 1316.61 seconds, 95% CI [3891.67-5119.35]; 2) game duration: 235.803 ± 115.982 seconds, 95%CI [217.636-253.97]; 3) point duration: 12.11 ± 12.95, 95%CI [11.303-12.92]; 4) games per match: 14.36 ± 2.06 [12.98-15.75]; 5) points per match: 90.00 ± 13.01, 95%CI [81.26-98.74]; 6) points per game: 6.23 ± 2.29, 95%CI [5.87-6.59]; 7) rest between games: 82.12 ± 23.19 seconds, 95%CI [78.36-85.87]; 8) rest between points: 30.174 ± 15.37 seconds, 95%CI [29.14-31.21]; 9) hits per match: 419.82 ± 102.75, 95%CI [350.79-488.84]; 10) hits per game: 29.03 ± 14.54, 95%CI [26.75-31.30]; 11) hits per point: 4.66 ± 3.76, 95%CI [4.42-4.89].
CONCLUSION: This study presents the structural features of escala i corda. The findings presented can be of interest to coaches, athletes, and strength and conditioning specialists to further understand the sport and design training programs based on the specific structure of this sport modality. Future scientific evidence further analyzing the specific characteristics of escala i corda is guaranteed.
REFERENCES
1 .Astorgano A,Escala i Corda: a traditional spanish professional sport structure (2007)
2.Pilota Valenciana Federation. Game rules. (2021)
3.González G, The development of the research about Valencian Handball: Bibliographical guide and information sources. (2010)
4.Martinez JA. Tesis doctoral: Anàlisi dels factor de rendiment en pilota valenciana (2012)

**DIFFERENCES IN REACTION TIMES BETWEEN OPEN SKILL AND CLOSED SKILL SPORTS USING THE BATAKPRO, A CROSS-SECTIONAL OBSERVATIONAL STUDY**

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INTRODUCTION: Reaction times are an important component of sport performance; however, some athletes need to be more reactive (tennis, soccer and other open skilled sports) than others (cycling, swimming and other closed skilled sports) due to the nature of the sports. To our knowledge, no study has investigated the difference in reaction times between open and closed skilled sports using a simple, reliable and quick test that can be used by all different athletes, regardless of their sporting background. The aim of the study was to investigate the difference in reaction time between open and closed-skilled sports and the possible impact of physical characteristics (height and wingspan).
METHODS: Thirty-four participants (Age = 22.6 ±4 years) from sports including rowing, swimming, team field sports (rugby, GAA, handball), and combat sports (boxing and Muay Thai) had their reaction time tested using four pre-set protocols on the Batak Pro (protocol numbers 1,5, 12 and 24), which varied in difficulty and complexity. Each participant had four attempts (one practice and three testing trials) for each protocol. The primary outcome measure was their score on the Batak (targets struck or time taken to complete the task). A whole group correlation analysis was performed to investigate whether height, wingspan, or ape index was correlated with Batak performance and this was done for each protocol.
RESULTS: Surprisingly, there was not a significant difference between open and closed skill athletes in all four protocols ($p>0.05$). The only physical characteristic that was positively correlated to Batak score was wingspan for protocol 1 only ($r = 0.395$).
CONCLUSION: The results indicate that there is no differences in reaction times between open and closed skill athletes. This may suggest a limitation in the capacity of athletes to improve their reaction times in a general sports training setting. Further research may be needed to investigate the effects of sport-specific reaction time training. These findings may also be attributed to the sensitivity and specificity of the Batak Pro. However, the reliability of the Batak was demonstrated as the scores were largely unaffected by physical characteristics. In conclusion, the Batak Pro should not be dismissed as a useful tool for assessing and training general reaction times within the athletic population.

## Conventional Print Poster

### CP-MH12 Sports medicine

**MEDICAL ATTENTION INJURY RATES IN US WOMEN RUGBY-7S**

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INTRODUCTION: Lopez, V, Jr.1 2, Victoria, C.1 2 3, Ma, R.1 2 4, Weinstein, MG.1 3, Strong, JM. 1 5, Borthwick, KG.1 6, Borrego, JD. 1, Borrego, MA. 1, Allen, AA.1 2 7 8.

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There is a lack of injury data on women's rugby, and less on the Olympic format of Rugby-7s among the amateur playing population (Lopez et al., 2012; Ma et al., 2016). The aim was to determine medical attention (no time-loss) injury incidence in U.S. women's Rugby-7s.
METHODS: A prospective epidemiology study of U.S. women Rugby-7s (6,768 players; 564 teams), in multi-level USA Rugby and USA Sevens LLC tournaments (2010-2014). Incidence (per 1000 player-hour (ph)) and biomechanism of medical attention injuries were captured via the Rugby Injury Survey & Evaluation (RISE) Report methodology (Lopez et al., 2012), adhering to the rugby consensus statement (Fuller et al., 2007). Medical attention injuries were injuries with no absence from play.
RESULTS: Medical attention injury rate was found at 84.4/1000 ph (n=356). Amongst positions, injuries were found at similar rates (backs: 60%, 59.3/1000ph, n=143; forwards: 40%, 53.6/1000ph, n=97; RR=1.11; P=0.447). Most injuries were acute (95%) occurring during the tackle (67%). Most match injuries were from a shoulder tackle (70%) (backs 72%; forwards 62%; RR=1.32; P=0.113). Recurrent injuries occurred at 25%. Lower extremity ligament sprains (53%) were most common, among injury types, muscle/tendon injuries were most common overall at 41% (backs 41/1000ph; forwards 42/1000ph; P=0.998). Knee injuries occurred more frequently in forwards (23%) than backs (16%; P<0.213). Head/neck injury rates, were 22% of all injuries. The sub-acute head contusion rate, where players were physician-cleared to return to sport was 6% (3.5/1000ph).
CONCLUSION: Documentation of medical-attention incidents is recommended in the literature, as this is likely to capture a far greater number of ailments, than time loss injuries alone and will therefore, provide a more inclusive picture of the true burden of injury and illness in a community population as compared to only studies on elite women. A panoptic view of rugby-7s injury rates collected by international standards among community rugby, provides fundamental gender injury data, to guide injury prevention protocols by stakeholders to guide player welfare. Head/neck and upper extremity injury rates (both at around 21%) support an emphasis on tackling techniques for injury reduction. A program, including contact-based-awareness, for women newly introduced to this collision-sport, would nurture injury prevention. Furthermore, adherence on return to play protocols would decrease recurrent injury rates seen in this gender-specific cohort.

## THE EFFECTS OF SOCCER HEADING ON THE DEVELOPMENT OF COGNITIVE AND SENSORIMOTOR PERFORMANCE IN FEMALE SOCCER PLAYERS

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INTRODUCTION: Within recent years, the proliferate concern about the consequences of sport-related head impacts has led to an increasing amount of research on soccer heading and its potentially adverse effects on brain function. While current evidence on the actual risk remains inconclusive, female players, despite an increased vulnerability (Rubin et al., 2018), are largely underrepresented in previous approaches. Consequently, our aim was to prospectively investigate a potential relationship between purposeful heading and changes in cognitive and sensorimotor performance in female soccer players.
METHODS: Before and after one soccer season, 22 semi-professional female players (22.0 ± 3.9 years) underwent a comprehensive examination consisting of questionnaires and an extensive test battery for the assessment of cognitive and sensorimotor performance. Throughout the season, matches were video-recorded and footage then analyzed to obtain players' individual number of performed headers. The association between individual heading exposure and cognitive or sensorimotor performance changes was assessed by means of multiple linear regression while controlling for the potential effects of previously sustained head injuries.
RESULTS: Analyses revealed a statistically significant regression model with four factors ($R2adj = 0.65$, $p < 0.01$). Greater heading exposure was linked to negative changes in fine motor performance as assessed by writing tasks ($p = 0.02$ and $p < 0.01$). Moreover, players with greater heading exposure showed negative alterations in postural control ($p < 0.01$) while exhibiting concomitant changes in working memory performance ($p = 0.03$). The number of previous head injuries did not affect the observed relationships.
CONCLUSION: In contrast to previous reports (e.g., Lipton et al., 2013), our findings suggest that a greater number of headers is associated with sensorimotor rather than cognitive performance changes. Moreover, the present results are the first to point towards a cumulative effect of soccer heading on both postural and fine motor control in female soccer players. These findings may serve as a basis for larger scale studies on the potentially persistent effects of repetitive soccer heading in both male and female athletes.
LITERATURE:
Lipton, M. L., Kim, N, Zimmerman, M. E., Kim, M., Stewart, W. F., Branch, C. A., & Lipton, R. B. (2013). Soccer Heading Is Associated with White Matter Microstructural and Cognitive Abnormalities. Radi-ology, 268(3), 850-857.
Rubin, T. G., Catenaccio, E., Fleysher, R., Hunter, L. E., Lubin, N., Stewart, W. F., Kim, M., Lipton, R. B., & Lipton, M. L. (2018). MRI-defined White Matter Microstructural Alteration Associated with Soccer Heading is More Extensive in Women than Men. Radiology, 289(2), 478-486.

## THE EFFECT OF PUBERTAL STATUS ON POST-ACTIVATION POTENTIAL IN YOUNG SOCCER PLAYERS

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INTRODUCTION: Post-activation potential (PAP) is a phenomenon in which neuromuscular performance characteristics are enhanced after intense contractile stimulation. Previous studies have documented that muscle twitch force can increase through a preceding dynamic conditioning stimulus. However, there is little research regarding the effects of aerobic exercise on subsequent neuromuscular performance in young soccer players. This study examined the effect of pubertal status on PAP after maximal cardiorespiratory exercise test in young soccer players.
METHODS: A total of 48 males aged 10-18 years (13.8 ± 2.3 years) were divided into three groups: pre-pubescent (n= 13, 11.2 ± 1.5 years); pubescent (n=15, 13.1 ± 0.8 years); and post-pubescent (n=20, 15.9 ± 1.3 years). The pubertal stage was determined from secondary sex characteristics. Participants underwent a countermovement jump (CMJ) test before and after maximal cardiorespiratory exercise test (CPET) in order to measure vertical jump height. The jumps were performed on a contact mat (Elite Jump, S2 Sports, São Paulo, Brazil). The obtained flight time (t) was used to estimate the jump height (h) (i.e., $h = gt^2/8$), where "g" is the gravitational acceleration. The PAP was assessed after CPET at 5 minutes of the recovery by calculating the difference between pre- and post-exercise CMJ height. The CPET (Cor-

tex, Metalyzer IIIB, Leipzig, Germany) was performed on a treadmill using a ramp protocol to determine maximal oxygen consumption (VO2 max) and maximal aerobic speed (MAS). One-way ANOVA was used to verify differences between groups.
RESULTS: Results are presented as mean and standard error of the mean. Pre-pubescent participants presented significantly lower CMJ height compared to pubescent and post-pubescent participants (23.8 ± 2.5 vs 29.0 ± 3.7 vs 34.9 ± 5.2, respectively). Both pre-pubescent and pubescent participants had significant lower PPA (1.5 ± 1.7 and 2.2 ± 1.9, respectively) than post-pubescent volunteers. Pre-pubescent players had lower VO2 max values (48.7 ± 7.3) than the other groups. However, no significant differences were observed between pubescent and post-pubescent participants (53.2 ± 5.6 vs 53.9 ± 4.7, respectively). Regarding MAS, pre-pubescent participants presented significant lower values compared to pubescent and post-pubescent (12.4 ± 0.9 vs 14.2 ± 1.9 vs 16.2 ± 1.4, respectively).
CONCLUSION: In conclusion, our results demonstrated that the enhancement of the PAP after maximal cardiorespiratory exercise test is lower in both pre-pubescent and pubescent children. These findings suggest that PAP effect on CMJ performance is associated with greater twitch potentiation in post-pubescent soccer players.

**SUBJECT-ENVIRONMENT RELATIONSHIP AND RUNNING PERFORMANCE: A MULTILEVEL APPROACH**

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INTRODUCTION: Previous studies showed that running was a low-cost practice that could lead to significant health benefits. However, little was known about which specific environmental characteristics could be associated with the performance of runners. In another way, a friendly environment can be related to the highest physical activity commitment, and these aspects can positively influence the running performance. The purpose of this study was to verify the influence of environmental factors on the running performance of Brazilian runners, based on a multilevel approach.
METHODS: We conducted a cross-sectional research project (2019 – 2020). A total of 1,151 runners from all Brazilian states were sampled (711 men and 440 women), aged 18 – 70 years. An online questionnaire was used for data collection (age, sex, body mass, body height, and training characteristics). Data regarding environmental characteristics were downloaded from the Brazilian Institute of Geography and Statistics, based on the Census 2010 – Urbanistic characteristics of household surroundings, which provided information about the presence of illumination, paving, curt, green, space, and sewer in Brazilian states. Running pace was considered the outcome measure, and two models (individual-level and environmental-level) were built. The multilevel regression model was computed in SuperMix software with a 95%confidence interval.
RESULTS: Athletes are from the five Brazilian regions (Southeast = 418; South = 143; Northeast = 411; North = 87; Midwest = 95). The largest number of athletes was from São Paulo (Southeast) and Sergipe (Northeast). Descriptive data for the artificial environment indicated that except for Amapá and Rondônia (both in the north region), Brazilian capital states indicated >90% of the illumination. The best index was presented in the states from the southeast and south for the pavement, sidewalk, curb, green space, and sewer. Approximately 3% of the total variance in runners' performance was attributed to the environmental differences between the states. Approximately 55% of the within-state variance was attributed to individual characteristics inserted in the model, while these variables explained 56% of the between-state variance. Individual characteristics (age, sex, body mass index, training volume, and frequency) were associated with running performance. Illumination (β = 2.07; p = 0.01) and sewer (β = 0.28; p = 0.01) were positively associated with running performance.
CONCLUSION: The variance of running performance for the state of residence is 3% which shows that training in a different state can influence runner's performance; that is, most of the performance variance is explained by the individual characteristics. Besides the individual characteristics (e.g., age, sex, BMI, volume, and training frequency), environmental characteristics are negatively related to running pace. This suggests that these indicators can influence the training commitment and performance.

**A COMPARATIVE STUDY ON THE INCIDENCE OF ELBOW JOINT PAIN IN ELEMENTARY SCHOOL BASEBALL PLAYERS 10 YEARS AGO AND AT PRESENT**

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INTRODUCTION: Baseball is one of the most popular sports in Japan. On the other hand, it is a problem that there is a high incidence of pitching disorders associated with baseball. In addition, the incidence of them with pain in the shoulder and elbow joint is estimated to be 20-40%. These disorders in youth have a significant impact on performance in adolescence and beyond, and prevention of them is said to be important. Many studies have been conducted in the United States mainly to investigate the actual conditions of pitching injuries and to identify risk factors and predictors of injuries. Our laboratory also conducted a survey on the occurrence of pitching disorders in elementary school students 10 years ago. At that time, awareness of the prevention of pitching injuries was not yet widespread, and as a result, there were many players with elbow joint pain. On the other hand, in recent years, rule revisions have been actively implemented from the viewpoint of injury prevention, such as the establishment of a daily/weekly pitch limit and a system for declaratory esteem. Given the official adaptation of the pitching restriction rule in high school baseball players for the first time in 2020, there may be an increased awareness of injury prevention. Therefore, the purpose of this study is to compare data from 10 years ago with the current data on the occurrence of disabilities in the elbow joint, and to examine what differences in the actual occurrence of disabilities occurred during the 10 years between the rule revisions.
METHODS: Paper questionnaires were distributed to baseball players in elementary school in Kyoto Prefecture to investigate the actual condition of disability. Questions included practice time and menus, pitching form, body part with pain, and time of onset of pain. The results were summarized in graphs and tables using descriptive statistics.
RESULTS: Data were collected from 791 baseball players. 235 players (29.7%) had pain in some part of the body, 79 players of them (10.0%) had pain in the elbow joint. In addition, elbow joint disorders accounted for 21% of all injury sites in elementary school students.
CONCLUSION: Data obtained 10 years ago showed that the percentage of elbow disorders occurring was 19.1%. Comparing this data with the percentage of elbow joint occurrence obtained this time (10.0%), it is clear that the percentage of players with elbow joint disorders has decreased significantly. Since the survey on disorders 10 years ago, rule revisions, including restrictions on the number of pitches in youth baseball, have been implemented, and shoulder and elbow examinations to check current physical conditions have been actively conducted. These factors suggest that the prevention of disabilities through rule revisions and the promotion of early detection and treatment of disabilities through medical examinations might have led to a decline in the incidence of elbow joint disabilities.

### RUNNING IN MINIMALIST SHOES: DOES IT PREVENT INJURIES?

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INTRODUCTION: The vast majority of runners sustain a running-related injury (RRI) every year [1]. Various studies report that specific lower extremity adaptations (e. g. stronger foot muscles), induced by wearing minimalist shoes (MS), could theoretically lower the risk of RRI [2, 3]. Additionally, wearing MS is associated with a non-rearfoot footstrike pattern which has been shown in a retrospective study as a factor reducing the RRI incidence [4]. On the other hand, various cross-sectional studies reported that MS could cause a higher injury risk by increasing the forefoot plantar pressure [5-7]. Therefore, the aim of this study was to compare the overall injury incidence in runners using MS and runners using cushioned running shoes (CRS) during a 31-week follow-up.
METHODS: The experimental group (ER) of 30 MS runners (22 males, 8 females) was obtained from a database of the Healthy Aging in Industrial Environment Study—Program 4 (4HAIE) (36.1±13.8 yrs, 1.8±0.09 m, 74.6±11.3 kg, 25.5±21.0 km, 20.8±18.8 %). The control group (CR) consisting of 30 CRS runners (22 males, 8 females) was paired to ER according to their sex, age, height, weight, weekly training volume, and footstrike pattern [8] (36.2±13.1 yrs, 1.8±0.08 m, 74.8±12.6 kg, 24.0±17.3 km, 20.3±18.2 %). The protocols for the data collection are described in detail in our previous publications [9, 10]. For this study, we used data from weekly injury self-report (injuries count per runner, injury incidence per group) via the mobile app during a 31-week period after baseline measurement. A Wilcoxon signed-rank test was used to compare the injury occurrence between groups. Multiple linear regression was used to determine the relationship between injury incidence and shoe type, gender, or training volume. The alpha level was set at $P<0.05$.
RESULTS: There were 7 (ER) and 10 (CR) injured runners, respectively. Results of the Wilcoxon signed-rank test revealed that there was no significant difference in injury incidence between groups (ER: 23.3 %, CR: 33.3%, P=0.18). According to multiple linear regression analysis, shoe type (r_partial =0.1, P=0.46), gender (r_partial=0.07, P=0.61), and training volume (r_partial=0.2, P=0.14) were not significant predictors of injury in our study group.
CONCLUSION: The results of our study show that there were no significant differences in the injury incidence in using MS or CRS during a 31-week follow-up. These findings contradict the results of retrospective and cross-sectional studies [4–7]. Future studies should consider incorporating more specific injury related variables (biomechanical risk factors, specific injury sites) to assess RRI incidence in runners using MS compared to runners using CRS.
REFERENCES: 1. Van Gent et al. (2007) 2. Chen et al. (2016) 3. Davis et al. (2021) 4. Perl et al. (2012) 5. Bergstra et al. (2014) 6. Ridge et al. (2013) 7. Ryan et al. (2014) 8. Cavanagh & Lafortune (1980) 9. Jandacka et al. (2020) 10. Elavsky et al. (2021)

### INFLUENCE OF KICK DIRECTION AND KICKING FOOT ON KICKING PRECISION.

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INTRODUCTION: In soccer, accurately kicking to where a player aims is critical to successful play. A previous research has shown that the precision of kicks is influenced by the height of the aiming position (Hunter et al., 2018). However, the paper was the only study that investigated the precision of kicks in a quantitative way: no study has tried to quantify whether aiming to left or right influences the kicking precision. In addition, soccer players are required to kick with either the dominant or non-dominant foot. It is expected that variability in the kicks with the dominant foot is less that that with the non-dominant foot, however, no quantitative study has been conducted. The purpose of this study was to determine the effects of kick direction and kicking foot on kicking precision.
METHODS: The participants were six right-footed people with at least six years of soccer experience. The participants kicked using an instep kick aiming at a circular target with a 33 cm diameter. The target was placed just inside the goal post, 1.6 m above the ground. The distance between the kicking place and the target was 11 m. The conditions were the direction of the kick (right/left) and the kicking foot (right/left). The same condition was repeated 20 times. The order of the 4 conditions was counterbalanced between the participants. We used three cameras for our measurements (120 fps). We measured the ball position using the 2D DLT method. We analyzed the area, the long axis length, and the short axis length of the 95% equal probability ellipses as indices of kicking precision.
RESULTS: The 95% equal probability ellipse area was 3.34-13.82 m2 (min-max) for the dominant foot and 4.54-18.55 m2 for the non-dominant foot. The short axis length of the 95% equal probability ellipse was 1.54-3.97 m for the dominant foot and 2.34-4.04 m for the non-dominant foot. The long axis length of the 95% equal probability ellipse was 0.66-1.55 m for the dominant foot and 0.66-1.56 m for the non-dominant foot.
CONCLUSION: Our analysis quantified the superiority of the dominant foot in kick precision. The results suggest that the precise kick in the dominant foot was attributed to the smaller short axis of the 95% equal probability ellipse comparing to the non-dominant foot.
REFERENCES
Hunter, A. H., Angilletta, M. J., Pavlic, T., Lichtwark, G., & Wilson, R. S. (2018). Modeling the two-dimensional accuracy of soccer kicks. Journal of Biomechanics, 72, 159–166.

### DO BIOFLUID MARKERS PROVIDE AN OBJECTIVE MEASURE OF THE EFFECTS OF SPORT-RELATED REPETITIVE SUBCONCUSSIVE HEAD IMPACT?

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INTRODUCTION: Exposure to routine head impacts, named sport-related Repetitive Subconcussive Head Impacts (RSHI), is increasingly thought to be associated with adverse long-term outcomes. Assessment of harm to the brain due to RSHI remains a major challenge because the effects are subtle and subjective, leading to an unmet need for accurate measurement tools. One promising solution is the use of biofluid markers to aid diagnosis and injury characterisation and help in medical decision-making. In this scoping review we therefore systematically examine the extent, nature and quality of evidence from studies investigating the effects of RSHI on fluid biomarkers.
METHODS: The review was carried out adhering to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews. Seven electronic databases were searched (including databases from the EBSCO platform, Scopus, and Cochrane Library) using descriptors for subconcussive head impacts, biomarkers and contact sports. Publications evaluating biofluid markers following RSHI

exposure were considered irrespective of publication date. Studies were assessed for bias and quality, and results were structured primarily by marker and study characteristics.
RESULTS: Sixty-two 'relevant' original research reports were identified. Most studies assessed the acute and semi-acute effects of RSHI, while approximately a third investigated chronic effects. Most investigated markers were tau, neurofilament light (NfL), and S100 calcium binding protein B (S100B), while neuron specific enolase (NSE), glial fibrillary acidic protein (GFAP) and brain-derived neurotrophic factor (BDNF) were also included in a meaningful number of studies. RSHI were most researched in American football, boxing and soccer. Many of the studies 1) employed an observational analytic design, with few using an experimental design, and 2) were found to have methodological and design problems, primarily due to failure to control for confounding variables such as the effects of exercise. Overall, NfL and NSE were associated most clearly with RSHI effects, but definitive conclusions are constrained by the heterogeneous and limited nature and quality of the evidence base.
CONCLUSION: The results of this scoping review indicate that biofluid markers might be used to objectively measure the effects of RSHI; however, at present evidence must be treated with caution given the variable quality of the research. We use the gaps and limitations identified within the existing literature to formulate guidelines and research priorities for future clinical studies, including focused examination of specific biomarkers, the use of controlled studies and replication of findings across multiple sports. Improving the quality of biomarker research is essential to advance the field and define clinical utility of biomarkers in this setting.

**REPEATEDLY HEADING A FOOTBALL DIMINISHES ATTENTION, REDUCES LEARNING AND IMPAIRS MEMORY: EVIDENCE FROM AN EXPERIMENTAL IMAGING STUDY.**

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INTRODUCTION: There is growing concern that heading in football (soccer) brings significant risks to brain health. A recent survey of medical records of ex-professional football players in Scotland found them more likely to have developed dementia and other neurological diseases compared to the general population and more likely to die with Alzheimer's disease and Parkinson's disease. Such retrospective post-morbidity data cannot, however, directly examine the immediate consequences of heading footballs. Using a pre-vs-post heading experimental approach we have previously demonstrated changes in brain health due to heading, including impaired memory function. Building on that, we hypothesised that the electrophysiological correlates of attention, memory and learning will also be diminished after heading.
METHODS: The current study extended our previous work by examining football players performing twenty headers in a controlled environment using a ball projecting machine, compared to a control condition involving kicking the ball. We replicated the finding that memory function (Paired Associate Learning on the automated CANTAB cognitive assessment battery) was impaired after heading the ball. We also conducted fine-grained assessment of the neural correlates of attention and learning, using 64 channel EEG (electroencephalography) to record brain activity while participants (N=20) were performing cognitive tasks associated with attention (Oddball), inhibition (Go/No-Go) and learning (Semantic Verbal Associations).
RESULTS: Neural data from the Oddball task revealed a reduction in the magnitude of the P300 effect after heading the ball, but not after kicking the ball, suggesting a reduction in attention. Importantly, the effect was selective, with no equivalent reduction in brain activity during the Go/No-Go task, suggesting that inhibition was unaffected. In addition, neural data from the Semantic Verbal Associations task revealed a reduction in the magnitude of the N400 effect after heading (but not kicking) reflecting a reduced ability to learn new words.
CONCLUSION: Taken together these findings demonstrate that repeatedly heading a football leads to changes in functioning in multiple aspects of cognition, including attention, learning and memory. These findings strengthen concerns about the long-term influences of heading on brain health, adding additional evidence that repeated heading also has immediate effects on brain function.

## Conventional Print Poster

### CP-MH05 Intervention and effect of study programmes

**PHYSICAL ACTIVITY AND ERGONOMIC INTERVENTIONS FOR DIFFERENT NURSING SETTINGS AND ITS EFFECTS ON WORKING ABILITY: A SYSTEMATIC REVIEW**

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INTRODUCTION: Nurse health in European countries is jeopardized by stress, lack of time, or shift work. However, given the increased need for nursing personnel due to demographic trends, retention of nurses work ability is essential. The aim of the current study was to systematically review physical activity intervention studies and associated effects on the work ability of nurses.
METHODS: The review was preregistered on PROSPERO International Prospective Register of Systematic Reviews (CRD42021239665). Following PRISMA guidelines, three electronic databases (CINAHL, MEDLINE, and PsycINFO) were searched. The search identified intervention studies within three settings (hospital, outpatient, and elderly care) by combining search terms such as "nurses", "physical activity", "musculoskeletal disease", and "stress" and related synonyms thereof. Quality assessment of studies was performed by applying 14 quality criteria of the "Standard quality assessment criteria for evaluating primary research papers from a variety of fields" from the Alberta Heritage Foundation.
RESULTS: N = 30 studies with moderate quality (M = 0.73) intervened predominantly in the hospital setting (n =24; outpatient care n = 2; elderly care n = 2; mixed settings n = 3). Content, total intervention time and outcome parameters varied strongly between studies. Short-term positive effects on work ability exhibited n = 25 studies. Merely n = 14 studies reported follow-up measurements. Programs comprised of ergonomic work behaviors (n = 12), strength and endurance training (n = 8), physiotherapy (n = 4), Back School training (n = 3), and Yoga (n = 2). Yoga and Back School training improved outcome parameters such as pain and stress perception, sleep quality, and mindfulness, while strength and endurance training was linked to increased exercise-specific self-efficacy. Ergonomic work behavior can be addressed via didactical and practical programs, as well as by the provision of assistive lifting equipment. Physiotherapy yields positive results on work ability by applying an individual approach to the complaints of nurses.

CONCLUSION: The current results indicate the efficacy of physical activity-based health promotion with regard to work ability of nurses. However, effects typically diminished with follow-up measurements. More long-term intervention studies are necessary to maintain positive effects. Furthermore, evidence in the settings of elderly and outpatient care is scarce. Therefore, high-quality, setting-specific intervention trials are necessary to research the efficacy of physical activity and ergonomic work behavior on work ability in different care settings.
Literature
Van Poel, E., Ketels, M., & Clays, E. (2020). The association between occupational physical activity, psychosocial factors and perceived work ability among nurses. Journal of Nursing Management, 28(7), 1696-1703.

### NECESSITIES AND DESIRES OF PERSONS WITH OCCUPATIONAL DISEASES FOR A SPORTCOACH

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Introduction
A sport-related lifestyle takes on a significant role in the context of preventive and rehabilitative dimensions. In this regard, one aim of the project „Inclusion through Sport- applying a sportcoach for advising, accompanying and mediating of persons with occupational diseases into sport and an active lifestyle, by the German Social Accident Insurance Institution for the health and welfare services (BGW), is about the collaboration of sportcoaches with persons with occupational diseases. The collaboration starts after the participants completed their medical rehabilitation and the sportcoaches accompany them into organized or self-organized sports programs via a one-to-one consulting process. Next to that, in this pilot study a preferred and suitable method for implementing a sportcoach will be investigated. For this reason, the evaluation of all involved parties is important, in particular the participants. Therefore, the necessities and desires of persons with occupational diseases for a sportcoach during the project period are depicted here.
Methods
Participants go through an 18 months intervention time within four measurement periods in total. The research project uses a mixed-methods study design and participants were included from five regions, which are set by the BGWs regional distribution, throughout Germany. At each measurement period, participants evaluate the collaboration with their sportcoach (e.g. satisfaction, progress, behaviour, skills, etc.) in a structured interview.
Results
A total of 49 participants were included in the study. Interviews were analysed using Mayring (2010) qualitative content analysis. First results show that there is a huge discrepancy among the participants' sporting activity at starting point, which led to various participants' goals and therefore to different desires and necessities. Furthermore, it could be shown that participants' necessities and desires for a sportcoach differ over time. Hence, at t1 most mentioned desire for a sportcoach was to get healthier long-term by using a customized sport program/ method designed by the sportcoach. During t2 and t3 analysis revealed that the participants' desire was to gain more in-depth information and advices about preventing from falling back into physical infirmity. However, the actual need for a sportcoach declined for most participants.
In addition, all participants indicated that they appraised the sportcoach's knowledge, persistence and his/her presence led to an increase in motivation to continue their sport program. In addition, all participants stated that good communication is eminent and a necessity for the process.
Discussion & Conclusion
Preliminary results have shown that the one to one sport coaching can be beneficial for a wide range of participants. Furthermore, the sportcoach's services has led to an increase in motivation, enthusiasm and self-confidence of persons with occupational diseases towards physical abilities.

### DEVELOPMENT OF A SYSTEM AIMED AT IMPROVING MOTIVATION FOR SQUAT TRAINING

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Introduction
In recent years, people have begun to exercise for their health. However, many people find it difficult to exercise continuously and often drop out of training before realizing the benefits of exercise. In this study, we considered that a more enjoyable and motivating training system would increase the enjoyment of exercise and lead to continued exercise. Therefore, we developed a system that makes people performs squats by presenting visual and auditory feedback. In addition, as a new approach, we attempted to use real-time recognition of the participants facial expression to evaluate the enjoyment of exercise.
Methods
In order to compare the effect of the contents on the participants, four types of contents were created using Unity: the first one displays only text (text condition), the second one counts the number of squats with an avatar squatting with one participant (avatar condition), the third one displays the avatars cheer while dancing, and at four avatars appear every two seconds (cheering condition), and the fourth one presents an avatar lying down and simply watching over the participant (watching condition). The participants were 16 healthy male university students. They were asked to experience four contents in one day. The measurement items were electrocardiogram, 6 types of facial expression recognition, a questionnaire at the end of each content, and a final questionnaire after the completion of all the contents.
Results
The heart rates were 101-105 beats per minute during the content experience, about 10 beats higher than that at rest. In the facial expression recognition, neutral facial expressions were shown about 60% of the squatting time, and happy expressions were expressed about 20%. Negative emotions (anger, fear, sadness, and surprise) were about 20%. The results of the final questionnaire showed that the avatar condition and the cheering condition were more effective enjoying exercise and increasing motivation. In the watching condition, many participants answered that their motivation did not improve much.
Discussion
The results of this study indicate that, for the purpose of exercise continuation, it is effective to have an avatar on the display that trains with the participants and cheers for the participants as a feedback display. Future prospects include increasing the number of movement patterns of the avatar and presenting instructions on effective squatting methods. We conclude that by conducting research with a wider range of participants, we can find a more effective feedback method that is appropriate for younger and elder people.
References

Hirasawa, Y., Ishioka, T., Gotoda, N., Hirata, K., Akagi, R. (2019). LNCS 11570, 492-501.

### ICT-ENABLED COOPERATIVE LEARNING IN PHYSICAL EDUCATION

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Introduction
There is an extensive international and national literature on the potential and impact of integrating ICT tools in education. However, the use of ICT in the physical education is not universal and its applicability is often questioned due to the nature of physical education lessons. In the present study, the authors investigated how ICT tools used in PE lessons determine student achievement and motivation.
Methods
A four-week intervention programme included the use of ICT devices and applications (smartphone, website, Runtastic, Facebook) by students in PE lessons. The research was carried out in two study groups and one control group. The participants were secondary school students (n=85), 21 boys (24.7%) and 64 girls (75.3%), with an average age of 16.6 years. During the research, the students participated in a 12 lesson project, where the Experimental 1 group took part in lessons supported by ICT tools, while the Experimental 2 group did not use ICT tools. During the study, the change in students performance was measured by a 20 m shuttle-run test (psychomotor endurance test), the change in perceived motivational climate was measured by the PMCSQ-2 questionnaire, while the change in motivation was measured by the SMS questionnaire.
Results
Results show that in the group where ICT tools were used, students performance improved significantly, students increased the distance they ran and the time they ran, students task orientation and intrinsic motivation increased. In the group not using ICT tools, performance also improved as a result of the intervention, although there was an increase in ego-orientation and an increase in amotivation at the end of the project.
Discussion
Based on our results, we can conclude that ICT tools have a place in the teaching of physical education, as they increase students performance and motivation. Pupils performed better when given the opportunity to use ICT tools, were more interested in physical education lessons and were motivated to implement the 12-hour intervention. Pupils who did not use ICT tools had lower interest and did not strive for high levels of performance.

### THE EFFECTIVENESS OF ATTENTIONAL STRATEGIES ON THROWING PERFORMANCE AND GAZE BEHAVIOR OF SELF-PACED TASKS UNDER FATIGUE AND NON-FATIGUE CONDITIONS

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INTRODUCTION: It has been widely accepted that an external focus enhances motor performance and learning relative to an internal focus. While evidence exists, the available literature still lacks studies that incorporate physiological stress. Specifically, the relation between attentional focus, gaze behavior (Quiet Eye; QE) and performance under these conditions is lacking. Therefore, the purpose of this study was twofold: (a) to examine the effectiveness of attentional strategies on learning and performance of a closed, self-paced motor task under rested and fatigue conditions, and (b) to examine the effectiveness of these strategies on QE duration under both settings.
METHODS: Sixty-four male (n=31) and female (n=33) adults (age = 26.19 + 4.04) novice in dart-throwing skill participated in our study. They were randomly assigned to three attentional groups (Internal - I, External – E, and Control - C). The participants in all groups received technical throwing instructions. In addition, the I group received instructions to focus attention on their arm movements, while the E group received instructions to focus their attention on the bullseye and the dart.
The study was composed of two phases. In Phase 1, the dart-throwing skill was learnt and performed by the participants during acquisition, retention, and transfer sessions. On phase 2, the participants were randomly assigned to performed either upper or lower repeated sprint protocol and following the exertion, performed the motor task. Gaze behavior and performance were analyzed during all phases.
RESULTS: During acquisition and retention stages, the participants in both I and E groups performed better compared with the C group, reflecting in lower Absolute Error, Variable error and Target Misses. During the transfer phase, all groups were less proficient and only the I group displayed an improved performance compared with the C group. Longer QE was measured in the E group compared with the I (only in the acquisition phase) and C groups during all stages and conditions. In phase 2, the performance of the I and E groups was reduced, yet both were able to maintain longer QE duration compared with the C group. For example, the QE durations during the fatigue stage were for the E group (1347.12+547.06 msec), I group (1106.52+602.69 msec) and C group (741.93+390.44 msec).
CONCLUSION: The results of the current study suggest that providing attentional instructions to novice participants will improve their performance and lengthen their QE compare to not providing attentional instructions. Both attentional groups were able to maintain a longer QE under the fatigue conditions, while in the C group a reduction was apparent. Yet, this was not translated to improved performance under these conditions since reduced performance was apparent. In order to elucidate how the ability to lengthen the QE duration under strenuous conditions might benefit performance, additional research is needed using different populations and expertise levels.

### EFFECTS OF A PHYSICAL EXERCISE PROGRAM IN WORKERS WITH SEDENTARY OCCUPATIONS ON ANTHROPROMETRIC MEASURES, PHYSICAL CONDITION AND PRODUCTIVITY COSTS ACCORDING TO GENDER

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Objective: To assess the effect of a supervised physical exercise intervention in the workplace on anthropometric measures, physical condition and productivity costs in physically inactive workers according to gender.
METHODS: A pre-experimental study was conducted in office workers with sedentary occupations. Recruited participants underwent a physical exercise intervention (n = 75; mean age 43 ± 8 years). An intragroup analysis was carried out according to the gender of the subjects on anthropometric measures, physical condition and productivity costs.

Results: After the intervention, the men presented a significant decrease in their weight (p = 0.001; ?2 = 0.24), and improvements in balance (p = 0.009; ?2 = 1.71) and flexibility in the back (p = 0.011; ?2 = 0.46). Women had a reduction in weight (p = 0.003; ?2 = 0.22), BMI (p = 0.004; ?2 = 0.26), as well as improvements in cardiac recovery (p = 0.018; ?2 = 0.18). They also showed a significant increase in their scores in pectoral and triceps strength (p = 0.006; ?2 = 0.24). No differences in productivity costs were observed according to gender after the intervention (p > 0.05).
Conclusions: The 20-week supervised aerobic and strength physical exercise program with 3 weekly alternate-day training sessions could be effective in improving physical fitness in men and women, although no improvements in productivity costs were observed.

# Invited symposia

## ISB-01 50 years of the International Society of Biomechanics (ISB) - a lifelong connection with sports

### MUSCLE-TENDON UNIT MECHANICS AND SPORTS PERFORMANCE

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The stretch shortening cycle (SSC) of muscle-tendon units is generally understood to facilitate stored energy during eccentric loading leading to increased performance in subsequent concentric actions. It is accepted to provide performance enhancement of the human musculoskeletal system, as seen for example in performance diagnostic tests such as countermovement jumps. The exact mechanisms underlying such a performance enhancement are however still not clearly understood.
One proposed mechanism is associated with a stretch-induced increase in steady-state force, referred to as residual force enhancement (rFE). There are indications that rFE generated during lengthening affects force depression when an eccentric action is followed by a concentric contraction. It therefore appears that stretch-induced rFE contributes to increased force and work during SSC. Recent studies have shown that SSC occur on the sarcomere level and that the SSC effect
is dependent upon the stretch-shortening velocity. The complexity of muscular mechanisms underlying the SSC effect is therefore receiving considerable attention, whereas the role of the tendinous tissue is less explored. Recent data investigating the effect of SSC on the non-homogeneous displacement of collagenous tissue in the human Achilles tendon will be presented and related to running performance.

### SPORTS INJURY BIOMECHANICS: SUCCESS STORIES, CHALLENGES AND OPPORTUNITIES

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*UNIVERSITY OF PRETORIA*

Injuries occur when the load applied to the tissue exceeds its capacity to withstand that load. Research on the biomechanics of sports injuries therefore aims to understand the injury mechanism by describing situational and behavioural factors, whole body motion, and detailed joint- or tissue-level biomechanics of the inciting event. With regards to acute onset injuries (e.g., anterior cruciate ligament rupture and concussion), this approach has yielded a body of evidence that provides the
basis for interventions to reduce injury risk. Gradual onset injuries present additional challenges as the inciting events are more difficult to identify. Recent technological advances pose new opportunities for enhancing our knowledge of injury mechanisms and effective injury risk reduction by moving biomechanical analysis out of the lab and into the field and providing real-time data.
Building on primary prevention goals, biomechanics also underpins comprehensive return to sport assessments that aim to reduce reinjury risk as neuromuscular deficits may not be detected by traditional screening tests. This presentation will discuss the successful integration of biomechanical research and practice for injury risk reduction and return to sport management, and the challenges and opportunities for progress in this area.

### OPTIMISATION OF SPORTS TECHNIQUES: HOW MODELLING AND SIMULATION CAN BE OUR HOLY GRAIL

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*UNIVERSITY OF BATH*

The ability to predict athletes' performance or the outcome of a specific intervention is the holy grail for sport scientists and coaches interested in either performance enhancement or injury prevention. Predictive computer simulation and modelling approach can now be used to support decision making processes and explore 'what if ' scenarios, particularly given the advancements made with this type of approach (e.g. ease of model development, tractability of performing simulations, computational power, and algorithm efficiency). However, the creation of a valid 'model' for the athlete, the availability of unique experimental datasets to train or validate the model, and the implementation of a realistic simulation framework are key challenges that hinder the actual applicability of such approach. In this talk, we will (i) explore what are the research questions that could be answered using modelling and computer simulations, (ii) discuss the key requirement for model development, and (iii) identify the most appropriate methods and algorithms to run realistic simulations. Finally, we will briefly discuss how to enable simulations to be performed routinely and with relative ease to inform changes in the techniques of athletes and the coaching principles, as well as supporting sport governing bodies in their decision-making processes.

## CP-PN04 Cardiovascular physiology and regulation

### REPRODUCIBILITY OF DEVICE-MEASURED SEDENTARY TIME AND PHYSICAL ACTIVITY IN PATIENTS WITH ARRHYTHMOGENIC CARDIOMYOPATHY. DO THESE PATIENTS MEET THE 2020 WHO GUIDELINES?

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INTRODUCTION: Major organizations universally recommend regular physical activity for the general population. However, in patients with arrhythmogenic cardiomyopathy (ACM), exercise has shown to trigger and accelerate disease progression, and exercise participation is generally restricted. Therefore, individuals with ACM may be susceptible to engage in low physical activity levels. This study aimed to describe the physical activity patterns using raw acceleration data in patients with ACM and to examine the reproducibility of accelerometer-based measures over 4 consecutive weeks.
METHODS: A total of 71 (49.6 [SD=17.5] years) patients with ACM wore a wrist-worn Axivity AX3 accelerometer for 30 consecutive days, and the raw signal was processed using the R-package GGIR. For descriptive analysis of metrics related to sedentary behavior and physical activity, participants were block-matched on sex, age (<50 years, >=50 years) and BMI. The participants were classified as meeting the 2020 World Health Organization guidelines if they engaged in >=150 min/week of moderate to vigorous physical activity (MVPA) using the previously proposed thresholds for wrist accelerometers [1]. The reproducibility of each metric was determined based on Intraclass Correlation Coefficients (ICCs; 95% CI) that were calculated using linear-mixed models adjusted for age, BMI, and season.
RESULTS: In total, 59.2% of participants did not meet the physical activity guidelines. ACM patients spent 71.1% of awake time in sedentary behavior (SED) and only 2.5% of awake time in MVPA. No significant differences were found in physical activity related variables between sex and age groups. However, patients >=50 years (n= 33) spent longer periods of sedentary time in comparison to those <50 years (mean difference 38.9 min/d, 95% CI 5.8 to 72.2, p = <0.05), and participants with obesity (BMI >=30 kg/m², n= 10) accumulated longer periods of SED and less MVPA than those without obesity. The ICCs ranged from 0.65 for MVPA (95% CI=0.57, 0.72) to 0.91 for light-intensity physical activity (95% CI=0.89, 0.93).
CONCLUSION: More than half of the patients with ACM did not meet minimum physical activity guidelines. Accelerometer-based classifications of activity are moderately stable over time, with some within-subject variability observed. It is highly advisable to assess the extent to which sedentary time and device-measured physical activity of different intensities are associated to the arrhythmic risk and other health outcomes in this population. It might be advisable to establish personalized recommendations for physical activity, taking into account the clinical circumstances and identification of individual barriers with the ultimate purpose of optimizing the care of people with ACM.
References:
1. Hildebrand M, Hansen BH, van Hees VT, Ekelund U. Evaluation of raw acceleration sedentary thresholds in children and adults. Scand J Med Sci Sports. 2017;27(12):1814-1823.

### HEART RATE VARIABILITY: HOW OFTEN AND WHICH PROTOCOL SHOULD WE USE IN ATHLETES?

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INTRODUCTION: Heart Rate Variability (HRV) is a non-invasive measure commonly used in clinical settings to evaluate cardiovascular health and autonomic nervous system (ANS) function. In athletes/athletic populations it provides insight into recovery status and readiness for training. The majority of research in HRV is conducted in clinical populations, with a lack of detailed guidelines for use in athletic populations especially in relation to optimal frequency of measurement and protocol selection.
We hypothesized that a protocol taking the average HRV result from 2 tests per week (4 tests in total) would be a reliable monitoring tool for athletic populations.
METHODS: This test-retest reliability study assessed 16 athletes (5 male, 11 female, average age 22 y.o.) from an array of sports (including endurance, team sport, and combat sports). Participants were tested for HRV on 4 occasions over a two week period using a 30-minute, 3-lead electrocardiogram (ECG) BIOPAC measurement System. All tests were performed by the same operator, in standardized laboratory conditions (comfortable seated position, room temperature and brightness) at the same time of the day and on the same days of the week. The resulting data was then analyzed for inter- and intra-week reliability, as well as for accuracy when using shorter time periods for measuring HRV.
RESULTS: The study conducted showed that the use of an average of two 30-minute HRV measures within a one-week period is a reliable method to assess HRV (ICC = 0.798, CV = 5.88 +/- 4.34%) in standardized test conditions . Inter-week results were more reliable than intra-week results. It was also shown that shorter HRV measurements are as reliable as the 30minute reference measure when using this protocol.
CONCLUSION: HRV can be a reliable tool for monitoring autonomic function in athletic populations if suitable protocols are followed and standardized testing conditions are respected. Shorter protocols such as the one used in this study can give reliable results, and will allow longitudinal HRV monitoring to become more accessible to athletes and practitioners.

### WELL-TRAINED INDIVIDUALS HAVE AN EXAGGERATED BLOOD PRESSURE RESPONSE DURING EXERCISE TESTING

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INTRODUCTION: Blood pressure (BP) measurement is included as a regular component of exercise stress testing, in order to evaluate the physiological status of the individual and detect subclinical cardiovascular disease (CVD). However, the number of studies assessing systolic BP response (SBPR) during high-intensity exercise in well-trained populations is limited, and there is currently no consensus on what is to

be defined as a normal BPR during exercise for athletes. In addition, continuous bio-signal measurements are increasingly investigated to overcome limitations of intermittent cuff-based BP measurements during exercise testing. Therefore, the primary aim of this study was to investigate the SBPR during a lactate threshold and maximal cycle ergometer test in a population of well-trained male cyclists. As a secondary aim, we investigated whether pulse arrival time (PAT) measured with a novel cuff-less device can be used as a continuous SBP surrogate during exercise testing in an athletic population.
METHODS: Eighteen well-trained male cyclists were included (32.4 ± 9.4 years; maximal oxygen uptake 63 ± 10 ml/min/kg). The participants performed a stepwise lactate threshold test with 5-minute stages, followed by a stepwise test to voluntary exhaustion with 1-min increments when cycling on an ergometer. BP was measured with a standard automated exercise BP cuff, whereas PAT was measured continuously with a non-invasive physiological measurements device (IsenseU). Metabolic consumption was measured continuously during both tests.
RESULTS: Our findings confirm an exaggerated SBPR in well-trained individuals compared to suggested normative cut-off values. At lactate threshold (281 ± 56 W) and maximal intensity test (403 ± 61 W), SBP increased from resting values of 136 ± 9 mmHg to maximal values of 219 ± 21 mmHg and 231 ± 18 mmHg, respectively. The results further demonstrated that, on an individual level, PAT has a strong association with SBP, with linear within-participant regression lines between PAT and SBP at a mean of r2 of 0.81 ± 17.
CONCLUSION: This study provides new data on the SBPR in well-trained populations. The findings demonstrate higher SBPR at peak exercise compared to most comparable studies, and strengthen the assumption that athletes have different cut-off values than less trained populations. In addition, the results support the potential for using PAT as a surrogate measurement for SBP on an individual level. This has not previously been assessed in an athletic population with corresponding exercise intensities. However, our study population was limited. Comparison of results with the few existing studies on SBPR during exercise involving athletes is furthermore challenging, due to differences in reported exercise testing methods and protocols, BP measurement methods and determinations of SBP at maximum or submaximum workloads. Future research is needed to clarify the clinical implications of the high BPR in well-trained individuals.

## THE EFFECTS OF DIFFERENT TYPES OF RESISTANCE EXERCISE FOR LOWER LIMBS ON PULSE WAVE VELOCITY AND BLOOD PRESSURE IN ADULTS

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INTRODUCTION: Both isometric resistance exercise (IM) and isotonic resistance exercise (IT) can improve muscle mass and strength. Moreover, resistance exercise is beneficial in regulating blood pressure and the marker of arterial stiffness (pulse wave velocity, PWV). However, the current study did not determine the different effects of blood pressure and PWV between IT and IM. Therefore, the purpose of this study was to investigate the alterations of PWV and blood pressure after lower limbs IT or IM in healthy adult males.
METHODS: 28 participants from university were randomly divided into IM group (n = 14) and IT group (n = 14). Participants were asked to perform two trials respectively: the loads of isometric resistance exercise was 75% maximum voluntary isometric contraction (MVIC), the loads of isotonic resistance exercise was 75% one repetition maximum (1RM). Blood pressure and finger-toe PWV (ftPWV) were measured at pre-exercise (Rest), 0 min (T0), 15 min (T15), 30 min (T30), 45 min (T45), 60 min (T60), and 24 hour (T24H) after exercise. Two-way analysis of variance (ANOVA) was used to assess the differences between variables.
RESULTS: IM and IT group had a greater significantly increased in ftPWV at T0 post-resistance exercise than Rest (5.13 ± 0.54 vs 5.64 ± 0.47 m/s ; 5.13 ± 0.41 vs 5.62 ± 0.48 m/s ). In addition, the IM group at T45 (4.63 ± 0.47 m/s) were significantly lower than the IT group at T45 (5.03 ± 0.49 m/s) and IM group at Rest (5.13 ± 0.54 m/s). IM group had a greater significantly decreased in SBP and mean arterial pressure (MAP) at T45 post-resistance exercise than Rest (118.71 ± 10.51 vs 110 ± 9.03 mmHg ; 84.93 ± 5.12 vs 77.9 ± 7.09 mmHg ), heart rate (HR) and systolic blood pressure (SBP) significantly increased at T0 in both groups for resistance exercise (75.14 ± 14.57 vs 101.71 ± 18.7 bpm ;118.71 ± 10.51 vs 131.64 ± 10.25 mmHg).
CONCLUSION: The study showed that the significant reduction of ftPWV, SBP, and MAP was found in healthy adults participating isometric resistance exercise for lower limbs. Post exercise hypotension (PEH) was induced, which decreased to the lowest point at 45 minutes after exercise and returned to the baseline at 60 min and 24 hours later. In addition, there was no significant change in adults undertaking isotonic resistance exercise.

## EFFECTS OF HYDROXYUREA ON SKELETAL MUSCLE MICROVASCULATURE OF MICE WITH SICKLE CELL DISEASE

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INTRODUCTION: Hydroxyurea (HU), also known as hydroxycarbamide has been commonly used as a therapeutic strategy in Sickle Cell Disease (SCD) since 19841. HU has been recognized as efficient in SCD patients with an acceptable toxicity2. From a clinical point of view, HU has been shown to reduce painful episodes, hospitalizations, blood transfusions, acute chest syndrome and mortality3,4. These beneficial roles of HU are mediated by the increase of fetal hemoglobin (HbF) production and the decrease of abnormal hemoglobin (HbS) levelin erythrocytes. HU can then reduce the polymerization-sickling cascade thereby causing a decrease in the number of circulating sickled red blood cells5. HU also induces physiological changes such as an increase in both number and size of erythrocytes. It can also decreases hemolysis6. HU is also known as a nitric oxide (NO) donor which can directly affect the microvascular function. Although microvasculature is known to be remodeled in SCD (capillary rarefaction and enlargement8), the corresponding effects of HU have been scarcely reported. Given that HU improves hemorheologic and hemodynamic functions in SCD patients, one can hypothesize that HU may be beneficial for skeletal muscle microvasculature.
METHODS: Gastrocnemius muscles of 11 HbSS mice and 12 HbSS HU-treated mice (Townes model) were used to perform histochemical analyses. Morphometric analyses of microvasculature were performed by staining the endothelial cells with CD31 antibody. Microvascular network analysis included Capillary Outer Diameter (COD), Perimeter (CP), Surface Area (CSA), and Density (CD, number of capillaries per mm2) as well as the capillaries to muscle fibers ratio for a given muscle area (C/F). ANOVA and Tukeys post-hoc tests were used to compare data of HbSS and HbSS HU-treated mice. Significance was accepted when p≤ 0.05.
RESULTS: HbSS HU-treated mice displayed significantly higher COD, CP and CSA. than control HbSS mice (p = .033, p = .013, and p = .005 respectively, Figure 1). On the other hand, CD and C/F did not differ between HbSS and HbSS HU-treated mice (Figure 2).
CONCLUSION: Given that HU is a NO donor on the one hand and that NO can induce hyperemia on the other hand, one can hypothesize that that the widening of capillaries might be related to hyperemia related to HU-treatment. As supporting evidences, Bosman et al 9

reported that hyperemia induced capillary distension/enlargement while Kano et al.10 observed a reduced capillary luminal diameter in response to a reduced blood flow

### ASSOCIATION BETWEEN CARDIORESPIRATORY FITNESS LEVEL AND VISCERAL ADIPOSE TISSUE IN MIDDLE-AGED MALE RUNNERS

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INTRODUCTION: Cardiorespiratory fitness (CRF) level is defined as a component of physiological fitness related to the ability of the circulatory and respiratory system to supply oxygen during sustained physical activity. Low CRF level is independently associated with increase in all-cause mortality and cardiovascular diseases risk (Barry et al., 2014). Abdominal obesity, especially the increase of visceral adipose tissue (VAT), is closely associated with increased mortality related to cardiovascular disease (Fang et al., 2018). Regular physical activity or exercise is associated with higher level of cardiorespiratory fitness and lower amount of visceral adipose tissue compare to inactive individuals. We assume, there will be association between CRF level and VAT in middle-aged male runners.
METHODS: 128 male-runners, with age 36-45 was obtained from a database of the Healthy Aging in Industrial Environment Study— Program 4 (4HAIE). VAT values were obtained via dual-energy X-ray absorptiometry (DEXA) and CRF level values (VO2max) were obtained during graded exercise test (GXT). The association between CRF level variable (VO2max) and visceral adipose tissue (VAT) the correlation analysis was used. Due to deviation of data from normality (Shapiro-Wilk test) the non-parametric Spearmen´s rho (ρ) correlation was used, level of statistical significance was set at level p value ≤ 0.05 for all test.
RESULTS: The statistically significant moderate negative association was observed between parameter of VO2max and VAT (ρ = -.565, p = .001) with r2 = 32%.
CONCLUSION: Our hypothesis was confirmed. We found statistically significant moderate negative association between parameters of CRF level and visceral adipose tissue in healthy middle-aged runners. These results confirm that higher level of cardiorespiratory fitness is associate with lower amount of visceral adipose tissue which can be considered as protective factor against cardiovascular diseases in these specific group population.

### EFFECT OF EXERCISE INTENSITY AND EXERCISE DURATION ON SALIVARY IGA SECRETION RESPONSE TO ACUTE EXERCISE

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INTRODUCTION: Salivary immunoglobulin A (s-IgA) secretion is the predominant antibody in mucosal fluids and plays a role of prevention of viral replication and inhibition of upper respiratory infection. High-intensity and/or prolonged exercise, such as a marathon, transiently induces depression of oral immune system function through reduced s-IgA secretion, and this state is called an “open window” (Kakanis et al., 2010). However, it is unclear whether s-IgA decreases depending on exercise intensity and exercise duration, that is, the onset point of the “open window” remains unclear. Therefore, we aimed to investigate the changes in s-IgA secretion response to acute exercise at different exercise intensity and exercise duration.
METHODS: Nine healthy young males with no exercise habits participated in two studies. Before starting the studies, we measured maximal oxygen uptake (VO2max) during an incremental cycle ergometer exercise test. [Study1] Subjects randomly performed three conditions: cycle exercise for 30 min at a work rate equivalent to 35%VO2max, 55%VO2max, and 75%VO2max. [Study2] Subjects randomly performed three conditions: cycle exercise for 30 min, 60 min, and 90 min at exercise intensity of 55%VO2max. Saliva samples were collected at baseline, immediately after, and 60 min after each exercise in both Study 1 and 2. The s-IgA secretion rate was calculated from s-IgA concentration and saliva flow rate per minute. The s-IgA concentration was measured by enzyme-linked immunoassay.
RESULTS: [Study 1] No significant differences in change in s-IgA secretion rate over time were observed at either 35%VO2max, 55%VO2max and 75%VO2max exercise intensity. However, the change in s-IgA secretion rate immediately after exercise at 75%VO2max exercise intensity was significantly lower than that at 55%VO2max (P<0.05). [Study 2] The change in s-IgA secretion immediately after exercise for 60 min and for 90 min was significantly lower than that for 30 min (for 60min, P<0.05 and for 90 min, P<0.01). In addition, the change in s-IgA secretion rate at immediately after exercise for 90 min was significantly lower to compare with the baseline (P <0.05) and return to baseline at 60 min after exercise (P<0.01). No significant differences in change s-IgA secretion rate over time were observed for 30 min and 60 min exercise.
CONCLUSION: These results suggest that the transient decrease in s-IgA secretion to acute exercise may be depending on both exercise intensity and the s-IgA secretion to acute exercise may decrease at 75% VO2max exercise intensity for 30min or at 55% VO2max exercise intensity for 60-90 min.
Reference:
Kakanis MW et al., (2010) Exerc Immunol Rev. 16: 119-137.

## Conventional Print Poster

### CP-AP03 Warm - up / Recovery

### DOES PROPRIOCEPTIVE TRAINING INTERVENTION IMPROVE BALANCE SCORES IN COLLEGIATE WOMEN’S BASKETBALL PLAYERS WITHIN SIX WEEKS?

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INTRODUCTION: Several attempts have been made through several studies to derive variables that can improve overall balance scores in various sport athletes over the past several years [1,2]. Balance is an even distribution of weight that upholds an individual in the upright position. Proprioception training has been identified as an intervention that improves stability scores which could result in decreased ankle

injuries among college athletes who rely on quick movements of the lower limbs. However, there is no current investigation if an intervention on an unstable surface could improve Center of Pressure and Limit of Stability scores in collegiate women basketball athletes?
METHODS: Nine female college student athletes from a Midwestern University volunteered for the study (age 22.66±.87, height 174.77±4.12 cm, mass 76.56±9.17 kg, body mass index 25.06±2.75). A one group experimental pre-posttest design was selected for this study. Center of pressure (CoP) measurements was taken with the eyes open stable surface (EOSS), eyes closed stable surface (ECSS), eyes open perturbed surface (EOPS), and eyes closed perturbed surface (ECPS) using a Bertec Computerized Posturography Plate. Limit of Stability (LoS) were also assessed on a perturbed surface in 4 different body planes: left sagittal (LoSL), right sagittal (LoSR), frontal (LoSF), and posterior (LoSP). A 6-week intervention consisting of 15-minute sessions of shooting a basketball barefoot on a 0.5-centimeter soft mat surface from the 3-point line, twice a week occurred for the participants. A posttest assessment following the exact steps of the pre-test on CoP and Los measurements were taken after the intervention. Dependent t-tests were analyzed through SPSS (version 26) of pre to post scores of CoP and LoS scores.
RESULTS: There was no statistical difference within subject group with CoP scores EOSS ($p = 0.087$), ECSS ($p = 0.40$), EOPS ($p = 0.09$), and ECPS ($p = 0.19$). LoS variables indicated no statistically significant results LoSF ($p = 0.267$), LoSP ($p = 0.124$), LoSL ($p = 0.70$), LoSR ($p = 0.390$). The findings of our study did not match with similar studies previously performed on athletes [2].
CONCLUSION: A six-week intervention process of balance and proprioceptive training on a soft surface gym mat was found to have no significant changes on CoP variables EOSS, ECSS, EOPS, ECPS, or LoS variables of LoSF, LoSB, LoSL, and LoSR scores in women basketball players. Future studies should use a larger population, add session frequencies, and safely increase instability requirements on the intervention process.

## THE ACUTE EFFECTS OF VIBRATION FOAM ROLLING AND STATIC STRETCHING OF THE HAMSTRING MUSCLES ON RANGE OF MOTION, MUSCLE SHEAR MODULUS AND PHYSICAL PERFORMANCE

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INTRODUCTION: Static stretching (SS) and foam rolling are common tools used as a warm-up routine. Both can acutely increase the range of motion (ROM) of a joint to the same extend (1). Moreover, a recent meta-analysis reported significantly favourable effects of foam rolling on performance when compared to static stretching (2). Although not clearly understood, it is assumed that foam rolling with an additional vibration has a more pronounced effect in increasing ROM compared to static stretching (3). Therefore, the first goal of this study was to investigate vibration foam rolling (VFR) or SS of the hamstrings on the hip flexion ROM, counter movement jump (CMJ) performance and hamstring maximum voluntary isometric contraction (MVIC) torque. Moreover, to understand a potential mechanism the shear modulus of three hamstring muscles (semitendinosus (ST), semimembranosus (SM), and biceps femoris long head (BFlh)) was measured pre and post both interventions.
METHODS: Twenty-five healthy male volunteers (mean ± SD; 27.62±6.63 years; 83.72±11.75 kg; 184.36±7.68 cm) were asked to visit the laboratory on two separate days within 48 hours and were randomly assigned to either a SS or a VFR treatment. Both interventions were performed continuously for 2 min on the hamstring muscles on both legs. Before and after each treatment, the shear modulus of the hamstrings of the right leg were measured with shear wave elastography and the hip flexion ROM was assessed using a sit and reach test. Moreover, MVIC of the right leg flexors was measured with a dynamometer and CMJ was performed on a force plate. After testing for normal distribution, two-way repeated measures ANOVA and if applicable t-tests were performed.
RESULTS: Following SS and VFR, ROM increased significantly by 8.0%, and 9.2%, respectively. However, no difference between the modalities was observed. Following VFR, muscle shear modulus of ST (-6.7%) and SM (-6.5%) deceased while there was no change in the shear modulus of BFlh. SS lead to a decrease in the shear modulus of the ST (-6.7%) only. Moreover, MVIC peak torque significantly decreased following SS (-5.1%), whilst no significant change was observed following VFR (+0.6%). Furthermore, no significant changes and differences were found in CMJ height.
CONCLUSION: According to our study and recent meta-analyses (2,3) it can be recommended that VFR should be preferably used as a warm-up routine compared to SS when the goal is to increase ROM without a subsequent decrease in performance.
References:
1.) Konrad, A., et a. (2022).. European Journal of Applied Physiology, 1-13.
2.) Konrad, A., Tilp, M., & Nakamura, M. (2021). Frontiers in Physiology, 12. 720531.
3.) Wilke, J., et al. . (2020). Sports Medicine, 50(2), 387-402.

## THE ACUTE EFFECTS OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION STRETCHING WITH POST-STRETCHING DYNAMIC ACTIVITIES ON TISSUE STIFFNESS AND JUMP PERFORMANCE ARE MUSCLE- AND TASK-SPECIFIC

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INTRODUCTION: Proprioceptive neuromuscular facilitation stretching (PNF) incorporates static stretching and isometric contractions in a cyclical pattern. To overcome detrimental effects on performance parameters after stretching, post-stretching activities (PSA) were suggested [1]. During most stretch intervention studies testing for performance, all task-related muscle groups were stretched during the same intervention. Hence, possible positive effects of the intervention for one muscle group (e.g. quadriceps) might be cancelled out by negative effects for another muscle group (e.g. triceps surae), resulting in a lack of performance change [2]. Therefore, the aim of this study was to test jump performance parameters while stretching two task-specific muscle groups (quadriceps vs triceps surae) on separate days using PNF in combination with PSA (PNF+PSA). To further gain insight into possible mechanisms involved, tissue stiffness was measured.
METHODS: On two separate days, sixteen participants performed either PNF+PSA on the quadriceps or the triceps surae (PNF+PSAquad, PNF+PSAtri) for 60s on both legs. Participants stretched the target muscle for 10s, followed by 5-s maximal contraction of the target muscle in stretching position. This procedure was repeated three times. A force plate was used to test the performance of Countermovement-Jumps (CMJ) and Drop-Jumps (DJ) pre and post intervention. A MyotonPro device was used to measure tissue stiffness.
RESULTS: For DJ, ANOVA showed no effect for contact time (CT), however significant time effects (pre-post) for reactive strength index (RSI) and jump height (JH) ($p<.05$). Paired t-tests tests showed a large decrease ($d>1.1$) for RSI and JH after PNF+PSAtri and a small-to-medium decrease for PNF+PSAquad ($d>.25$). For CMJ, ANOVA showed no interaction or time effects ($p>.05$) on the tested parameters. Following PNF+PSAquad, overall quadriceps stiffness decreased ($p<.05$), however patella tendon stiffness did not change. In contrast, Achilles tendon stiffness decreased following PNF+PSAtri ($p<.05$, $d=0.83$), whereas triceps surae stiffness was unchanged.

CONCLUSION: Results showed that an acute bout of PNF+PSA on either the quadriceps or the triceps surae muscles influenced performance in fast, reactive but not slow muscle contractions (i.e., CMJ). For fast contractions involving strong time restrictions, PNF+PSA might disturb the well-coordinated interaction of the involved muscles and the series elastic component resulting in a performance decrease. Because of the lower time pressure for CMJ, these effects might play a less dominant role in CMJ. In contrast to previous research [2], this is the first study showing acute negative performance effects despite using PSA. Consequently, more research in needed to clarify the influence of PSA after stretching in acute settings.

References
[1] Behm et al., 2016, J.Clin.Exerc.Physiol.
[2] Blazevich et al., 2018, Med.Sci.Sports.Exerc

## INTRAMUSCULAR TEMPERATURE CHANGES IN THE QUADRICEPS FEMORIS MUSCLE AFTER POST-EXERCISE COLD-WATER IMMERSION (10°C FOR 10 MIN): A SYSTEMATIC REVIEW WITH META-ANALYSIS

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INTRODUCTION: Post-exercise cold-water immersion (CWI) is a widely accepted recovery strategy for maintaining physical performance output [1]. However, existing review articles about the effects of CWI commonly pool data frequently from heterogenous studies and thus, do rarely differentiate between exercised muscles, CWI-protocols (duration, temperature, etc.), forms of activating the muscles before CWI, and thickness of the subcutaneous adipose tissue [2, 3]. This systematic review therefore aimed to investigate the effects of one particular post-exercise CWI protocol (10°C for 10 min) on intramuscular temperature changes in the quadriceps femoris muscle while accounting for skinfold thickness.
METHODS: An electronic search was conducted on PubMed, LIVIVO, Cochrane Library, and PEDro databases. Pooled data on intramuscular temperature changes were plotted with respect to intramuscular depth to visualize the influence of skinfold thickness. Spearmans rho (rs) was used to assess a possible linear association between skinfold thickness and intramuscular temperature changes. A meta-analysis was performed to investigate the effect of CWI on pre-post intramuscular temperature for each measurement depth.
RESULTS: A total of six articles met the inclusion criteria. Maximum intramuscular temperature reduction was 6.40°C with skinfold thickness of 6.50 mm at a depth of 1 cm, 4.50°C with skinfold thickness of 11.00 mm at a depth of 2 cm, and only 1.61°C with skinfold thickness of 10.79 mm at a depth of 3 cm. However, no significant correlations between skinfold thickness and intramuscular temperature reductions were observed at a depth of 1 cm ($r_s = 0.0$), at 2 cm ($r_s = -0.8$) and at 3 cm ($r_s = -0.5$; all $p > 0.05$).
CONCLUSION: The CWI protocol resulted in significant temperature reductions in the muscle tissue layers at 1 cm ($d = -1.92$ [95% CI: −3.01 to −0.83]) and 2 cm ($d = -1.63$ [95% CI: −2.20 to −1.06]) but not at 3 cm ($p < 0.05$). Skinfold thickness and thus, subcutaneous adipose tissue, seems to influence temperature reductions in the muscle tissue only to a small degree. These findings might be useful for practitioners as they demonstrate different intramuscular temperature reductions after a specific post-exercise CWI protocol (10°C for 10 min) in the quadriceps femoris muscle.

References
1 Bleakley C, et al., Cold-water immersion (cryotherapy) for preventing and treating muscle soreness after exercise. Cochrane Database Syst Rev, 2012. CD008262(2).
2 Hohenauer E, et al., The Effect of Post-Exercise Cryotherapy on Recovery Characteristics: A Systematic Review and Meta-Analysis. PLoS One, 2015. 10(9): p.1-22.
3 Leeder J, et al., Cold water immersion and recovery from strenuous exercise: a meta-analysis. Br J Sports Med, 2012. 46(4): p.233-240.

## EFFECT OF DRY-COOLING AND COMPRESSION SOCKS RECOVERY ON BLOOD LACTATE CONCENTRATION AND SOME PHYSIOLOGICAL VARIABLES AFTER ANAEROBIC EXERCISE IN TRAINED ATHLETES

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INTRODUCTION: The effect of combining two recovery methods such as dry-cooling recovery (DCR) and wearing compression socks (CS) on blood lactate concentration and some physiological variables following anaerobic exercise such as Wingate test (30 seconds) in well trained athletes are not fully understood especially in short term approach.
METHODS: Total of 44 male athletes (aged: mean= 28.8 ±6.14) randomly grouped in this experimental design study into two experimental groups and one control group. Following signing the consent, participants underwent two laboratory visits. The first visit was to evaluate anaerobic power using Wingate test (30sec.). In the second visit, participants completed Wingate test followed with one of the recovery methods, dry-cooling recovery (DCR), dry-cooling recovery with compression socks (DCR&CS), or passive recovery (PR). The DCR group was exposed to (-20℃ for 2m), where DCR&CS group was exposed to (-20℃ for 2m) with wearing compression socks grad . Blood lactate concentration, heart rate and blood pressure were measured after Wingate test (30 seconds) at minutes (15-20-25-30-45-60).
RESULTS: Data of the present study reported lower lactate concentration and HR in both examined recovery methods (DCR and DCR&CS) compared to the passive method. Moreover, the recovery method of DCR&CS reported the lowest values significantly in both blood lactate and HR compared to the passive recovery method. However, no significant difference was found between DCR recovery method compared to the DCR&CS recovery method.
CONCLUSION: One of the potential benefits of DCR and CS methods is to decrease body temperature and increasing the mechanical pressure of the blood vessels and to improve related-metabolic recovery. consequently, the blood flow increases and cleaning rate of the metabolic wastes (Versey, N. G. 2013). Lovell et al. (2011), concluded that wearing compression socks during recovery stage of 60 minutes may increase recovery speed and reduce blood lactic concentration after strenuous exercise but does not affect blood pH (Lovell et al., 2011). While recent study found that wearing compression socks did not lead to significant effect on recovery indicators in elite judo (Brown et al., 2021), the results of the present study may explain that the combination of the two recovery methods DCR and CS together cloud help to improve recovery more compared to one recovery method such as DCR or CS. We suggest that the external pressure of the CS combined with the reduction in temperature may accelerate the reduction of blood lactic concentration and heart rate in intense anaerobic exercise. Thus, where possible, using both recovery methods DCR and CS may help for short term recovery (60 min) in well trained athletes. Further researches are encouraged to understand the mechanism of the effect of two methods to accelerate the recovery in athletes.

### COLD AND HOT WATER RECOVERY IN ELITE YOUTH FOOTBALL PLAYERS: THERMAL ADAPTATIONS DURING A TEN-WEEK TRAINING PERIOD.

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INTRODUCTION: Considerable physical demands are associated with frequent training sessions and matches in elite football and require optimal strategies for recovery. For this purpose, many elite players use immersion in cold (CWI) and/or hot water (HWI) following training and matches. Although shown to enhance recovery parameters, these approaches are physically stressful for the players, involving sweating or shivering, as well as discomfort. At present, little is known about the effects of long-term exposure to post-exercise CWI and HWI. The aim of the current study was to assess thermal adaptations to post-exercise CWI and HWI in elite youth football players during an intervention-period of ten weeks.
METHODS: Twenty-five elite male football players (15-20 years old) were assigned randomly to undergo either CWI (10°C for 10 min), HWI (42°C for 20 min) or 6 min sham-laser treatment (placebo; PLA) immediately after training at least twice each week for ten weeks. To compare their thermal adaptation prior to the intervention and after five and ten weeks, each player rated his thermal sensation (TS: 1-9; cold-to-hot), thermal comfort (TC: 1-5, comfortable-to-uncomfortable) and sweating/shivering (SS: 1-7, sweating-to-neutral-to-shivering) during the initial and final minute of CWI, HWI or PLA.
RESULTS: After prolonged post-exercise usage, players felt less cold during the first (TS after 5 weeks = 2.8±1.0, after 10 weeks = 2.4±1.1, Pre-intervention = 1.1±0.4, $p<0.05$) and final minutes of CWI (corresponding values at 10 weeks and Pre-intervention of 3.8±0.7 vs. 2.6±0.5, $p<0.05$). In addition, players reported reduced shivering during the final minute in CWI (SS at 10 weeks : 4.4±0.5 vs. Pre-intervention: 5.7±0.5, $p<0.05$). Players subjected to post-exercise HWI reported feeling less comfortable during the final minutes after 5 and 10 weeks compared to pre-intervention (TC:4.1±1.1,4.0±0.6, vs2.4±1.2, $p<0.05$). Treatment with the PLA modality resulted in no significant changes in any of the parameters examined.
CONCLUSION: Exposure of elite youth soccer players to either CWI or HWI following training at least twice a week for 10 weeks resulted in significant changes in their experience of the treatment. More specifically, CWI reduced the sensation of feeling cold and attenuated shivering, while HWI augmented the sensation of discomfort.

### OPTIMIZATION OF 10 M SPRINT PERFORMANCE WITH A SLED STIMULUS IN CONTRAST SPRINT TRAINING

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INTRODUCTION: Resisted sled sprint training used to improve sprint performance (1). Some authors studied the adaptations after a training period with sled training but not the immediate effect in contrast training (2). The aim of the present study was to examine the effect of load (on percentage of body weight) on 10 m sprint with a sled stimulus in the performance of the following 10 m sprint without sled in the context of contrast sprint training.
METHODS: Twenty-one subjects (20.8±2.2 yrs), after 15 min warm up performed 4 sprint in 10 m alternately with 3 sprint in 10 m with sled resistance. Rest of 2 min realized after each sprint. Subject performed in randomized order four training sessions separated from 1 week [1] control condition only sprint [2] sled 25% [3] sled 50% [4] sled 75%.
RESULTS: Time in 10 meters sprint decrease during the 2nd sprint after a sprint with a sled stimulus at 50% of body weight ((-1.9% compared to the 1st sprint) $P<0.05$). The speed at the second step and the amplitude of stride between the 2nd and 3rd step, are greater on the last 3 sprints of the condition at 50% with a sled push stimulus at 50% of body weight ((+6% for speed and +3% for amplitude stride to compared to the 1st sprint) $P<0.05$). No significant changes were observed for any sprint time after the control session of sprint and 25% and 75% body mass sled pull.
CONCLUSION: Ten-meter sprint performance in contrast training between sled sprint and normal sprint is potentiated 1min following a sled push loaded with 50% body mass while it is not affected after a 25% and 75% body mass sled or normal sprint in control condition. The determining factor of speed imporving seems to be the amplitude stride. These results are of great importance for coaches seeking to potentiate sprint performance in speed session with the sled exercise.
REFERENCES
1 Seitz et al., J Sci Med Sport, 2017
2 Winwood et al., J Strength Cond Res, 2016

### EFFECTS OF MENTAL FATIGUE ON REACTION TIME IN ATHLETES

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Aim
Mental fatigue (MF) has been defined as a psychobiological state caused by prolonged periods of demanding cognitive activity and characterized by subjective sensations that are felt with the semantic expression of "fatigue" or "lack of energy" (Boksem & Tops, 2008; Van Cutsem et al., 2017)). However, mental fatigue plays a role in endurance athletes (Meeusen et al., 2021), while the impact of mental fatigue in motor task as reaction time (RT) to visual stimuli remains largely unknown.
Materials and methods
For this aim, 45 athletes (age 29.18±3.25 y) took party in this study. MF were induced by a routine of 15 minutes of Stroop Task (PsyTool), with 600 tasks and 5 different colours choice. Heart rate (HR) was recorded with Cardio-Polar H7 in pre-Stroop-Test, during Stroop-Test (every 5'), post-Stroop-Test and 1', 3' and 5' after post Stroop-Test. While RT were evaluated in pre and post Stroop-Test with a Cognitive Fun software. The variables considered was HR (bpm), RT on Pre-Stroop-Test (RTPR), RT on Post-Stroop-Test (RTPO). Univariate ANOVA and Bonferroni Post-hoc was used to compare HR in-between conditions and t-test to compare the RT performance before/after Stroop-Test. The significance level was fixed at priori as $\alpha < 0.05$.
Results

Analysis of variance (ANOVA) for HR showed a Fischer value of 6.051 and η2= 0.101 with p<0.001; while the post-hoc showed a significant difference (p<0.05) during the Stroop-Test (HR were 36.58±5.40, 40.31±6.36 and 42.87±7.36 %HRMAX at the 1st 2nd 3rd point, respectively) compared to the other conditions. RTPR and RTPO was 310.29±38.34 and 334.12±38.79 ms, with p=0.0029, respectively.
Conclusion
The present findings suggest that the parasympathetic branch of the autonomous nervous system functioning as a relaxation system tends to be activated under increasing mental fatigue with a decreased performance (RT). Therefore, the athletes could use MF induced during the training to improve the time delay related to the motor task.
These data have numerous implications. In the first place it suggests how MF has a direct relationship to the RT and how its alteration can become a determining factor in sports performance. Secondly, it suggests that the detection of HR can be used as a verification marker of mental fatigue, in the absence of physical fatigue.
Boksem, M. A. S., & Tops, M. (2008). Mental fatigue: Costs and benefits. Brain Research Reviews, 59(1), 125–139.
Meeusen, R., Van Cutsem, J., & Roelands, B. (2021). Endurance exercise-induced and mental fatigue and the brain. Experimental Physiology, 106(12), 2294–2298.
Van Cutsem, J., Marcora, S., De Pauw, K., Bailey, S., Meeusen, R., & Roelands, B. (2017). The Effects of Mental Fatigue on Physical Performance: A Systematic Review. Sports Medicine, 47(8), 1569–1588.

## Conventional Print Poster

### CP-MH06 Endurance exercise

#### ASSOCIATIONS BETWEEN CARDIORESPIRATORY FITNESS, MUSCULAR FITNESS AND ENDOCANNABINOIDS SYSTEM IN ADULTS WITH DIAGNOSED DEPRESSION: SONRIE STUDY

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INTRODUCTION: Physical fitness is considered one of the most powerful indicators of health status, as well as predictor of morbidity and all-causes mortality (1,2). Endocannabinoids system (ES) is a widespread neuromodulatory network which appear to be modulate by physical fitness and seems to be altered in patients diagnosed with depression (3). Our aim was to examine the association of physical fitness, in terms of cardiorespiratory fitness (CRF) and muscular fitness (MF), with ES in adults with mild or moderate depression.
METHODS: ES ligands (AEA and 2-AG) were assessed in 85 participants (14 male) aged 25-65 years diagnosed with mild or moderate depression). CRF was measured by the 6 minutes walking test and MF by handgrip test. Stepwise linear regression models were used to examine associations of CRF and MF with ES biomarkers, adjusting for age, sex, smoking habits, cancer and diabetes disease.
RESULTS: CRF and MS were inversely associated with 2-AG (b coefficient: -50.96 and 95% confidence interval (CI): -82.58 to -19.34; b: -0.92 and 95%CI: -3.29 to 1.45 for CRF and MS, respectively) and positive associated with AEA (b: -53.62 and 95%CI: -103.52 to -3.71 for CRF and b: 1.05 and 95%CI: -2.72 to 4.82 for MS; all P values <0.01) after controlling for potential confounders.
CONCLUSION: Physical fitness components in terms of CRF and MS are associated with ES ligands after controlling for potential confounders in depressive adults. These results should stimulate a debate on whether the metabolism of ES could be a way in which the benefits of high fitness levels are exerted. Moreover, higher fitness level may be an additional target for clinical management of ES deregulation in depressive disorders.
References:
1. Ortega FB, Ruiz JR, Castillo MJ, Sjöström M. Physical fitness in childhood and adolescence: a powerful marker of health. Int J Obes 2008 321 [Internet]. 2007 Dec 4 [cited 2022 Mar 30];32(1):1–11. Available from: https://www.nature.com/articles/0803774
2. Evaristo S, Moreira C, Lopes L, Oliveira A, Abreu S, Agostinis-Sobrinho C, et al. Muscular fitness and cardiorespiratory fitness are associated with health-related quality of life: Results from labmed physical activity study. J Exerc Sci Fit. 2019 May 20;17(2):55–61.
3. Desai S, Borg B, Cuttler C, Crombie KM, Rabinak CA, Hill MN, et al. A Systematic Review and Meta-Analysis on the Effects of Exercise on the Endocannabinoid System. https://home.liebertpub.com/can [Internet]. 2021 Dec 3 [cited 2022 Mar 31]; Available from: https://www.liebertpub.com/doi/abs/10.1089/can.2021.0113
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#### INFLUENCE OF CHRONOTYPE AND HABITUAL TRAINING TIME-OF-DAY ON RATING OF PERCEIVED EXERTION IN YOUNG ADULTS

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INTRODUCTION: To date, there has been little agreement on circadian variation in sports performance. It seems that both chronotype and habitual training time-of-day (HTT) need to be considered when assessing diurnal variation in performance [1]. Therefore, the aim of this study was to evaluate if chronotype and HTT may influence the rating of perceived exertion (RPE) after two different intensity trials performed in three times of day.
METHODS: The chronotype of participants (N56: age 23.8±2.1 yrs, BMI 22.1±2.0 kg/m2, V'O2max 40.1±9.1 ml/kg/min) was assessed using the Morningness Eveningness Questionnaire (MEQ) [2] and their maximal oxygen uptake (V'O2max) was determined via direct gas analysis (Fitmate-Pro, Cosmed, Italy) on a cycle ergometer (LC6, Monark, Sweden) using a submaximal exercise-based protocol. Subjects' HTT was objectively evaluated using an activity monitor (Lifecorder Plus, Kenz, Japan) worn for one week. Participants performed two 6-minute bouts of exercise on cycle ergometer at 60% and 90% of V'O2max at 8.30am (morning trial, MT), at 1.00pm (afternoon trial, AT) and at 5.30pm (evening trial, ET) in a randomised order. Training sessions were interspersed by 48 hours. After each session, participants reported their RPE (CR10) [3].

RESULTS: Distributions of chronotype and HTT were 27% of Morning-types (M-type), 59% of Neither-types (N-type) and 14% of Evening-types (E-type) and 21% of subjects trained in the morning, 55% in the afternoon and 23% in the evening, respectively. When the RPE of all the subjects were examined as a whole, there was no difference between the MT, the AT and the ET (60% V'O2max MT: 3.0±1.5, AT: 2.9±1.4, ET: 2.8±1.5; 90% V'O2max MT: 7.3±2.4, AT: 7.1±2.4, ET: 7.0±2.3). No time-by-group interaction effect on RPE was observed when participants were grouped by chronotype (60% V'O2max p=0.2931; 90% V'O2max p=0.7653) or HTT (60% V'O2max p=0.9370; 90% V'O2max p=0.9862). However, M-type reported lower RPE scores post MT and E-type post ET both at moderate (60% V'O2max M-type_MT: 2.6±1.1, AT: 3.3±1.7, ET: 3.1±1.5; E-type_ MT: 3.3±2.0, AT: 2.7±0.9, ET: 2.6±1.8) and vigorous (90% V'O2max M-type_MT: 6.8±2.7, AT: 7.3±2.8, ET: 7.4±2.1; E-type_ MT: 7.4±2.2, AT: 7.0±1.9, ET: 6.4±2.5) exercise intensity. Interestingly, the same trend was not observed for RPE and HTT.
CONCLUSION: In contrast to previous study findings [1], neither chronotype nor HTT have significantly influenced diurnal variation in RPE. Nevertheless, the lowest RPE scores found post MT for M-type and post ET for E-type, regardless of their HTT, seem to suggest that only chronotype might influence RPE. Future research needs to confirm this hypothesis.
REFERENCES:
1. Rae DE. Eur J Appl Physiol. 2015;115(6):1339-1349.
2. Horne JA. Int J Chronobiol. 1976;4(2):97-110.
3. Borg E. Scand J Med Sci Sports. 2006;16:57–69.

### ATHEROSCLEROTIC CARDIOVASCULAR RISK IN PARALYMPIC ATHLETES WITH A LOCOMOTOR IMPAIRMENT: BENEFICIAL EFFECTS OF HIGH AEROBIC FITNESS AND PRACTICED SPORT

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INTRODUCTION: Atherosclerotic cardiovascular disease (ACVD), the leading cause of morbidity and mortality in individuals (I) with a locomotor impairment (LI), occurs at earlier ages in I-LI than in ambulatory individuals because I-LI, in particular those with a spinal cord injury (SCI), display a higher prevalence of ACVD risk factors (RF) mainly due to their increased sedentary habit. However even in Paralympic Athletes (PA) with a LI (PA-LI) the prevalence of ACVD-RF is very high. We tested the hypotheses that both a high oxygen uptake peak (VO2peak) and different types of practiced sport (skilled sport – SS; power sports – PS; intermittent, aerobic and anaerobic mixed metabolisms, sports – IS; endurance sports – ES) affect ACVD-RF prevalence, which is supposed to be low in PA-LI competing in ES and having high VO2peak.
METHODS: Data from a total of 118 male PA (62 PA-SCI and 56 PA with other health conidiations (HC) determining a LI – PA-OHC) were retrospectively evaluated. Thirty-six PA competed in SS, 20 in PS, 42 in IS and 20 in ES. They had been screened through anthropometric and blood pressure (BP) measurements and laboratory blood tests to estimate an ACVD-RF score summing 1 point for each of the following RF: central obesity –OB- (waist circumference ≥102 cm), hypertension –HT- (rest systolic BP ≥ 140 mm Hg and/or diastolic BP ≥ 90 mm Hg), dyslipidemia -DL- (total Cholesterol -TC ≥200 mg·dl-1 or LDL-C ≥130 mg·dl-1 or HDL-C <40mg·dl-1), impaired fasting glucose -IFG (glycemia≥100 mg·dl-1) and subtracting 1 point when serum HDL-C was higher than 60 mg·dl-1. All PA underwent to an incremental cardiopulmonary maximal exercise test to assess VO2peak.
RESULTS: Prevalence of HT, TC, LDL-C, low-HDL-C, IFG and OB were equal to 8.1% and 8.9%, 39.3% and 41.2%, 45.2% and 41.1%, 27.9% and 24.3%, 33.9% and 32.1%, 19.4% and 7.1% in PA-SCI and PA-OHC, respectively, being significantly different only the OB prevalence (p=0.046). Based on the ACVD-RF score, 3 ACVD-RF groups were formed: group 1 (RF≤0, N=43, 13 PA competing in ES, 15 in IS, 8 in PS and 7 in SS), group 2 (RF=1, N=43, 6 PA competing in ES, 16 in IS, 8 in PS and 13 in SS), group 3 (RF≥2, N=32, 1 PA competing in ES, 11 in IS, 4 in PS and 16 in SS). Grouping the PA depending on sports and ACVD-RF determined a significant difference ($\chi 2$), indeed 65% of PA competing in ES had no ACVD-RF while 30% and 5% were in Group 2 and group 3, respectively, while 6.3% of PA competing in SS were in group 1 and 50% in group 3. VO2peak equal to 36±8.3 ml/kg/min in PA of group 1 was significantly higher than the VO2peak of PA included in group 2, equal to 31±8.9, which was significantly higher than that of the PA of group 3 (25±7.5).
CONCLUSION: Prevalence of RF was similar in the 2 groups of HC, with the exception of OB which was more prevalent in PA-SCI. DL had a relevant and dangerous prevalence in PA regardless the HC. Competing in ES and having high levels of VO2peak seems to provide a protective effect against the risk of developing ACVD.

### MODERATE-INTENSITY AEROBIC EXERCISE UNDER HIGH FINE PARTICULATE MATTER CONCENTRATION ACUTELY AUGMENTS PULSE WAVE REFLECTION IN HEALTHY YOUNG MEN

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INTRODUCTION: Fine particulate matter (PM2.5) influences arterial stiffness, an independent predictor for cardiovascular diseases. Regular aerobic exercise has been demonstrated to be an effective behavioral intervention to improve arterial stiffness. However, the effect of aerobic exercise on arterial stiffness under higher level of fine dust environment has not been completely understood. Therefore, the purpose of this study was to investigate the acute effects of moderate intensity aerobic exercise on various arterial stiffness measures in young adults at the two different PM2.5 conditions (high vs. low).
METHODS: Seven young men (23-27 years) were recruited for this study with a randomized crossover design. Participants performed 30 minutes of treadmill running at 70% of peak heart rate under both high PM2.5 (HPM) and low PM2.5 (LPM) conditions. Arterial stiffness indices were measured before and after the exercise intervention. To assess aortic stiffness, both carotid-femoral pulse wave velocity and augmentation index adjusted at 75 beats per minute of heart rate (AIx@75) were measured by SphygmoCor Xcel System. Carotid arterial stiffness was assessed by using the Aloka Prosound α7 ultrasound system and the FDA-approved Cardiovascular Suite software.
RESULTS: After acute moderate-intensity aerobic exercise under HPM, AIx@75 was significantly increased (P = 0.007). However, in response to the exercise, there were no significant changes in the other arterial stiffness measures under HPM and also no significant alterations in any arterial stiffness indices under LPM.
CONCLUSION: In conclusion, acute moderate-intensity aerobic exercise under HPM adversely influences on wave reflection, a measure of arterial stiffness.

**ACUTE AEROBIC EXERCISE UNDER HIGH FINE PARTICULATE MATTER CONCENTRATION NEGATIVELY MODULATES BRACHIAL ARTERY FLOW-MEDIATED DILATION RESPONSE TO ITS PHYSIOLOGICAL STIMULUS**

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INTRODUCTION: Fine particulate matter (PM2.5) is one of the air pollutants attracting global attention recently. High-level PM2.5 introduced into human body has a negative effect on vascular endothelial function by increasing both local and systemic oxidative stress and inflammation. Regular aerobic exercise plays a critical role in improving brachial artery flow-mediated dilation (FMD), a validated non-invasive measure of human vascular endothelial function. However, the effect of aerobic exercise under high PM2.5 concentration on vascular endothelial function has not been clearly elucidated. Thus, the purpose of this study was to investigate the effect of moderate intensity aerobic exercise under high PM2.5 level on brachial artery FMD in young adults.
METHODS: A randomized crossover research design allowed seven young men (25±1 yrs) to perform 30 minutes of treadmill running at 70% of peak heart rate under both high PM2.5 (HPM) and low PM2.5 (LPM) conditions (57±1 vs. 7±1 μg/m3, P=0.002, HPM vs. LPM). To assess participants' vascular endothelial function, we measured brachial artery FMD using Aloka Prosound α7 ultrasound system and FDA-approved Quipu Cardiovascular Suite analysis software.
RESULTS: Compared to pre-exercise measures, there were no significant changes in both absolute FMD (0.29±0.05 vs. 0.29±0.05 mm, P=0.5, pre vs. post) and relative FMD (8.05±1.41 vs. 7.80±1.50 %, P=0.338 pre vs. post) responses to the aerobic exercise in HPM condition. Interestingly, FMD adjusted for shear rate area under the curve (FMD to SRAUC) was significantly decreased after the aerobic exercise only in HPM condition (0.14±0.02 vs. 0.10±0.02 a.u., P=0.02, pre vs. post). In LPM, absolute and relative FMD, and FMD to SRAUC did not change after the aerobic exercise (P >0.201).
CONCLUSION: Moderate intensity aerobic exercise under HPM level may adversely influence on FMD response to its physiological stimulus even in healthy young adults.

**SYNERGISTIC EFFECT OF ACUTE SELF-PACED RUNNING AND SOCIAL CONNECTION ON CIRCULATING ENDOCANNABINOIDS LEVEL AND AFFECT: A RANDOMIZED AND COUNTERBALANCED CROSSOVER TRIAL**

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INTRODUCTION: The number of patients with psychiatric disorders such as depression is increasing, and these diseases are suggested to difficult to completely cure. Although exercise itself might work as a primary prevention of depression, it is unclear the situation where to be done is optimal. The aim of this study was to investigate the synergistic effects of exercise and social connection during exercise on blood endocannabinoid (eCB) level and affect.
METHODS: Twelve young males participated six 20-min experimental trials: resting alone (1R), paired resting (2R), paired resting with cooperative task (2Rtask), exercise alone (1E), paired exercise (2E), and paired exercise with cooperative task (2Etask). The exercise consisted of a 20-minute submaximal treadmill running at the intensity that the participants felt comfortable. 2R and 2E trials allowed the participants to verbal and nonverbal communication during each trial. In cooperative tasks (2Rtask and 2Etask) promoting active and deeper interaction between 2 participants, one monitored the others heart rate (HR) and instructed to maintain HR within target HR range (2Rtask, + 5 bpm of resting HR; 2Etask, ± 5 bpm of 50% HR reserve), and vice versa.
Before and immediately after experimental trial, plasma concentrations in eCB, namely anandamide (AEA) and 2-arachidonoylglycerol (2-AG) were measured, and affect state was also evaluated by the physical activity affect scale consisting of four subscales: positive affect, negative affect, fatigue, and tranquility.
RESULTS: The average running speed in 2Etask (7.8 ± 1.1 km/h) was significantly lower than those in 1E (9.1 ± 1.1 km/h, p = 0.02) and 2E (8.7 ± 0.9 km/h, p = 0.03). However, no significant differences were observed in the rating of perceived exertion between three exercise trials (1E, 2E, and 2Etask). Two-way analysis of variance for changes in plasma AEA and 2-AG concentrations revealed significant main effects of exercise ($p < 0.01$, $p < 0.001$, respectively), but not in the main effect of social connection. With respect to the difference in affect state before and after experimental trial, significant main effects of exercise were observed in "fatigue" ($p = 0.04$) and "tranquility" ($p < 0.001$).
CONCLUSION: Although the present study demonstrated that circulating eCB level was significantly increased by a 20-min moderate comfortable exercise intervention, there was no synergistic effect of exercise and social connection. However, communicative cooperative task during exercise might facilitate eCB secretion even if the intensity of the exercise is relatively low.

**SCALING PEAK OXYGEN CONSUMPTION IN FONTAN PATIENTS**

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INTRODUCTION: Peak oxygen consumption (peak V̇O2) is traditionally divided ('ratio-scaled') by body mass (BM) for clinical interpretation. Yet, it is unknown whether ratio-scaling to BM can produce a valid size-independent expression of peak V̇O2 in people with a Fontan Circulation. Furthermore, people with a Fontan circulation have deficits in lean mass and increased fat mass, and it is unexplored whether using measures of body composition may improve scaling validity. The objective was to assess the validity of scaling peak V̇O2 to BM and fat free mass (FFM), using ratio and allometric scaling.
METHODS: METHODS: Eighty-nine participants (age: 23.3 ± 6.7 y; 53% female) with a Fontan circulation had their cardiorespiratory fitness and body composition measured by cardiopulmonary exercise testing and dual-energy X-ray absorptiometry. Ratio and allometric (log-linear regression) scaling was performed and Pearson correlations assessed scaling validity.
RESULTS: Results: Peak V̇O2 relative to BM (mL·kg-1·min-1) was significantly negatively correlated to BM and fat mass in both males and females (BM males, r=-0.34, BM females, r=-0.4, P<0.05; Fat mass males r=-0.52, fat mass females r=-0.46, P<0.01). However, peak V̇O2 relative to FFM (mL·kg-1·min-1) was not correlated to FFM or fat mass in both sexes (r range 0.01 to 0.08, P>0.6). Allometrically expressed peak V̇O2 resulted in no significant correlation to any scaling denominator (R2=0.03).
CONCLUSION: Conclusion: The traditional and accepted method of ratio-scaling peak V̇O2 to BM is invalid as it fails to create a size-independent expression of peak V̇O2 in people with a Fontan circulation. However, ratio-scaling to FFM creates both a size and body com-

position independent expression of peak V̇O2 in people with a Fontan circulation. Allometric scaling techniques also produced size-independent expressions of peak V̇O2 regardless of the body size variable used.

### IBUPROFEN INTAKE BEFORE INTENSE ENDURANCE EXERCISE INCREASES INTESTINAL DAMAGE OF HEALTHY MALE ATHLETES IN THE AGE GROUP OF 18 - 40 YEARS: A RANDOMIZED, PLACEBO-CONTROLLED CROSSOVER STUDY

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INTRODUCTION: It is well known that strenuous endurance exercise increases intestinal permeability, a phenomenon known as leaky gut associated with gastrointestinal discomfort and compromised performance [1]. On the other hand, non-steroidal anti-inflammatory drugs such as ibuprofen (IBU) are widely consumed by athletes to relieve pain or to increase pain tolerance [2], whereby negative consequences on gastrointestinal integrity cannot be excluded. The aim of the current study was to determine the effect of oral IBU administration before exercise on markers of intestinal damage, inflammation and performance.
METHODS: Eleven male participants with a mean (±SD) age of 28.6 (±5.5) yrs and a rel VO2peak of 53.0 (±5.2) $ml \cdot min^{-1} \cdot kg^{-1}$ were randomly assigned to one of two treatment orders (placebo-IBU or IBU-placebo) with a wash-out period of at least 7 days. At both testing days, participants had to run for 45 min at 75% of their individual VO2peak on a treadmill followed by a 5% increase of running velocity every 2 min until exhaustion. One hour before the respective exercise, participants received either a placebo or IBU (400 mg), whereby participants and assessors were blinded to the treatments. To assess small intestinal injury and inflammation, intestinal fatty acid binding protein (I-FABP) levels and immune parameters were determined pre as well as 0, 1, 3, 24 h post exercise from venous blood. A two-factorial ANOVA was used to assess treatment and time effects as well as treatment×time interactions.
RESULTS: A significant treatment×time interaction was detected for I-FABP ($F(2.06, 20.59) = 3.83$, $p = 0.037$, partial $\eta^2 = 0.277$), whereby the exercise-induced increase in I-FABP levels were higher after IBU intake at 0 ($p = 0.005$) and 3 h ($p = 0.011$) post exercise. Leukocytes increased significantly over time ($F(2.04, 22.47) = 32.94$, $p < 0.005$, partial $\eta^2 = 0.750$) returning to baseline 24 h post exercise with no differences between treatments. Interestingly, IBU intake resulted in 1.5 (± 0.8) min longer time to exhaustion ($p=0.019$) with a lower rating of perceived exertion at 15, 30 and 45 min of running (all time points $p<0.05$).
CONCLUSION: As hypothesized, even a single low-dose dose of 400 mg IBU may have a negative effect on the human gastrointestinal barrier as measured by damage to the intestinal epithelium despite slightly increasing time -to- exhaustion, potentially through lowering perceived exertion. The extent to which chronic use, higher doses and the intensity, duration or type of activity might influence this effect must be clarified in further studies.
References:
[1] Lundberg, TR, et al., Scand J Med Sci Sports, 2018. 28(11): p.2252–2262.
[2] Ribeiro FM, et al., Front Nutr, 2021. 8: p.627289.

### THREE MONTHS OF NORDIC WALKING: EFFECTS ON ANTHROPOMETRIC, BODY COMPOSITION AND FUNCTIONAL PARAMETERS IN THE NONCLINICAL POPULATION

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INTRODUCTION: Nordic Walking (NW) is an outdoor physical activity performed with the use of specific poles, which is easily accessible. NW does not require expensive equipment, special skill or special facilities and it can be practiced by anyone. In addition, several research suggest that performing outdoor physical activity have additional benefits, such as restoration from stress and mental fatigue [1,2]. The effects of NW in the nonclinical population were little studied, because it usually proposed for elderly and clinical population. So, the aim of the present study was to examine the effects of three months of NW training in a group of middle-aged people, without chronic diseases, on anthropometric, body composition and functional parameters.
METHODS: A pre-test/post-test study design was conducted on seventy-seven participants: 56 women (72.7%), with a mean age of 55.53±9.73 years, and 21 men (27.3%), with a mean age of 60.51±8.15 years. Anthropometric measurements (height, weight, skinfolds and circumferences), body composition and with three physical tests (handgrip, 30" squat test and six minutes walking test) were assessed. The baseline measurements were carried out in February 2021, while the follow up in June 2021. The participants did two weekly NW training sessions of about 60 minutes each. A questionnaire was administered to evaluate the attitude and the feels after the training period. Paired Students' test was carried out to value the pre-post differences and the analysis of variance was performed to evaluate the answers to the questionnaire.
RESULTS: Men and women showed different results with respect to the proposed activity period: women presented a significant decrease in fat parameters, as skinfolds, calf area, fat mass and percentage of fat mass and hip circumference. In addition, the arm muscle area increased. Men showed a significant decrease only in the subscapular skinfold, in fat mass and percentage of fat mass. Both women and men presented a significant increase in lower body strength, and women also showed an increase in the six minutes walking test. The phase angle presented a significant increase in both sexes after the period of training. Finally, participants showed a decrease of anxiety and stress after the activity.
CONCLUSION: NW has several potential benefits for the nonclinical population. In fact, it influences the resistance, the lower body strength and body composition. The popularity of this sport is increasing, because it answers two human needs: the possibility to easily perform physical activity and the contact with the green space. For these reasons, it would be important encourage people of all ages to practise this sport.
1.Pretty, J.; Griffin, M.; Sellens, M.; Pretty, C. Green Exercise Complementary Roles of Nature, Exercise and Diet in Physical and Emotional Well-Being and Implications for Public Health Policy. University of Essex 2003.
2.Hartig, T., Mang,M; Evans, GW. Restorative Effects of Natural Environment Experiences. Sage Pub 1991.

## CP-PN05 Women/metabolism

### CHANGES IN ANDROGEN PROFILE OVER THE MENSTRUAL CYCLE IN PHYSICALLY ACTIVE WOMEN

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INTRODUCTION: Eumenorrheic women experience fluctuating levels of female sex hormones during the menstrual cycle (MC). Regrettably, research regarding changes in androgen profiles over the MC in physically active women is limited. Therefore, we examined changes in androgen concentrations over four pre-determined MC phases of physically active women.
METHODS: Thirty-six healthy, trained (tier 2) [1], naturally menstruating women [2] (age 26±4 y, height 1.67±0.06 m, weight 64.7±7.1 kg, fat percentage 23.5±6.5%, and VO2max 44.9±5.5 ml·kg-1·min-1) participated in this study. Blood samples were collected at bleeding (days 2-4), mid-follicular (mid FOL, 7-11 days from the onset of bleeding), ovulation (OV, 1-2 days after positive ovulation test) and mid-luteal (mid LUT, 7 days after positive ovulation test). Ovulation was confirmed using daily urine tests (luteinizing hormone (LH)) completed by the participants. Estrogen (E2), progesterone (P4), total testosterone (tT), free testosterone (fT), sex hormone-binding globulin (SHBG), dehydroepiandrosterone (DHEA) and its sulphate (DHEA-S) were analyzed from serum. Statistical analyses were conducted using repeated measures ANOVA with Bonferroni as post-hoc.
RESULTS: Serum concentrations of E2 were significantly higher at mid FOL ($p<0.05$), OV ($p<0.001$) and mid LUT ($p<0.001$) compared to bleeding. Ovulation was detected in all included participants whereas serum concentrations of P4 were significantly higher at mid LUT ($p<0.001$) compared to bleeding. However, only 21 participants had serum P4 concentrations >16 nmol·l-1 at mid LUT [2]. Concentrations of tT were significantly higher at OV than at bleeding ($p<0.05$) and mid FOL ($p<0.05$). Concentrations of fT were highest at OV being significantly different from bleeding ($p<0.001$), mid FOL ($p<0.05$), and mid LUT concentrations ($p<0.01$). DHEA concentrations were significantly higher at OV than at bleeding ($p<0.05$) while DHEA-S and SHBG concentrations remained unchanged throughout the MC.
CONCLUSION: Serum concentrations of E2 and P4 mimicked hormonal fluctuation expected during the MC. Despite positive urinary ovulation tests, serum concentrations of P4 remained lower than anticipated in 42% of participants during mid LUT, suggesting that our timing for blood sampling was not optimal or luteal phase defect possibly existed [3]. Concentrations of tT, fT and DHEA appeared to be highest at ovulation. Endogenous hormonal milieu, including androgens in women, may have implications for training responses and adaptations. As such, investigating the concurrent changes in female sex hormones and androgens may improve our understanding of mechanisms behind training adaptations in women.
References:
1. McKay AKA et al. (2022). Int J Sports Physiol Perform. 17(2): 317-331.
2. Elliott-Sale KJ et al. (2021) Sports Med. 51(5): 843-861.
3. Allaway HC et al. (2016) Horm Mol Biol Clin Investig. 25(2): 91-119.

### EFFECTS OF MENSTRUAL CYCLE PHASE ON WORKLOAD, RECOVERY AND STRESS IN ELITE FEMALE FIELD HOCKEY PLAYERS: A PILOT STUDY.

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INTRODUCTION: The hormonal fluctuations during the phases of the menstrual cycle (MC) have an impact on female athletes' self-reported physical fitness and performance (1) and they also lead to changes in mood and fatigue (2). Female athletes perceive their worst state of fitness and performance during bleeding, the early follicular phase (EFP), while their perceived best state of fitness and performance is in the late follicular phase (LFP) (1). In contrast to that, the physiological ability to recover after exercise is better in the luteal phase (LP) compared to the EFP (3).
METHODS: In total eight female German national field hockey players (17.0 ± 1.8 years; 164.5 ± 7.7 cm; 54.3 ± 4.4 kg) were included in this pilot study. They were not using hormonal contraceptives and had a regular MC (26.9 ± 3.2 days cycle length; 3.8 ± 0.9 days bleeding length). The phases of the MC were determined with a menstrual bleeding calendar. Based on the self-reported menstrual bleeding days, the MC was divided by the calendar method into three phases: EFP, LFP and LP. To assess individuals' acute recovery and stress levels the psychometric Short Recovery and Stress Scale for Sport (SRSS) was filled-in every morning (4). To assess their daily physical workload the Acute: Chronic Workload Ratio (ACWR) was used (5). A one-way repeated measures ANOVA was used to detect differences in means within the MC phases ($p< 0.05$).
RESULTS: No significant changes in the SRSS states and the ACWR (EFP 1.0 ± 0.3; LFP 1.0 ± 0.3; LP 1.1 ± 0.1) across MC phases were observed ($p > 0.05$). However, athletes' states of physical (EFP 4.1 ± 1.0; LFP 4.2 ± 0.8; LP 4.3 ± 0.8), mental (EFP 4.1 ± 0.4; LFP 4.3 ± 0.8; LP 4.3 ± 0.6) , emotional (EFP 4.3 ± 0.7; LFP 4.6 ± 0.9; LP 4.4 ± 0.8) and overall recovery (EFP 4.0 ± 0.7; LFP 4.3 ± 0.6; LP 4.1 ± 0.8) tended to be higher in the LFP, while the states of physical (EFP 1.4 ± 0.7; LFP 1.3 ± 0.5; LP 1.5 ± 0.7), mental (EFP 1.8 ± 0.7; LFP 1.5 ± 1.1; LP 1.7 ± 0.9), emotional (EFP 1.5 ± 1.1; LFP 1.0 ± 0.6; LP 1.3 ± 0.6) and overall stress (EFP 1.8 ± 0.6; LFP 1.4 ± 0.5; LP 1.8 ± 0.7) tended to be lower in the LP.
CONCLUSION: There is no significant effect of MC phase on workload and the acute states of recovery and stress in elite female field hockey players. However, the athletes have a higher states of recovery and a lower states of stress in the LFP than in the EFP and the LP. Especially the emotional and overall states of recovery and stress tend to be more sensitive to MC phases.

### MARKERS OF IRON STATUS AND HEAVY MENSTRUAL BLEEDING IN TRAINED FEMALES – A PILOT STUDY

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INTRODUCTION: Trained females are prone to iron deficiency due to exercise-induced iron loss, menstrual bleeding, and insufficient dietary iron [1], where 24–47% of exercising women experience iron deficiency in the absence of anemia [2]. Regrettably, research regarding iron status and heavy menstrual bleeding (HMB) in trained eumenorrheic women and hormonal contraceptive users is limited. Therefore, the purpose of this study was to investigate changes in markers of iron metabolism (ferritin, hemoglobin, and hematocrit) and self-reported HMB over one menstrual or hormonal contraceptive cycle.
METHODS: Blood samples were collected from trained (tier 2 [3]) women in two groups including naturally menstruating (NM, n=16) women and women using combined monophasic hormonal contraceptives (HC, n=12). Characteristics for NM: age 26±4 y, height 167±6cm, weight 67.0±7.6kg, fat percentage 21.8±6.6%, VO2max 44.1±5.8 ml·kg-1·min-1 and HC: age 23±3 y, height 170±5cm, weight 61.0±4.3kg, fat percentage 19.2±3.2%, VO2max 44.1±4.8 ml·kg-1·min-1. Measurements were conducted in NM at bleeding (days 2-4), mid-follicular (mid FOL, 7-11 days from the onset of bleeding), ovulation (OV, 1-2 days after positive ovulation test) and mid-luteal (mid LUT, 7 days after positive ovulation test) and in HC at bleeding/placebo (days 22-28), the beginning (day 8) and middle of hormone taking (day 15), and the beginning of placebo (days 21-24). Analyses were performed using repeated measures ANOVA with Bonferroni post-hoc and independent samples t-tests.
RESULTS: Ferritin, hemoglobin, and hematocrit did not fluctuate significantly over the experimental period in either group. HMB was reported in 69% of NM and 59% of HC while 25% of NM and 27% of HC had mean ferritin (over 4 measurements) <30 µg·L-1 indicating iron deficiency. NM with HMB had lower average ferritin across their menstrual cycle ($p < 0.05$) than those not reporting HMB whereas HC users reporting HMB and not reporting HMB had similar ferritin levels.
CONCLUSION: Serum ferritin, hemoglobin, and hematocrit remained stable over one menstrual/hormonal contraceptive cycle. No statistically significant between-group differences were observed between any variables. Lower average ferritin was observed in NM participants reporting HMB than those not reporting HMB while no differences were observed between HC users. These findings may reflect the reported beneficial effects of hormonal contraceptive use on serum ferritin [4]. As the investigated variables did not fluctuate over one menstrual/hormonal contraceptive cycle, longer follow-up research may be needed to elucidate the relationships between iron status and HMB including the possible influence of hormonal contraceptive use.
REFERENCES:
1. Petkus D et al. (2017). Sports Med, 47(9), 1721-1737.
2. Rowland T. (2012) Am J Lifestyle Med. 6(4):319–27.
3. McKay AKA et al. (2022). Int J Sports Physiol Perform. 17(2), 317-331.
4. Milman N et al. (1992). Ann Hematol. 65(2), 96-102.

### EFFECT OF IRON SUPPLEMENTATION ON EXERCISE PERFORMANCE OF WOMEN WITH IRON DEFICIENCY OR ANEMIA - A SYSTEMATIC REVIEW.

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INTRODUCTION: Female athletes have athletic performance impaired by iron deficiency or anemia. It is important that appropriate iron supplementation be prescribed, to improve womens health and physical performance. The aim of this review was to determine the effect of iron supplementation on exercise performance of women with iron deficiency or anemia.
METHODS: Pubmed, Web of Science, LILACS, SciELO, and Scopus databases were searched using specific Medical Subject Headings terms for clinical studies that enrolled women in an iron supplementation intervention. Athletic performance was considered as the primary outcome. PROSPERO registration ID: CRD42021245452.
RESULTS: A total of 253 studies were identified. However only 26 studies met the eligibility criteria. Twenty-five studies were randomized, placebo-controlled trials (15 double-blind; 2 single-blind, including 1 crossover; 8 did not inform blinding, including 1 crossover). One study was a randomized noncontrolled by placebo trial (blinding not informed). A total of 1179 women were included in the studies (610 allocated to treatment groups and 538 to control groups; one study did not inform participants distribution), aged 9-55 years. Sixteen studies (61,5%) showed positive effects on performance (improved time to complete time trials or treadmill endurance time; increased number of steps climbed or strength exercise repetitions) or its predictors (higher VO2max/VO2peak; lower lactate concentration, submaximal VO2, heart rate), along with unchanged results or improvement without significant differences when compared to controls (submaximal VO2, VO2max/VO2peak, lactate concentration, energy expenditure, ventilatory threshold, heart rate, work rate, muscle fatigue, strength, time to exhaustion, time to complete time trial). Three studies (11,5%) reported only positive results (improved VO2max, running time). Seven studies (27%) reported only unchanged results or improvement without significant differences when compared to controls (Wingate test, speed test, and repeat sprints performances, time to exhaustion, VO2max, lactate concentration). Iron supplementation related to positive results (18 studies, 95%) was mainly characterized by oral ingestion of 50-1135 mg $FeSO_4$, for 2 weeks to 1 year. Thirteen studies (72%) supplemented 10-135 mg elemental iron/day for 6-8 weeks (total supplementation of 420-7560 mg elemental iron), and 16 (84%) involved women aged 17-25 years. Women with improved performance were sedentary/untrained (7 studies), physically active (5), well trained athletes (2), or elite athletes (2). Two studies did not inform participants' training status. Finally, they were anemic (2 studies), anemic or iron deficient (2), nonanemic iron deficient (11), and non-deficient, iron deficient or anemic (4).
CONCLUSION: Despite the great variety of study designs, most studies show physical performance improvement of iron deficient or anemic young women of different training status, following oral iron supplementation.

### LOWER SYMPTOMS OF DISORDERED EATING AND TRAINING BEHAVIOUR AND DEPRESSION IN NATIONAL TEAM GYMNASTS COMPARED TO HEALTHY CONTROLS.

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INTRODUCTION: Compulsive Exercise (CE) is characterised by excessive and increasing training loads, abstinence without training and an inability to reduce exercise amounts. In females CE is often associated with disordered eating behaviour (DE). Potential harmful consequences are injuries, depression and impaired social relations. Studies comparing the prevalence of CE, DE and depression among aesthetic

athletes and healthy controls are scarce. We therefore aimed to investigate CE and DE among individual and team national team gymnasts and healthy controls.
METHODS: 94 gymnasts (52 females, 42 males) aged 19 ± 4 years were recruited from the Swedish national team (team gymnastics n=53 and individual disciplines n=41). Controls consisting of 159 non-elite athletes (79 females, 80 males) aged 18 ± 4 were recruited from Swedish high schools and universities. The participants filled out a questionnaire comprising of the Eating Disorder Inventory (EDI) including subscales Bulimia, Drive for Thinness (DT), Body Dissatisfaction (BD), the EDI total score, Compulsive Exercise test (CET), and Montgomery Åsberg Depression Rating Scale-Self (MADRS-S).
RESULTS: EDI total score (15.1 ± 13.8 vs. 21.4 ± 17.5, p=0.003), BD (8.3 ± 6.8 vs. 11.6 ± 8.5, p = 0.002), and Bulimia (2.0 ± 3.4 vs. 3.6 ± 5.1, p = 0.004) scores were lower among gymnasts than controls, as well as MADRS-S (8.7 ± 6.6 vs. 11.8 ± 8.7, p=0.007) and CET (25.1 ± 8.8 vs. 50.7 ± 17.7, p < 0.001) scores. No difference in DT score was observed between groups. Gymnasts were less likely to have high scores of total EDI [OR 0.33, 95% CI (0.13-0.84)] and CET [OR 0.033, 95% CI (0.017 - 0.067)], as well as to moderate or severe depression [OR 0.31, 95% CI (0.12 - 0.77)] than controls. Gymnasts from team disciplines were more likely to report high CET score [OR 4.12, 95% CI (1.09 – 15.59)] than gymnasts in individual disciplines, where 13 vs. 3 had high CET score. Among gymnasts, total CET score was positively associated with total EDI score (r=0.516, p<0.001), and MADRS-S (r=0.254, p=0.014).
CONCLUSION: CE was associated with EDI and MADRS-S scores, but in this group of healthy national team gymnasts, gymnasts had lower symptoms of DE, CE and depression compared with controls, while gymnasts competing in individual disciplines were less likely to suffer from CE than team gymnasts.

**LOW-LOAD RESISTANCE EXERCISE INDUCES SIMILAR RESPONSES ON HUNGER SENSATION, GUT HORMONES, AND LACTATE AS MODERATE-LOAD RESISTANCE EXERCISE IN YOUNG HEALTHY MEN**

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INTRODUCTION: Continuous aerobic exercise on the hunger sensation have been widely explored, nevertheless the influence of resistance exercise (RE) with different variables, including training loads, training volume, and inter-set rest, on appetite responses requires further investigation. The study aimed to determine the importance of training load in RE-induced appetite suppression; total training volume and inter-set rest were equalized.
METHODS: In total, 11 healthy young men (mean ± SD age 23 ± 2 years, body mass index 22 ± 2 kg/m2) were included. Participants completed three trials, including moderate-load RE (MOD; 4 sets of 8 repetitions at 85% 8RM), low-load RE (LOW; 4 sets of 15 repetitions at 45% 8RM) and a control (CON; no exercise), in a randomized, crossover design. Subjective appetite ratings, ghrelin, peptide YY (PYY), lactate, and the autonomic nervous system were evaluated pre-exercise and during post-exercise 1 hour.
RESULTS: Area under the curve (AUC) of hunger and predicted food consumption ratings, and ghrelin levels during the trial period were significantly lower in MOD and LOW (p < 0.05 vs. CON). AUC of PYY and lactate levels during the trial period were significantly higher in MOD and LOW (p < 0.05 vs. CON). No difference was observed between MOD and LOW (p > 0.05). Changes in lactate was negatively associated with AUC of ghrelin (r = -0.565, p = 0.001) and hunger ratings (r = -0.470, p = 0.006). Slower recovery of heart rate variability recovery was observed in MOD.
CONCLUSION: These findings suggest that MOD and LOW with equal training volume and inter-set rest induces similar responses on hunger suppression and orexigenic signals, except for slower recovery of autonomic modulation after MOD.

**EFFECT OF VO2MAX ON BASELINE SERUM LACTATE AND BETA-ENDORPHIN LEVELS IN MALE BODYBUILDERS USING ANABOLIC STEROIDS, NON-USERS AND NON-BODYBUILDERS**

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INTRODUCTION: Volume oxygen maximum is the maximum rate of oxygen consumption during strenuous exercise and a measure of physical fitness. Lactate accumulation occurs when anaerobic metabolism predominates. Exercise of sufficient intensity stimulates Beta Endorphin release in the blood. There is a difference of opinion among researchers on the intensity of exercise needed to cause endorphin release and the role of lactate. The use of anabolic steroids is increasing globally, particularly among bodybuilders hypothesized to affect body systems.
METHODS: This cross-sectional study was conducted at the exercise physiology laboratory at the Postgraduate Medical Institute, Lahore, Pakistan. The study involved 30 healthy male subjects (20 to 30 years) recruited through convenience non-probability sampling. The study population included 3 groups: Group I (non-bodybuilders), Group II (bodybuilders not using anabolic steroids), and Group III (bodybuilders using anabolic steroids). All participants underwent a graded exercise test on cardiopulmonary exercise testing (CPET) equipment up till exhaustion for VO2max assessment. Blood sampling was done pre and post-exercise (80% of VO2max) to measure blood lactate and beta-endorphin levels. Data were analyzed by SPSS version 23. Paired t-test, ANOVA, and Pearson were applied. p-value <0.05 taken statistically significant.
RESULTS: Bodybuilders achieved a significantly higher VO2max as compared to non-bodybuilders (43.4 ± 4.2ml/min/kg, 35.4 ± 4.8 ; p <0.001) respectively. Anabolic steroids using bodybuilders showed a significantly lower VO2max compared to non-users (38 ± 3.1ml/min/kg, 43.4±4.2 ml/min/kg ; p = 0.016) respectively. No statistically significant difference was seen in the respiratory exchange ratio among groups both at rest (0.9 ± 0.1 , 0.8 ± 0.1, 0.83 ± 0.1 ; p = 0.148) and at max (1.2 ± 0.1 , 1.1 ± 0.1 , 1.1± 0.1 ; p = 0.097). Minute ventilation showed a non-significant difference between the three study groups( 98.6 ± 38.2 , 121.6 ± 18.2 , 109 ± 15.3 ; p = 0.103) . Blood lactate and beta-endorphin levels increased significantly in all the three study groups at an exercise intensity of 80% of VO2max (p <0.001). A non-significant difference in blood lactate levels was found between anabolic steroids using bodybuilders and non-users (3.75 ± 0.3 , 4.00 ± 0.6 ; p = 0.756). Beta-endorphin levels were found to be significantly lower in anabolic steroid users than in non-users (26.4±10.0 , 40.4±12.8 ; p = 0.029). There was a significant positive correlation found between blood lactate and beta-endorphin levels post-exercise, r (28) = 0.31, p = 0.05.
CONCLUSION: Exercise intensity of 80% of VO2max is sufficient for the significant increase in blood lactate and beta-endorphin levels in bodybuilders using anabolic steroids, non-users, and non-bodybuilders. Exogenous steroid intake blunts the release of exercise-induced beta-endorphins. Acidosis caused by lactate accumulation is likely to contribute to an increase in beta-endorphins.

## Conventional Print Poster

### CP-BM03 Biomechanics of the knee

**ALTERATIONS IN LOWER-LEG FUNCTION AND BIOMECHANICS IN ATHLETES AND RUNNERS WITH ACHILLES TENDINOPATHY: A SYSTEMATIC REVIEW**

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INTRODUCTION: Achilles tendinopathy (AT) is a persistent injury in athletes, especially for those engaged in repetitive stretch-shortening cycle activities such as running. Clinical risk factors are numerous, but it has been suggested that altered biomechanics might lead to or be associated with the development of AT. No systematic review has been conducted investigating these biomechanical alterations in specifically athletic populations. Therefore, the aim of this systematic review was to synthesise research comparing the lower-limb biomechanics of athletes with AT to asymptomatic controls.
METHODS: MEDLINE, Web of Science and Cochrane were searched in March 2021 for relevant studies investigating biomechanics and neuromuscular performance during gait activities and other motor tasks such as hopping, isolated strength tasks, and reflex responses. Inclusion criteria for studies were an AT diagnosis in at least one group, cross-sectional or prospective data, a minimum of one outcome comparing biomechanical data between an AT and healthy group, and athletic populations (e.g., run >20km / week). Studies were excluded if patients had Achilles tendon rupture/surgery, participants reported injuries other than AT, and when only within-subject data was available (e.g., no healthy control group). Search terms were based on four key areas: “Biomechanics”, “Movement Task”, “Pathology (Tendinopathy)” and “Anatomical Location (Achilles tendon)”. Effect sizes (Cohen’s d) with corresponding 95% confidence intervals were calculated for relevant outcomes.
RESULTS: The initial search yielded 4442 studies. After screening, twenty studies (775 total participants) were synthesised, reporting on a wide range of biomechanical outcomes. Females were generally under-represented and patients in the AT group were 3 years older on average. Biomechanical alterations were identified during running, hopping, jumping, strength tasks and reflex activity, with small to large effect sizes. Kinematics in AT patients appeared to be altered during stretch-shortening activities of the lower limb, indicating a pattern of “medial collapse” e.g., increased hip adduction/ ankle pronation. Muscular activity of the calf and hips was different between groups, whereby in two studies AT patients exhibited greater calf muscle EMG amplitudes despite lower plantar flexor strength. Overall, dynamic maximal strength of the plantar flexors, and isometric strength of the hips might be reduced in the AT group. One study indicated an up-regulated reflex activity with AT.
CONCLUSION: In summary, this systematic review reports on several biomechanical alterations in athletes with AT. These factors may form potential treatment targets, although this needs further research and clinical approaches should additionally take other contributing health factors into account. Based on the cross-sectional design of most studies, it is difficult to discern whether these factors are causative or consequential of AT.

**BIOMECHANICAL ANALYSIS OF THE PATTERNS OF FEMALE FUTSAL PLAYERS WITH AND WITHOUT KNEE PAIN, ACCORDING TO LATERALITY. CROSS-SECTIONAL STUDY.**

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INTRODUCTION: The incidence of knee injuries, especially anterior cruciate ligament injuries, in womens soccerl is very high and higher than in mens soccer, being an injury with a long time off work and a high recurrence rate (1). The identification of risk factors is key to the design of specific prevention programmes. Futsal, by incorporating the ball, conditions the motor pattern in the dominant leg (PD) and non-dominant leg (PND) (2).
METHODS: A sample of 16 female futsal players (23,94 ± 5,03 years) was selected. They were divided into two groups: knee pain (DR) and no knee injury (SL) subdivided into PD and PND. A 3D capture system consisting of 12 infrared cameras (Qualisys A.B, Gotegorg, Sweden) was used. Visual3D software was then used to create an 8-segment biomechanical model for the calculation of biomechanical variables. A pressure platform system was used to detect the peak torque of the braking reaction force. Specific tests were performed. A contrast of variables according to laterality was performed classifying by groups, KP and NI using Students t-test and an analysis of the effect size using Cohens d. A 95% confidence level was established.
RESULTS: Eight KP players and eight NI players were analysed. The contrast by laterality did not reach significant results, although relevant differences appeared when analysing the effect size. Both KP and NI players had more knee valgus in PD (d=1.19 , d=0.73), with a higher mean valgus in KP players (-10.58 ± 5,64) than in NI players (-8.87 ± 8,45). In the hip, both groups presented different biomechanics. KP players tended towards internal rotation (IR) in PD versus external rotation (ER) in PND (d=0.77). The NI tend towards ER in both hips, being greater in PD than in PND (d=0.77).
CONCLUSION: In both groups, KP and NI, there could be differences between the biomechanical pattern of PD and PND, corroborating the difference of roles in futsal. But being different patterns, in KP players the PD tends towards joint injury, while in NI players it would be the PND that presents worse control, although without reaching risk positions.
REFERENCES
1. Ruiz-Pérez I, López-Valenciano A, Jiménez-Loaisa A, Elvira JLL, de Ste Croix M, Ayala F. Injury incidence, characteristics and burden among female sub-elite futsal players: a prospective study with three-year follow-up. PeerJ. 2019;7:7989.
2. Arundale AJH, Bizzini M, Giordano A, Hewett TE, Logerstedt DS, Mandelbaum B, et al. Exercise-based knee and anterior cruciate ligament injury prevention. J Orthop Sports Phys Ther. 2018;48(9):A1–25.

**DIFFERENT STRATEGIES IN PERFORMING A CUTTING MANEUVER ARE ASSOCIATED WITH THE BIOMECHANICAL RISK FACTORS FOR ACL INJURY**

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INTRODUCTION: The number of females participating in sport and exercise is increasing (1). Many studies are focused on risk factors for anterior cruciate ligament (ACL) injury during cutting maneuver, particularly in female participants. ACL rupture is more common in females more than males (2). The findings of current studies (3; 4; 5; 6) in relation to ACL injury during cutting maneuvers are focused on the knee adduction moment, knee flexion, menstrual cycle, laxity, and muscle activation. The results of these studies could be significantly affected by different strategies used to perform the cutting maneuver. However, there are no controlled studies which compare or evaluate different types of cutting maneuvers in relation to possible risk factors for ACL injury. Therefore, the purpose of this study was to compare biomechanical risk factors for ACL injury (knee adduction moment) according to different strategies of cutting maneuver used by females to accomplish the cutting task.
METHODS: Ninety-four females (age 23.0±3.8 yrs; height 167.7±6.2 m; mass 61.1±11.3 kg) performed two tasks: 1) a straight run; and 2) an unanticipated cutting maneuver, fully described previously (7). Five trials of cutting maneuvers for each female were qualitatively evaluated. We assessed foot position from the mid-line perspective of the left foot before force platform and subsequent step of the right foot on force platform. From the first 30% of stance phase the maximum of knee internal adduction moment was identified and normalized to body weight and approach velocity.
RESULTS: We defined four types of cutting maneuver and the mean values with standard deviation for adduction moments: 1) left foot without cross-over and the right foot without cross-over, 14.1±8.0 Nm·s·kg-1·m-1; 2) left foot without cross-over and right foot with cross-over, 5.3±3.7 Nm·s·kg-1·m-1; 3) left foot with cross-over and right foot without cross-over, 14.4±7.9 Nm·s·kg-1·m-1; and 4) left foot with cross-over and right foot with cross-over, 9.5±6.2 Nm·s·kg-1·m-1. The higher values of internal knee adduction moment for the different types of cutting maneuver were related to cutting maneuver without crossover of right foot.
CONCLUSION: Our results suggest that the main risk factor for ACL injury (e.g. knee adduction moment) may be different with regard to type of cutting maneuver. Cutting maneuvers without a crossover of right foot may be associated with an increased biomechanical loading of the ACL compare to other strategies for accomplishing cutting tasks in females possibly placing these females at risk for ACL injury.
REFERENCES
1) Elliott-Sale et al.,Sports Med,2021
2) Hewett,Sports Med,2000
3) Hanson et al.,J Athl Train,2008
4) Fedie et al.,Sports Biomech,2010
5) Pollard et al.,Clin Biomech,2006
6) Wojtys et al.,Am JSports Med,2002

**ANTERIOR CRUCIATE LIGAMENT INJURY IN YOUTH – IDENTIFYING MODIFIABLE RISK FACTORS FOR EFFECTIVE RISK REDUCTION IN 6- TO 13-YEAR-OLDS**

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INTRODUCTION: An anterior cruciate ligament (ACL) injury impacts an individuals' life forever. Along the actual injury, subsequent concerns include long-term health risk and large public health care costs. Growing ACL injury incidence levels are reported in developed countries for 5- to 14-year-olds yet research on injury risk reduction is focused on populations aged over 13 years. For successful early intervention and injury risk reduction, it is crucial to understand which modifiable risk factors are associated with ACL injury in youth aged 6 to 13 years and how they are examined.
METHODS: A rigorous scoping review was performed in five databases in August 2021 and included articles which examined modifiable risk factors of primary ACL injury in children aged 6 to 13 years. Articles were grouped according to sex and/or maturational and age differences and parameters extracted on modifiable risk factors during different physical screening tasks
RESULTS: Thirty-five included articles focused on intrinsic risk factors (97%) e.g., knee landing biomechanics or muscle strength, in 12-13-year-olds (81%). Assessment varied from muscle strength (22%), jump-landing tasks (49%) and motion capture (31%) to force plates (24%). Out of over 60 variables, seven variables had robust evidence (> 2 articles on the same physical screening task (e.g., drop vertical jump (DVJ))). Injury risk relevant variables in youth were knee flexion angle with decreased angles for males, knee joint moments with no sex difference, knee valgus/varus angle with increased valgus in older more mature participants but no difference between sexes, take-off force and concentric hamstring strength indicated no difference for age or maturational stage.
CONCLUSION: Research on youth (< 12 years) ACL injuries is limited to a small range of variables and physical screening tasks with robust evidence (> 2 articles on same risk factors at the same physical screening task). Variables, e.g., knee flexion angle, associated with increased ACL injury risk in adolescents and adults show relevance in youth aged 6-13 years. In contrast to findings in adolescents, smaller knee flexion angle, associated with increase ACL loading, were observed in males and not females during DVJ in youth. Indicating that injury risk in youth might differ from that after the onset of puberty, emphasising the unique needs of that age group.
This scoping review highlights, for the first time, the lack of evidence in youth ACL research in variables associated with increasing risk in adolescents and adults (e.g., knee adductor moment) in a range of physical screening task. The DVJ was predominantly used but has been criticised for not representing the actual injury mechanism and using more dynamic tasks such as unanticipated side-cutting (e.g., change in direction) has been proposed. Future research needs to focus on youth risk factors in tasks that reflect the actual injury mechanism to be able to plan effective interventions according to the needs of youth.

### CHARACTERISTICS OF LOWER EXTREMITY MUSCLE ELECTROMECHANICAL DELAY DURING AMATEUR ATHLETES AFTER ACL RECONSTRUCTION

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INTRODUCTION: Anterior Cruciate Ligament (ACL) reconstruction (ACLR) is a more common treatment for athletes after an ACL rupture (1). It has been suggested that the impact on neuromuscular control function due to ACLR is one of the causes of secondary injury (2). Electromechanical delay (EMD) is an index that can reflect the neuromuscular control of the target muscle precisely (3). There do not have many studies on EMD of lower limb muscles after ACLR in amateur athletes. This study aimed to investigate the EMD performance of quadriceps, biceps, and gluteus medius after ACLR in amateur athletes.
METHODS: Ten amateur athletes who were 24.7±4.47 years old and suffered from ACLR after 15.34±3.2 months were selected. Muscle strengths were collected using Isomed-2000 in isometric mode on the affected and healthy lower limbs in knee extension, flexion, and hip abduction, respectively. The surface electromyography (EMG) of the target muscles (quadriceps, biceps, and gluteus medius) were collected separately using Yunwei surface EMG instrument. During the test, subjects closed their eyes and performed isometric contractions of the target muscles immediately after receiving the sound signal to complete. Paired sample t-test in SPSS 25.0 was used to analyze the data.
RESULTS: The EMD of quadriceps, biceps, and gluteus medius on the healthy side was 50.6±19.03ms, 54.8±14.67ms, 87.6±31.03ms; on the injured side was 53.0±19.70ms, 57.0±15.68ms, 114.8±38.06ms. Statistical results showed a statistically significant difference in EMD between the healthy and the affected side of the gluteus medius ($p=0.022$, $p<0.05$).
CONCLUSION: In amateur athletes after ACLR, there is a difference in neuromuscular function between the healthy side and the affected gluteus medius, which may be one of the causes of knee instability.
REFERENCES:
(1) Marx RG et al., Arthroscopy, 2003
(2) Hewett TE et al., Am J Sports Med, 2013
(3) Ingersoll CD et al., Clin Sports Med, 2008

### ACL LAXITY AND ACHILLES STIFFNESS DURING THE EARLY FOLLICULAR AND MID-LUTEAL PHASES OF THE MENSTRUAL CYCLE

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INTRODUCTION: Previous studies have reported that the risk of musculoskeletal injury in women participating in sports is heightened during particular phases of the menstrual cycle (1). A systematic review found that women experience a substantially higher rate of ACL injuries during the first half of the menstrual cycle compared to the premenstrual phase (2). However, a systematic review with meta-analysis that concluded that ACL ligament's laxity increased during days 10-14 and 15-28 of the menstrual cycle (3). Though, the authors pointed out some major methodological shortcomings in this area of research suggesting that pre-selected measurement times led to false assumptions about the timing of ovulation in all studies included. Despite discrepant findings and limitations in previous research, there is a scientific rationale to suspect that ovarian hormone levels have a physiological impact on the mechanical properties of ligament and tendinous connective tissues (4,5,6). The aim of the current study is to use precise menstrual cycle timing methodology to assess and compare measures of mean ACL laxity and Achilles tendon (AT) stiffness in the early follicular (EF) and mid-luteal (ML) phases of the menstrual cycle.
METHODS: Using a prospective study design, 28 women with normal ovulatory cycles (28.9±4.1 yrs; 24.3±5 BMI) completed EF (within 4-8 days of menstruation) and ML (within 7 days of quantitative basal temperature increase) phase appointments. 11 women with anovulatory cycles (30.3±4.3 yrs; 26.3±4.7 BMI) were included as a low-hormone comparison group. The investigator was blinded to the ovulation status of each participant. ACL laxity (mm) was assessed using a KT-1000 arthrometer (load of 15-, 20- and 30-lbs) and AT stiffness (N/mm) was assessed using a MyotonPro digital palpation device at EF and ML appointments. Outcomes for dominant and non-dominant sides were combined into composite variables. Paired t-tests were used to statistically test for variable differences between the two timepoints.
RESULTS: The ovulation group exhibited an increase in ACL laxity from EF to ML (15-lbs: 5.0±1.2mm vs. 5.5±1.5mm; 20-lbs: 6.1±1.4mm vs. 6.7±1.7mm; 30-lbs: 8.2±1.78mm vs. 8.8±2.1mm; all $p<0.05$). There were no differences in the anovulatory group's ACL laxity at any load. AT stiffness did not significantly change in both the ovulatory and anovulatory groups.
CONCLUSION: Similar to the previously cited meta-analysis, results showed an increase in ACL laxity from a low hormone time point (EF) to an elevated hormone timepoint (ML) in women that are normally ovulating. The lack of ACL laxity change shown in the anovulatory group provides further evidence of the hormonal effect on ligament tissue. There was no difference in AT stiffness over the cycle, suggesting that the tendon may not be as sensitive to short term hormone fluctuations as it is to chronic exposure (7).
1. Arendt, 1999 2. Hewett, 2007 3. Zazulak, 2006 4. Burgess, 2009. 5. Dehghan, 2015 6. Lee, 2015 7. Bryant, 2008

### ACTIVE KNEE JOINT POSITION SENSE IN HEALTHY PARTICIPANTS: INFLUENCE OF LEG DOMINANCE, GENDER AND QUALITY CRITERIA

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INTRODUCTION: Integration and processing of sensory information is mandatory for goal directed movement. Sensorimotor performance of the knee can be measured with the active joint position sense (JPS) test. However, data on influences of leg dominance and gender as well as reliability measures is limited.
METHODS: 20 healthy participants (10 male, 10 females, age: 29±8 years; height: 165±39 cm; weight: 69±13 kg) performed in a test-retest design an active knee angle reproduction task in seated position with a target angle at 50° flexion (0° = full extension). Two sessions were executed separated by a 2-week interval. Angular performance assessed with an electrogoniometer, was recorded during 2 blocks of 3 minutes of continues reproduction cycles with self-selected movement velocity per leg and sessions. The order of legs was randomized. Relative and absolute angular errors were presented descriptively. Friedman-test for repeated measures was used to determine differences in absolute angular errors between leg dominance and gender ($\alpha = 0.05$). Intra- and inter-session reliability was assessed with the

Intraclass correlation coefficient (ICC(2,A), Bland-Altman analysis (bias and limits of agreement (LoA)) and minimal detectable change (MDC).
RESULTS: Median (interquartile range) relative and absolute angular error over all participants per session and block were -5.2° (8°) and 7.5° (4°), respectively. No significant differences in angular error in leg dominance (p = 0.11) and gender (p = 0.44) were found. All participants combined showed limited inter-session ICC (0.366), bias of 3° (LoA -10.2° to 16.4°) and MDC of 8.8° and reasonable intra-session ICC (0.738), bias of 2.1° (LoA -5.9° to 10.2°) and MDC of 5.6° reliability measures.
CONCLUSION: No significant differences in leg dominance and gender are in line with findings in the literature. Lower inter- and higher intra-session ICC values confirm previous findings and bias as well as minimal detectable changes must be considered when comparing to other studies. Due to the small sample size and inclusion of only healthy participants the findings need to be handled with caution when applied to another population.

## Conventional Print Poster

### CP-MH07 Ageing and physical activity

#### RELATIONSHIPS OF PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOURS WITH MARKERS OF OXIDATIVE STRESS IN THE OLDER POPULATION.

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INTRODUCTION: The scientific evidence has stated sex differences in oxidative stress markers such as homocysteine and total antioxidant capacity (TAC), establishing sex hormones as the possible mechanism. However, the evidence showed that these differences still occur in the older population which could imply that other lifestyle factors, such as physical activity (PA) or sedentary behaviours have a relevant role, due to increased susceptibility to oxidative stress associated with ageing. Therefore, the current aim was to compare the oxidative stress markers between sexes and their relationships with accelerometer-based PA and sedentary behaviours.
METHODS: Sixty-three participants (36 women, 68.84±3.02 years) from a randomised control trial (NCT03923712) were included in the analysis. The PA levels [light, moderate, vigorous, and moderate-to-vigorous(MV), min/day] and sedentary behaviours (min/day) were measured using hip-worn accelerometers for 7 consecutive days. Raw data from accelerometers were used with the open-source package GGIR for analysis and transformed to euclidean norm minus one with negative values rounded to zero. Three 24 h dietary recalls were obtained from each individual to evaluate the nutrient intake. Plasma TAC levels (µmol/L) were measured using the ferric reducing antioxidant power method with some modifications. Serum homocysteine levels (µmol/L) were obtained using standard enzymatic methods. We conducted multiple regression models, with homocysteine and TAC as dependent variables and PA and sedentary behaviours as predictors after controlling sex.
RESULTS: Men showed significantly higher levels of TAC (1063.31±158.22 vs 894.12±171.75 µmol/L, p<0.001) and homocysteine (15.18±2.91 vs 12.43±2.70 µmol/L, p<0.001) compared to women, which remained significant after adjusting for nutrient intake. No significant differences between sexes were found for any of the PA or sedentary behaviours variables. In the multiple regression models, only MVPA was positively associated with TAC (β=0.25, p=0.042) which remained significant after controlling for sex (β=0.24, p=0.033). No significant associations were found between homocysteine and PA and sedentary behaviours.
CONCLUSION: The findings of the present study showed that, in our sample, there are still sex differences in oxidative stress which are independent of PA levels or sedentary behaviours. Additionally, even though it is well established that daily PA is beneficial for ageing, this study suggests that only MVPA intensity may have a protective and beneficial effect, even though it can acutely increase oxidative markers, it is also able to induce an adaptive response increasing the antioxidant defence without chronically increasing oxidative markers among older adults, contributing to a better overall oxidative stress balance.
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#### INHERITED MUSCLE STRENGTH PREDICTS FUNCTIONAL CAPACITY, COMMON DISEASES AND ALL- CAUSE MORTALITY

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INTRODUCTION: Muscle strength is a highly heritable trait and especially low grip strength, measured at any time during adulthood, predicts future adversities and mortality. We hypothesized that muscle strength genotype is an important predictor of future health and lifespan. To test this hypothesis, we validated a polygenic risk score for grip strength (PRS GRIP) and investigated how it associates with functional capacity, most common age-related diseases and all-cause mortality among the Finnish population.
METHODS: PRS GRIPs (based on Pan-UB biobank GWAS summary statistics, N=418,827) were calculated for the older Finnish twin cohort (FTC, N=8,823) and FinnGen Data Freeze 9(N=315,594). FTC partipants (born 1938-1957) were followed up from the time of DNA sampling until December 31, 2020. Death dates were obtained from the population register of Finland and Statistics Finland. A subsample of FTC (N=429) had undergone measurements for maximal isometric grip and knee extension strength and several functional tasks. FinnGen data included genotyped individuals (age 40-108 years, women 53%) with longitudinal health register data. Endpoints were based on ICD codes and included cardiovascular, metabolic and pulmonary diseases, cancers, dementia and depression as well as musculoskeletal and connective tissue disorders. Analysis was conducted with linear, logistic and cox regression models.
Results: In FTC subsample, PRS GRIP accounted 6.1% of the variation in the measured grip strength (β 14.2, SE 3.1, P<0.001), 5.4% of the variation in the knee extension strength (β 19.6, SE 4.7, P<0.001) and was systematically associated with measures of functional capacity. In FinnGen, a high PRS GRIP predicted a lower BMI ( β = −0.059 kg/m2 per one SD change in PRS GRIP, SE = 0.011, P = 1.3 x 10 -7 ). Higher PRS GRIP was also associated with

a lower risk for ischemic heart diseases, hypertension, and stroke (odds ratio [OR] range 0.95-0.96.), osteoporosis, rheumatoid arthritis and knee and polyarthrosis (OR 0.90-0.98), type 2 diabetes and obesity (both OR 0.94), asthma (OR 0.93) and COPD (OR 0.94). Participants with higher PRS GRIP had also lower risk for some dementia subcategories (OR 0.93-0.98) and depression (OR 0.95). In FTC, 35% of the men and 26% of the women died during the mean follow-up time of 16.3 years. A significant sex* PRSGRIP interaction was found (p=0.023). In men, mortality risk decreased when PRSGRIP increased (HR 0.93, 0.88-0.98), while no association were found in women (HR 1.01). In men, mortality HR for PRSGRIP remained similar (0.93) also after adjusting for adulthood physical activity and other lifestyle covariates. Conclusion:Inherited muscle strength may reflect an individual's intrinsic capacity to resist pathological changes in old age. Origins of significant sex interaction in mortality need to be studied further. Whether high genetic muscle strength also helps to recover from episodes of poor health remains to be investigated.

### METHODS: RESULTS: CONCLUSION: DIFFERENCES IN VASTUS LATERALIS MUSCLE THICKNESS AND MAXIMUM KNEE EXTENSION FORCE BETWEEN MASTER ATHLETES, NON-ATHLETES AND PATIENTS UNDERGOING MAJOR ABDOMINAL SURGERY

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INTRODUCTION: An important cause of frailty in old age is sarcopenia, which is associated with poor prognosis in major abdominal surgery1. While muscle mass is important, there is increasing evidence that the force generating capacity is proportionally more reduced during ageing than muscle mass2. The aim of this study is to obtain a measure of muscle size (Vastus Lateralis (VL) thickness), muscle function (maximal voluntary force generating capacity (MVC)) and the ratio between MVC and VL thickness, providing a measure of 'muscle quality'. As a substantial component of the development of frailty is likely to be attributable to low levels of physical activity, we hypothesise that 1) muscle mass and function are lower in patients undergoing a major abdominal surgery compared to age-matched Master athletes (MAs) and non-MAs and 2) poor muscle function is predictive of poor surgical outcomes in patients undergoing major abdominal surgery.
METHODS: Major abdominal surgery patients (hepatobiliary, MASP) were recruited during a preoperative clinic at MFT (UK). Non-MAs were recruited from the general population of Manchester, presented without any co-morbidities, whilst sprint-trained MAs were recruited from members of Finnish Track and Field Organizations. Ultrasound images of the VL were processed (ImageJ v.1.80) to obtain VL thickness (in mm). A strap placed above the tibial malleolus and attached to a custom dynamometer recorded MVC (in N) during a maximal isometric knee extension while participants were sitting down on a chair with knee and hip at 90°. Surgical outcomes were length of stay in hospital (LOS) (in days) and readmission after surgery. Differences in VL thickness and MVC/VL thickness between groups was assessed with an ANCOVA with age as covariate to assess differences in the age-related decline. Bonferroni post-hoc test assessed differences between groups.
RESULTS: A total of 98 male participants were included (MASP: N=31, 73±6 yrs, non-MAs: N=20, 73±5 yrs and MAs: N=47, 71±6 yrs). The mean LOS was 6 days (range: 2-12 days) No significant differences were found in VL thickness between groups (p=0.099), however MVC/VL thickness was lower in MASP compared with MAs and non-MAs (p<0.01). VL thickness and MVC/VL thickness declined similarly with age between groups (p>0.05). In the patient group, no significant relationship was found between VL thickness or MVC/VL thickness with LOS, and no difference was found in VL thickness and MVC/VL thickness between readmitted and non-readmitted patients (p>0.05).
CONCLUSION: Muscle quality, but not muscle thickness, appears to be negatively affected in MASP when compared to age matched controls. Future work should explore the impact of muscle quality on long-term surgical outcomes (1-year and 3-year survival rate) as similarly to our previous work, we found no relationship between any muscle parameter and short-term surgical outcomes3. A limitation of this study is that only male was included.

### RISK OF FALLS AND PHYSICAL ACTIVITY BEHAVIOUR IN COMMUNITY-DWELLING OLDER ADULTS. A CROSS-SECTIONAL ANALYSIS

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INTRODUCTION: Falls in older adults are a public health problem and physical activity (PA) is an important behavioural factor in falls prevention. Following the reopening of community centers post Covid-19 restrictions, the study aimed to compare physical activity (PA) and sedentary behaviour (SB) of older adults at different levels of fall risk (FR) and identify socio-cognitive PA determinants.
METHODS: This is baseline data from ASPIDA, an on-going, longitudinal study, with 96 current recruits from community centers for older adults in Municipality of Rodopi, Northern Greece. Measures included an adjusted version of John Hopkins Fall Risk Assessment Tool, the Geriatric Depression Scale, Falls Efficacy Scale-International, Multidimensional Outcome Expectations for Exercise Scale, Self-efficacy for Exercise Scale, administered during site-visits, and triaxial accelerometers (Actigraph GT3X, GT9X), hip-worn for a week.
RESULTS: Mean age was 73.6 years (SD=6.2), 77.7% women. The proportion of people at low, medium and high FR was 22%, 60% and 16% respectively, with 69% reporting no fall history in the last 12 months. On average participants wore the accelerometers for 6.4 days and spent 58.3 minutes (SD=28.9) in moderate-to-vigorous PA (MVPA), 126.2 minutes (SD=36) in light PA (LPA) and 9.9 hours (SD=2) in SB daily. The guidelines of 150 minutes of weekly MVPA were met by 91% of participants. 67% reported doing no exercise, whilst 13% reported doing ≥1hour/week. There was no effect of sex, BMI and depression on FR. There was a significant effect of MVPA [$F(2,34.35)=22.08$, $p<.001$, $\eta2= .15$], the proportion of time spent in SB [$F(2,30.39)=11.21$, $p<.001$, $\eta2= .12$] and fear of falls [$F(2,22.74)=10.60$, $p<.001$, $\eta2= .36$] on FR. Those at high FR spent significantly less time in MVPA, more time in SB and had greater fear of falls than those at medium and low FR groups. Participants' PA/exercise outcome expectations (OE) were overall positive [M=4.3 (SD=0.5) for physical OE, M=4.2 (SD=0.6) for self-evaluative, M=3.2 (SD=0.7) for social]; self-efficacy was average [M=5.33 (SD=1.9)]. Only self-evaluative outcome expectations were associated with MVPA [$r(73)= 0.26$, $p<.05$].
CONCLUSION: The majority of participants met MVPA, but not exercise guidelines. Those at high risk of falls had a distinct profile with regard to MVPA and SB. In terms of falls prevention, which is the overarching aim of the ASPIDA project, these preliminary findings have implications for behaviour change targets: (a) increase exercise time and (b) boost PA associations with well-being and self-efficacy for all, (c) tailor interventions for individuals at high FR, e.g. by focusing on SB reduction and addressing fear of falls and safety concerns.

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**ASSOCIATION OF MUSCLE FUNCTION, PHYSICAL PERFORMANCE, AND CARDIORESPIRATORY FITNESS WITH MILD COGNITIVE IMPAIRMENT: THE TOLEDO STUDY FOR HEALTHY AGING IN MIDDLE AGE**

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INTRODUCTION: Mild cognitive impairment (MCI) has been conceptualized as an intermediate stage between normal cognitive aging and dementia, with an estimated prevalence between 3% and 19% in older adults (1). MCI has a high risk of progression to dementia with a rate of 10–15% every year (2). However, it is considered to be a reversible process, as one-third of patients with MCI remain in clinical stability or even return to normal (3). On the other hand, previous evidence has shown an association between MCI and physical activity and exercise (4). Therefore, it seems reasonable to identify muscle function, physical performance, and cardiorespiratory fitness markers whose relationship with MCI may improve its early detection and subsequent intervention. Hence, this study aimed to examine the association between MCI and several physical fitness components in middle-aged adults.

METHODS: The sample comprised 138 middle-aged adults (53.9±0.1 years; 58% female) from the Toledo Study for Healthy Aging in Middle Age (THSA-ma). MCI was assessed by the Montreal Cognitive Assessment (MoCA), classifying patients with a score below 26 points as having MCI (5). Relative muscle power (30-second sit-to-stand muscle power test), handgrip strength (Jamar Dynamometer), functional mobility (Timed Up and Go Test), maximal walking speed (30-meter walk test), aerobic capacity (estimated VO2max; 6-min walk test), and balance (Y-balance test) were assessed. Logistic regression analysis adjusted for age, sex and education level was conducted.

RESULTS: The prevalence of MCI was 17.4%. Functional mobility was the only physical fitness component significantly associated with MCI (β= 0.019; [95 % CI 0.001 to 0.583]; p = 0.023). Relative muscle power (β= 1.079 [95 %, CI 0.698 to 1.667]; p= 0.732), maximal walking speed (β= 1.285 [CI 0.358 to 4,612]; p= 0.701),handgrip strength (β= 0.999 [95 %, CI 0.994 to 1.005]; p= 0.910),balance (β= 0.995 [95 %, CI 0.983 to 1.007]; p= 0.710) and aerobic capacity (β= 0,954 [95 %, CI 0.859 to 1.060]; p= 0.381) showed no associations with MCI.

CONCLUSION: Our preliminary data suggest that functional mobility was found to be the only physical fitness components associated with MCI in middle-aged adults from the TSHA-ma. Therefore, functional mobility could be a potential indicator when seeking for early detection of MCI. Future studies should focus on this relationship in the middle-aged population as there are no previous studies that have evaluated this association.

References:

1. Gauthier S, et al. (2006). Lancet; 367(9518):1262-70.
2. Eshkoor SA, et al. (2015). Clin Interv Aging; 10:687-93.
3. Montero-Odasso M, et al. (2014). J Gerontol A Biol Sci Med Sci.; 69(11):1415-21.
4. Demurtas J, et al. (2020). J Am Med Dir Assoc.;21(10):1415-22.e6.
5. Nasreddine ZS, et al. (2005) J Am Geriatr Soc.; 53(4):695-9.

**ASSOCIATIONS BETWEEN PHYSICAL FITNESS AND BRAIN-DERIVED NEUROTROPHIC FACTOR LEVELS IN COGNITIVE HEALTHY OLDER ADULTS AND WITH MILD COGNITIVE IMPAIRMENT**

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INTRODUCTION: Mild cognitive impairment (MCI) represents an intermediate stage between healthy cognitive aging and dementia (1). Its prevalence is estimated around 15-20% in aged more than 60 years (2). Brain-derived neurotrophic factor (BDNF) is essential for neuronal growth and survival, acting as a modulator neurotransmitter and being involved in neuronal plasticity (3). Increases in BDNF might be mediated by a response to exercise at the brain level. However, whether having a high fitness status could be linked to greater BDNF levels in cognitively healthy and MCI older adults, is still not clear. Therefore, this study aimed to examine the associations of a set of physical fitness components (cardiorespiratory fitness, muscular strength, flexibility, and coordination-agility), and BDNF in older adults cognitively healthy and with MCI.

METHODS: This study included cross-sectional baseline data from the EFICCOM project (Clinical Trial registration: NCT03923712). A total of 77 older adults (range 65 to 75 years, 39 women) participated in the study. Physical fitness was assessed by i) VO2peak through modified Bruce test and 6-minute walking test (cardiorespiratory fitness), ii) handgrip strength, arm curl, and 30 seconds-chair stand tests (upper and lower-limb muscular strength), iii) back scratch and chair sit and reach tests (upper and lower-limb flexibility, respectively) and iv) 8-foot up and go test (coordination-agility). BDNF levels were assessed in serum blood samples through by the Enzyme-linked immunosorbent Assay kit of RayBio Human BDNF. Neuropsychological criteria (non-MCI, MCI, and possible MCI) were determined by a specialist using a battery of cognitive tests. Linear regressions analyses were applied after adjusting for basic confounders (i.e., age, sex, and apolipoprotein E).

RESULTS: All physical fitness components were directly associated with BDNF levels in MCI group, (all $p<0.05$) in the overall adjusted model. Interactions of age and sex have been identified. However, physical fitness and BDNF levels were not significantly associated in non-MCI and possible MCI groups.

CONCLUSION: Cardiorespiratory fitness, muscular strength, flexibility, and coordination-agility were related to BDNF levels in older adults with MCI, but not in those cognitively healthy. Further studies analyzing the interaction role of age and sex in these relationships are needed.

KEY WORDS: cardiorespiratory fitness, muscular strength, flexibility, coordination, BDNF, old people, aging.

References:

1. Tangalos EG, Petersen RC. Mild Cognitive Impairment in Geriatrics. Clin Geriatr Med. 2018;34(4):563–89.

2. Petersen RC. Mild Cognitive Impairment. Contin (Minneap Minn) [Internet]. 2016;22(2):404–18.
3. Bathina S, Das UN. Brain-derived neurotrophic factor and its clinical Implications. Arch Med Sci. 2015;11(6):1164–78.

### ASSOCIATIONS OF LEAN MASS WITH OSTEOPOROSIS AND OBESITY AND THE INTERMEDIATE ROLE OF SEDENTARY TIME AND PHYSICAL ACTIVITY IN OLDER POPULATION

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INTRODUCTION: Osteoporosis and obesity constitute an important public health concern due to their high incidence (1, 2). Body composition changes are essential in the development of both pathologies, with physical activity (PA) and sedentary time (ST) as crucial parameters to reduce their risk (3, 4). However, no studies have been found in relation to the intermediate role of these confounders. Thus, the aim of this study was to determine the associations of lean mass with osteoporosis and obesity, and how these associations are moderated by PA and ST in older people.
METHODS: In total, 192 participants (53% women) from the TSHA study were analyzed in this study over a 4-year period. Lean mass determined by dual X-ray absorptiometry was the “exposure of interest” as a continuous variable (reference group includes participants who were in the lowest tertile). Osteoporosis and obesity were the “outcomes” and accelerometer-derived PA (light and moderate-to-vigorous) and ST were the “intermediate variables”. Associations between lean mass and outcomes were investigated using Cox proportional hazards models, adjusted for potential confounders. Interaction terms investigated whether intermediate variables modified these associations.
RESULTS: Lean mass was associated with a lower risk of obesity (hazard ratio [HR]:0.96; 95% confidence interval [CI]:0.94–0.99). This association persisted when the sample was categorized by tertiles, showing a decreased risk in the subgroups of greater lean mass (HR:0.46; 95% CI:0.26-0.80). Associations of lean mass with osteoporosis and obesity were not modified by PA and ST. Nevertheless, the stratification into different categories depending on the potential modifier, showed that those with higher moderate-to-vigorous PA presented lower obesity risk compared with the less active older people (HR:0.96; 95% CI:0.93-0.99). No significant associations were observed between lean mass and osteoporosis with this method.
CONCLUSION: Lean mass was strongly associated with obesity, even after adjustment for confounders. Interventions to reduce obesity incidence should be focused on increasing lean mass, which could be more effective if older people spend more time in moderate-to-vigorous PA. Further research focusing on the characteristics of lean mass is needed to reduce the risk of osteoporosis.
References
1. Cauley JA. Public health impact of osteoporosis. J Gerontol A Biol Sci Med Sci. 2013;68(10):1243-51
2. Fakhouri TH, et al. Prevalence of Obesity among Older Adults in the United States, 2007–2010. No.106. US Department of Health and Human Services, Centers for Disease Control and Prevention, NCHS, 2012
3. McMillan LB, et al. Prescribing physical activity for the prevention and treatment of osteoporosis in older adults. Healthcare. 5(4). Multidisciplinary Digital Publishing Institute, 2017
4. Weber D, et al. Development of novel methods to define deficits in appendicular lean mass relative to fat mass. PLoS ONE, 2016;11(10):e0164385

### DEVELOPING A FIELD-TEST FOR FORCE-VELOCITY PROFILING IN OLDER ADULTS

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INTRODUCTION: Muscle function is a marker of current and prospective health and mobility throughout life and in ageing. Force-velocity profiling (F-V) evaluates muscle function through the identification of maximum force (F0), velocity (V0) and power (P0). To assess this relationship, Isokinetic Dynamometry is the laboratory gold standard. However, the high cost, request of specialized personnel and the unphysiological contraction pattern that does not resemble that of real life, have triggered the search for more applicable alternatives. The 5 Sit to Stand Test (5STS) is a multi-joint, close chain and functional test widely used in clinical setting to assess muscle power of the lower limbs. In its original version the test does not permit the characterization of F-V. Therefore, the purpose of this study was to use a modified version of the 5STS (m5STS) to characterize muscle function in older adults. To this aim, we compared F0, V0 and P0 from m5STS and isokinetic knee extension (ISO).
METHODS: Forty-one older adults (20 females: 63,5±3,7 years) performed 5STS in four different load conditions (Bodyweight, +12.5%, +25% and +37.5% of Bodyweight) in random order. The position of a marker placed on the subject’s trochanter was monitored by Motion Capture (MOCAP) and, for each subject and trial, the mean concentric velocity (ascending phase of the movement) was extrapolated. In addition, each subjects performed isokinetic tests at 5 different velocities (60, 90, 150, 180 and 210 °/sec, in random order). Individual F-V relationships were built for both tests and F0 (corresponding to the null velocity), V0 (corresponding to null force) and P0 (corresponding to maximum power) were calculated. A correlation coefficient for the individual F-V relationships was calculated for both methods. Comparison between the above variables from m5STS test and ISO were evaluated by paired t-test and correlation.
RESULTS: Mean correlation coefficients from ISO (-0.97 ± 0.05) and m5STS test (-0.96 ± 0.06) showed strong within-individual relationships and were not different between methods. The group mean value of F0 (m5STS: 1952.29 ± 594.16 [N]; ISO= 310.92 ± 84.45 [N]), V0 (m5STS: 0.91 ± 0.22 [m*s-1]; ISO= 3.03 ± 0.42 [m*s-1]), P0 (m5STS: 431.83 ± 127.97 [W]; ISO= 233,64 ± 65,00 [W]) were significantly different ($p<0.001$) as is expected for bilateral vs single-limb exercises. Linear regression showed moderate correlation between F0m5STS and F0ISO (r= 0,55) and high correlation between P0 m5STS and P0ISO (r= 0,81).
CONCLUSION: The m5STS proposed in our study is a simple, submaximal, time- and cost-efficient test to evaluate lower limb muscle function in older adults of both sexes. The high correlation coefficients of both methods for individual F-V relationships and the strong correlation between values of P0, indicate a good ability of m5STS to correctly characterize muscle function, making it a promising tool for the large-scale assessment and monitoring muscle function in ageing.

**ESTIMATING MUSCLE POWER OF THE LOWER LIMBS THROUGH THE 5-SIT-TO-STAND TEST: A COMPARISON OF FIELD VS LABORATORY METHOD.**

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INTRODUCTION: Muscle power (MP) of the lower limbs is a key determinant of current and prospective mobility and independent living in ageing. The 5-Sit-to-stand test (5STS) has been proposed as simple "field method" to estimate lower limbs MP from the body's vertical velocity (vertical displacement/mean concentric time) and force (body mass*g). It relies on the chronometric measure of the time to perform 5 consecutive standing movements and the following unverified assumptions: i) vertical displacement (Vdspl) = (50% stature – chair seat height); ii) mean concentric time (meanT) = 10% trial duration; iii) mean force (meanF) = (90% body mass (BM) * g). We aimed to verify the correspondence between assumed and measured variables and the accuracy of field estimates of MP (MPfield) vs a laboratory approach (MPlab) that uses a motion capture system (MOCAP) and a force plate (FP) to measure the Vdspl, meanT and meanF.
METHODS: 40 older adults (20 females, 66 ± 6 yrs) completed two trials of the 5STS test. For the field method, total trial duration was measured with a chronometer, chair seat height with measuring tape and MPfield was computed as per the above listed assumptions. For the laboratory method, the Vdspl of a marker placed on the trochanter was identified by MOCAP; the meanT was identified based on the speed trajectory of the same marker over time; concurrently meanF was monitored with a FP positioned under the subject's feet in the concentric phase. MPlab was calculated as the product of speed and force. The correspondence between field and lab methods for Vdspl, meanT, meanF and MP was evaluated by paired t-test.
RESULTS: The assumptions of start (i.e. chair seat height) and end points (i.e. 50% of stature) of the displacement used in the field method were both overestimated compared to the direct measures by ~ 0.10 m. However, the Vdspl was similar for both methods (0.33±0.06 vs 0.34±0.05 m, p=0.28). Lab measures yield significantly lower meanT (0.63±0.14 vs 0.91±0.23 s, equal to 7±1 vs 10% of sit to stand time, p<0.001) and lower meanF (594.90±113.12 vs 646.62±96.42 N, equal to 82±9 vs 90% BM, p<0.001) and higher meanV (0.53±0.11 vs 0.40±0.09m*s-1, p<0.001) vs field. Finally, MPfield (257.71±75.24 Watt) was significantly underestimated compared to MPlab (321.24±103.11 Watt, p<0.001).
CONCLUSION: The 5STS field test is a valuable tool to estimate muscle power thanks to its simplicity and low cost. However, the assumptions on which it is based appear inaccurate, yielding to a significant and large underestimation (-21±21%) of muscle power of the lower limbs compared to the gold standard laboratory measures in a population of older adults. The identification of accurate and, possibly, population-specific assumptions is necessary to grant a generalised applicability of this time and cost-effective method for the monitoring of muscle power of the lower limbs.

**THE ROLE OF DEFAULT NETWORK AND EXECUTIVE CONTROL NETWORK IN THE IMPROVEMENT OF COGNITIVE FUNCTION IN THE ELDERLY BY EXERCISE**

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INTRODUCTION: With the deepening of the aging population, age-related cognitive decline has become the focus of social concern. Exercise has been shown to improve cognitive function in the elderly, and play an important role in delaying the onset of cognitive impairment (1, 2), but the brain mechanism behind the improvement of behavior in the elderly is unclear. Therefore, this study intends to use the resting-state brain network analysis to explore the role of default network and executive control network in the improvement of cognitive function in the elderly by exercise.
METHODS: The 69 subjects enrolled in the BABRI database were divided into control group and exercise group according to exercise frequency. A series of behavioral tests include mini-mental state examination (MMSE), clock drawing test (CDT), symbol digit modalities test (SDMT), trail making test (TMT), verbal fluency test (VFT) and Boston naming test (BNT) were used to measure the general cognitive performance, visuospatial ability, attention, executive function and language functions, respectively. Combined with imaging technology based on GIFT software, the independent component analysis method (ICA) was used to analyze the default network and executive control network of the elderly in two groups. The correlation analysis was made between different brain regions and cognitive performance.
RESULTS: (1) The exercise group had better behavioral performance on cognitive tests such as MMSE, SDMT, TMT, VFT and BNT than control group (P<0.05), but there was no significant difference in CDT between two groups (P>0.05). (2) In the default network, the brain functional activity in the dorsolateral superior frontal gyrus, middle left superior frontal gyrus, superior frontal gyrus and right anterior cingulate gyrus of the exercise group was significantly stronger than that of the control group (P<0.05). (3) In the executive control network, the brain functional activity in the left inferior parietal lobe, lower cerebellum, left inferior temporal gyrus and inferior frontal gyrus of the exercise group was significantly stronger than that of the control group (P<0.05). (4) In the executive control network, the left inferior parietal lobe of the exercise group was significantly positively correlated with the MMSE score (r=0.301, P<0.05). (5) In the executive control network, the left inferior parietal lobe of the exercise group was significantly positively correlated with the attentional SDMT score (r=0.374, P<0.05).
CONCLUSION: Regular exercise can improve the cognitive, attention, executive, and language functions in the elderly. Exercise improves cognitive function may be related to enhanced functional activity in the frontal, anterior cingulate, and inferior parietal regions of the default network and executive control network after exercise.
REFERENCE:1. Burdette JH, Laurienti PJ, Espeland MA, et al. Using network science to evaluate exercise-associated brain changes in older adults [J]. Front Aging Neurosci, 2010, 2: 23.

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### CP-PN06 Sleep/metabolism

#### INFLUENCE OF COMPETITIVE SCHEDULE ON SUBJECTIVE AND OBJECTIVE SLEEP DURATION IN PROFESSIONAL FEMALE SOCCER PLAYERS

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INTRODUCTION: To support performance, recovery and physical and mental health athletes are advised to achieve approximately eight hours of sleep. During the competitive season it is important to understand how sleep varies to inform sleep and recovery recommendations. In professional female soccer players there is limited sleep data available. In addition, no studies have compared objective and subjective measures of sleep duration within a comprehensive competitive soccer schedule. This information is important as objective measures are expensive and often cost prohibitive to teams. Therefore, the aims of this study were to 1) determine the impact of competitive schedule on sleep duration, 2) compare objective and subjective measures of sleep duration in professional female soccer players.
METHODS: Sleep was measured over 44 ± 10 d in seven professional female soccer players (age: 29 ± 5 y) during a competitive season (Women's Super League, England). Sleep duration (h:min) was measured objectively using wrist-worn actigraphy (Biostrap EVO, USA) and subjectively by a daily questionnaire completed the following morning. Only night time sleeping was included in the data set. Competitive schedule was categorised as: Match Day (MD), Training Day (TD; pitch based, soccer skills, gym based), Recovery Day (RD; non-soccer specific training), and Off Day (OD). Data are shown as mean ± SD; a statistical level of significance was set at $P<0.05$.
RESULTS: Objectively, players slept longer on TD (8:49 ± 1:21 h:min) compared to RD (7:59 ± 1:33 h:min, $P<0.05$). No differences between other days were found. Objective measures of sleep duration were higher (8:25 ± 0:36 h:min) compared to subjective measures (8:03 ± 0:28 h:min, $P<0.01$). Five out of the seven players consistently under-estimated sleep duration. Objective sleep duration was greater than subjective sleep duration on TD and OD (0:36 and 0:35 h:min respectively, $P<0.01$), with no differences observed on MD or RD ($P>0.05$). Subjectively TD and RD had highest sleep duration (TD: 8:13 ± 1:03 and RD 8:14 ± 0:56 h:min), MD had lowest (7:29 ± 1:34 h:min, $P<0.01$), with no differences observed on OD (7:54 ± 0:52 h:min, $P>0.05$).
CONCLUSION: The results of the present study show that competitive schedule does have an impact on sleep duration in professional female soccer players, however results varied between objective and subjective sleep measures. Further investigation is warranted to fully understand the depth of the interaction between competitive schedule and sleep in this cohort. Furthermore, this study shows that professional female soccer players underestimate sleep duration. This underestimation is limited at approximately 4% (0:22 h:min). As such, subjective measures may be appropriate for use on a longitudinal basis, especially when objective measures are not accessible or affordable. However, to determine a full sleep profile over a competitive schedule objective measures are advisable.

#### TIME-DEPENDENT CORTICAL PLASTICITY DURING MODERATE-INTENSITY CONTINUOUS TRAINING VERSUS HIGH-INTENSITY INTERVAL TRAINING OVER AN 8-WEEK PERIOD IN RATS

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INTRODUCTION: Beyond its role in improving cardiovascular and muscular functions, chronic endurance exercise is now recognized to enhance brain health by promoting cerebral plasticity. Nevertheless, the cortical plasticity which is heavily involved in sensorimotor tasks remains understudy. Hence, its temporal pattern specifically induced by various endurance training regimens is still to be defined to better clarify its benefits in preventing neurological disorders. Among the most common endurance training regimens are the moderate-intensity continuous training (MICT) defined by an intensity below the speed associated to the lactate threshold (SLT) or approximately 50–70% of the maximal speed (Smax) and the high-intensity interval training (HIIT) characterized by repeated bouts of intense exercise above the SLT. Thus, the purpose of this study is to define the time-dependent effects of work-matched HIIT and MICT on cortical plasticity, endurance and sensorimotor performances over an 8-week training period in healthy rats.
METHODS: Adult healthy rats performed incremental exercise tests on treadmill and sensorimotor tests before and at 2, 4, and 8 weeks of training. At the same timepoints, cortical markers related to neurotrophic, angiogenic and metabolic activities were assessed.
RESULTS: Our results indicate an effectiveness of both training regimens in maintaining forepaw mechanical sensitivity at the end of the training period as well as in enhancing forelimb grip strength, SLT and Smax over these 8 weeks. HIIT induces superior endurance improvements than MICT as observed by significant enhancement of SLT and Smax at 2 and 8 weeks. Nonetheless, MICT promotes early increases in the expression of neurotrophic, angiogenic and metabolic markers while it tends to show less influence at 8 weeks. Indeed, both brain-derived neurotrophic factor (BDNF) and the Apelin receptor (APJ) remain elevated until the 4th week of training whereas vascular endothelial growth factor (VEGF) returned to baseline at this timepoint with MICT. Interestingly, HIIT early triggers the insulin-like growth factor-1 (IGF-1) and upregulates VEGF later on as well as other neurotrophic, metabolic and angiogenic markers at 2 and 8 weeks. HIIT appears to be effective in the early downregulation of the neuronal K-Cl cotransporter KCC2 which has been shown to increase the neuronal activity and the upregulation of neurotrophic factors. Although HIIT does not alter BDNF levels, this training regimen is effective in triggering BDNF receptors levels which are a major cascade of its actions.
CONCLUSION: Hence, by altering specific markers of neuroplasticity at different timepoints, HIIT and MICT appears to be effective in a time-dependent manner suggesting a complementary effect that might be useful in physical exercise guidelines for maintaining brain health.

**EFFECTS OF ONE NIGHT'S SLEEP RESTRICTIONS ON MAXIMAL STRENGTH, MUSCLE POWER, AND STRENGTH ENDURANCE IN RESISTANCE-TRAINED WOMEN**

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*AKADEMIA WYCHOWANIA FIZYCZNEGO IM. JERZEGO KUKUCZKI W KATOWICACH*

INTRODUCTION: Although several studies analyzed the impact of sleep loss on resistance performance in trained individuals, to date, no investigation has been conducted on women. Therefore, the aim of this study was to explore the effects of sleep restrictions on maximal strength, muscle power, and strength endurance in resistance-trained women.
METHODS: Twelve resistance-trained women participated in a randomized, counterbalanced and crossover experiment. Each participant performed two identical experimental sessions in two sleep conditions a) with sleep restrictions (SR), where they experienced acute sleep restriction the night before the test session (i.e., 2 h of sleep restriction versus normal sleep) b) with the control condition (CON), where they followed their habitual sleep-wake routines. Testing procedures included in the following order: a) maximal strength bench press test, b) three sets of three repetitions of explosive bench press exercise at 50% of the load representing one-repetition maximum (1RM); (c) countermovement jump; d) muscle endurance test in the bench press exercise at 50% 1RM. Additionally, before the testing, participants completed subjective responses to a readiness-to-train questionnaire (RTT-Q) and reported the rate of perceived exertion (RPE; range 6 - 20) and pain on a visual analogue scale (VAS; range 0 - 10) immediately after the treatment.
RESULTS: Significant differences between CON and SR conditions were observed in peak (0.51 ± 0.13 vs 0.45 ± 0.14 m/s; p = 0.023) and mean (0.30 ± 0.12 vs 0.27 ± 0.11 m/s; p = 0.012) bar velocity during muscle endurance test, without significant differences in the maximal strength test (43.75 ± 6.07 vs 43.16 ± 7.18 kg; p = 0.492), peak (1.30 ± 0.19 vs 1.31 ± 0.21 m/s; p = 0.780) and mean (0.91 ± 0.13 vs 0.90 ± 0.12 m/s; p = 0.752) bar velocity during explosive bench press exercise, countermovement jump (29.15 ± 5.17 vs 29.51 ± 5.34 cm; p = 0.356), number of repetition (31.83 ± 9.08 vs 30.66 ± 7.74; p = 0.410) and time under tension during muscle endurance test (63.17 ± 23.10 vs 63.08 ± 20.38 s; p = 0 .637). Significant differences between CON and SR conditions were observed in the values of RPE (14.7 ± 2.4 vs 17.3 ± 1.7; p= 0.001), VAS pain scale (6.9 ± 1.5 vs 7.8 ± 0.7; p = 0.035) and in RTT-Q answers for questions "Do you feel physically strong today?" (3.7 ± 0.9 vs 2.8 ± 1.0; p = 0.014), "Do you feel mentally strong today?" (4.3 ± 0.9 vs 3.5 ± 1.4; p = 0.027) and "Rate your motivation to train today" (7.7 ± 1.4 vs 6.5 ± 2.4; p = 0.031).
CONCLUSION: The present study indicates that short-term sleep restriction only slightly affects upper-body resistance performance. However, performance responses to acute sleep restriction seem to be highly individual. Significant changes were observed in reports of RPE, pain and RTT-Q. These findings suggest that subjective measures are more sensitive to the effects of two hours of sleep restrictions in resistance-trained women.

**EFFECTS OF ACUTE WRIST TENDON VIBRATION ON SPINAL AND CORTICAL EXCITABILITY**

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INTRODUCTION: The application of tendon vibration (TV) stimulates the primary and secondary endings of the muscle spindles [1]. The integration of sensory information by the brain can produce illusions of movement in the opposite direction to the vibrated tendon. Prolonged application (several minutes) can induce cortical and spinal changes in the vibrated (agonist) and non-vibrated (antagonist) muscles of the same joint [2, 3]. The aim of this study was to improve our understanding of the neurophysiological adaptations induced by 30 minutes of continuous VT on the wrist joint.
METHODS: TV was applied to the FCR muscle (Duration: 30, Format: continuous, Frequency: 80hz, Amplitude: 0.5mm). The subjects had their arms masked during TV to promote an extension illusion. Motor-evoked potentials (MEPs, 17 subjects), Cervico-medullary-evoked potentials (CMEPs, 15 subjects), and Hoffmann-reflexes (H, 15) of the flexor carpi radialis (FCR) and extensor carpi radialis (ECR) were measured in three different sessions. Four blocks of measurement were performed: before TV (PRE) and at 0 (P0), 30 (P30) and 60 (P60) after vibrations were stopped. All measurements were performed at rest with an intensity set before the PRE block. All the results were expressed in percentage of the maximal muscular response (MMAX) obtained at each moment for the two muscles. Ratios MEP/CMEP for the FCR and ECR muscle (15 subjects) were measured as well as H/CMEP for the FCR muscle (12 subjects).
RESULTS: MEPs remained unchanged ($p > 0,073$) while CMEPs decreased at P0 ($p < 0,001$) for both muscles. The H-reflex of the FCR largely decreased at P0 and P30 ($p < 0,001$). The MEP/CMEP ratio increased for both muscles at P0 ($p < 0,05$). The H/CMEP ratio decreased at P0 and P30 for the FCR muscle ($p < 0,001$).
CONCLUSION: The MEP/CMEP ratio demonstrates that a temporary increase in cortical excitability occurs for both vibrated (FCR) and non-vibrated (ECR) muscles. The increase in the MEP response is masked by a decrease in the excitability of spinal motoneurons. Decreased spinal excitability alone does not explain the decreased H reflex for the FCR muscle. Apart from the H-reflex of the FCR muscle, the effects of TV on spinal (CMEP) and cortical (MEP/CMEP) excitability appear to be transient for both muscles, with a return to normal within 30 minutes after cessation of vibrations.
References:
1. Roll, J. P., Vedel, J. P. & Ribot, E. Alteration of proprioceptive messages induced by tendon vibration in man: a microneurographic study. Exp. Brain Res. 76, 213–222 (1989).
2. Souron, R., Baudry, S., Millet, G. Y. & Lapole, T. Vibration-induced depression in spinal loop excitability revisited. J. Physiol. 597, 5179–5193 (2019).
3. Nito, M.; Yoshimoto, T.; Hashizume, W.; Shindo, M.; Naito, A. Vibration Decreases the Responsiveness of Ia Afferents and Spinal Motoneurons in Humans. J. Neurophysiol. 2021, 1137–1147, doi:10.1152/jn.00168.2021.

**CAFFEINE SUPPLEMENTATION IS EFFECTIVE TO MODULATE THE TORQUE EVOKED BY WIDE-PULSE HIGH-FREQUENCY NEUROMUSCULAR ELECTRICAL STIMULATION.**

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INTRODUCTION: Neuromuscular electrical stimulation (NMES) is widely used in rehabilitation but holds some limitations, such as discomfort and limited evoked torque. Wide-pulse high-frequency (WPHF) NMES has been proposed to evoke larger torque ('extra torque') levels at relatively low stimulation intensity because of reflexive motor unit recruitment. However, there is a large interindividual variability in extra torque during WPHF NMES (Neyroud et al., 2018). Persistent inward currents (PICs), known as synaptic input amplifier (Heckman et

al., 2008), have been proposed as a potential mechanism underlying extra torque (Collins et al., 2001); thus any intervention aiming at enhancing PIC strength should increase WPHF NMES evoked torque. As caffeine has been suggested to enhance PIC strength (Walton et al. 2002), the present study aims at testing the hypothesis that caffeine supplementation would increase WPHF NMES torque through increased PICs.
METHODS: Sixteen healthy participants (25±5 years) participated in this double-blinded, randomized, placebo-controlled study. WPHF NMES was applied over the triceps surae during 10 s (pulse duration: 1 ms, frequency: 100 Hz) at an intensity evoking 10% of maximal voluntary contraction torque. One train of stimulation was delivered before (Pre) and 1h after (Post) placebo/caffeine (6 mg/kg) ingestion. The torque produced during stimulations was quantified using several parameters: torque time integral (TTI, area under the torque curve) and extra TTI (change in TTI relative to the value obtained during the 1st second of the train). Surface electromyography (EMG) was used on the Soleus (SOL) to measure sustained EMG activity (the persisting EMG activity after the end of the tetanic train, expressed in % maximal EMG activity), an index of PIC strength. Paired t-tests or Wilcoxon signed-rank tests were performed to test for differences in absolute changes (from Pre to Post) between conditions. Values are presented as mean ± SD.
RESULTS: Extra TTI increased after caffeine ingestion (Control: - 9±36% vs. Caffeine: +15±45%, P=0.046) as did SOL sustained EMG activity (Control: - 3±6% vs. Caffeine: + 3±4%, P=0.022), while the change in TTI values (Control: - 12±64 N.m.s vs. Caffeine: + 69±140 N.m.s, P=0.058) was close to significance. In the Caffeine condition, there was a significant positive relationship between the change in TTI and the change in sustained EMG activity (Spearman correlation coefficient = 0.57, P=0.027).
CONCLUSION: The present study shows that acute caffeine supplementation is effective to modulate WPHF NMES evoked torque. The association with the change in sustained EMG activity suggests that PICs may be involved, although this remains to be validated. These findings may pave the way for future therapeutic strategies aiming at enhancing torque production during NMES.

## THE EFFECT OF BODY TEMPERATURE DURING CYCLING EXERCISE, HOT AND COLD WATER IMMERSION ON CELL-FREE DNA LEVELS IN YOUNG ADULTS

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INTRODUCTION: As a versatile biomarker of pathophysiological conditions, cell-free DNA (cfDNA) is involved in immunomodulation, inflammation, and other biological processes (Kustanovich et al., 2019). Exercise markedly increases cfDNA values and is a promising marker for training load or overtraining (Breitbach et al., 2012); however, the underlying physiological and molecular mechanisms are still unknown.
METHODS: Here, we investigated the effect of body core temperature (Tc) on cfDNA release. To identify the relative contribution of Tc on cfDNA release, 15 young male participants completed an exercise trial (cycling at 60% VO2max until Tc reaches 39 deg), hot water (43-44 deg) immersion (until Tc reaches 39 deg), and cold water (10 deg) immersion for 1 hour. Blood samples for cfDNA analysis were taken every time the core temperature rose by 0,5 deg and returned to baseline during cycling and immersion in hot water. In cold water immersion, blood samples were collected every 15 minutes.
RESULTS: During cycling exercise, cfDNA levels increased steadily 5.98-fold from Pre (9.81 ± 4.36 ng/ml) to 39 deg (57.31 ± 31.82 ng/ml). Compared to Pre values, the cfDNA levels were significantly increased at each Tc and remained elevated until Tc returned to pre-exercise values ($p \leq 0.05$). In the passive heating trial, there were significant elevations of cfDNA concentrations measured at Tc 39 deg and 38,5 deg post compared to the baseline value. The values were increased by 1.85-fold and 1.95-fold, respectively (18.34 ±7.03 ng/ml, 19.34 ± 10.77 ng/ml). We found no significant changes in cfDNA concentration during and after cooling at each of the eleven-time points. The levels remained between a minimum of 9.18 ± 3.98 ng/ml and a maximum of 12.14 ± 11.49 ng/ml.
CONCLUSION: Our analysis reveals different responses of cfDNA depending on the changes in core temperature. Since neutrophils play a key role in the release of cfDNA under resting conditions (Moss et al., 2018), and during exercise (Neuberger et al., 2022), and increasing body temperature affects neutrophils homeostasis (Capitano et al., 2012), neutrophils might contribute to cfDNA increases during heating. However, since the fold changes are much higher during exercise (5.89-fold) compared to heating conditions (1.95-fold) a different activation of the cells is likely. Our observations indicate that the release of cfDNA is dependent on the duration of exercise and body temperature.

## GLUCOSE MONITORING DEVICES - A COMPARISON BETWEEN MEASURING IN INTERSTITIAL FLUID (CGM-SENSORS) AND CAPILLARY BLOOD AT REST AND DURING ENDURANCE EXERCISE

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INTRODUCTION: Continuous glucose monitoring (CGM) has become popular as a supportive tool in diabetic therapy. As CGM devices measure glucose in a minimally invasive manner in the interstitial fluid (ISF) in a frequency of 1 min-1, there is growing interest in the application of CGM systems in professional sports and research of glucose kinetics (Holzer et al., 2022). In a diabetic population, a lag-time between capillary blood (CB) glucose and ISF glucose was shown (Zaharieva et al., 2019). Therefore, the study's aim was to compare glucose concentrations from CB samples and from CGM measurements in an athletic population.
METHODS: Ten healthy athletes (training volume of 10±3 h, 26±4 yrs, 67±11 kg) underwent four tests at rest (R), and two running tests at 65% (65) and 85% maximal heart rate (HRmax) (85) following a standardized CHO meal in the evening prior to test morning. Tests were conducted either in a fasted (FAST) or postprandial state after intake of 1 g glucose / kg bodyweight (GLC). Glucose concentration was measured by CGM device (Abott Libre Sense Glucose Biosensor for Sport, Abbott Laboratories, Chicago, IL, US) using Supersapiens' Software for crude data access (TT1 Products Inc., Atlanta, GA, US) and CB samples (EKF Biosen C-line, EKF diagnostics Holding, Cardiff, UK). Descriptive data was calculated using Excel 2016 (Microsoft Corp., Redmond, WA, US). Further statistical analysis was performed using SPSS 28 (IBM SPSS Statistics, Chicago, IL, USA).
RESULTS: Pairwise T-test and Wilcoxon-Test analysis reveal a significant difference between CB and ISF glucose concentration for five out of six conditions ($p<.05$). Aggregated mean average relative deviation (MARD) is lowest for R_FAST (7±2%; 11±2%) and highest for 65 and 85 (22±14%; 18±11%). Pairwise T-test shows a significant difference in peak glucose concentration (PEAK) between CB and ISF for both R_Glc conditions (183±21 mg/dL vs. 167±20 mg/dL; 180±23 mg/dL vs. 159±17 mg/dL) ($p<.05$). Wilcoxon-Test for time to peak (TTP) reveals a significant difference between one out of two R_Glc conditions (27±9 mg/dL vs. 38±8 mg/dL) and for 85 (72±5 mg/dL vs. 43±20 mg/dL) ($p<.05$).

CONCLUSION: The present study shows a delay in ISF compared to CB glucose concentration. Beyond that, results show a higher deviation under exercising conditions compared to resting conditions. Further data collection especially postprandially and during physical activity is needed to confirm current findings and to estimate chances of CGM devices' application in practice and research.
Holzer, R., Bloch, W., & Brinkmann, C. (2022). Continuous Glucose Monitoring in Healthy Adults—Possible Applications in Health Care, Wellness, and Sports. Sensors, 22(5), 2030.
Zaharieva, D. P., Turksoy, K., McGaugh, S. M., Pooni, R., Vienneau, T., Ly, T., & Riddell, M. C. (2019). Lag Time Remains with Newer Real-Time Continuous Glucose Monitoring Technology During Aerobic Exercise in Adults Living with Type 1 Diabetes. Diabetes Technology & Therapeutics, 21(6), 313–321.

## RELATIONSHIP BETWEEN SUBMAXIMAL OXYGEN CONSUMPTION AND BONE MINERAL DENSITY DIFFERS BETWEEN TRI-ATHLETES AND MARATHONERS

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INTRODUCTION: Maintaining bone mineral density (BMD) is a crucial component of lifelong bone health and is particularly important for injury prevention in sport. Athletes participating in high impact sports have higher BMD compared to running athletes [1], underscoring the importance of mechanical loading in osteogenesis [2]. In contrast, cyclists and swimmers are at a greater risk for osteopenia due to low mechanical loading [3]. Currently, there is a dearth of information about BMD in triathletes, combining running, cycling and swimming. Given that aerobic fitness may influence the extent to which an athlete can generate osteogenic bone stress during training, the purpose of this study was to assess the relationship between submaximal and maximal oxygen uptake and BMD across endurance athletes involved in multiple activities vs. endurance running alone.
METHODS: Triathletes (TA; n = 14, age = 38.4 ± 13.5 yrs, 7M:7F), training for an Ironman or similar event, and high-level marathoners (HLM; n = 14, age = 44.2 ± 17.3 yrs, 7M:7F), as determined by recent achievement of a Boston Marathon qualifying time, volunteered for this IRB-approved study. Dual energy x-ray absorptiometry (DEXA; Lunar iDXA; GE Healthcare, Chicago, IL) assessed total body, spine (L1-L4), and femoral neck BMD, which were converted to T-scores accordingly. An incremental treadmill protocol using a metabolic cart (Quark CPET; COSMED, Rome, Italy) recorded submaximal oxygen consumption (VO2) at participants' self-reported half-marathon race pace (RP) and maximal VO2 (VO2max) at maximal exertion. Independent t-tests were used to assess group differences. Simple bivariate correlations were assessed between each BMD measure and both RP and VO2max for both groups. $\alpha$ was set $p \leq 0.05$.
RESULTS: There were no differences between groups in VO2max, RP, or BMD ($P > 0.05$). RP VO2 was higher in HLM (45.5±7.3ml/kg/min) vs. TA (39.25 ± 6.2; $p = 0.03$). There were significant positive and moderate relationships between RP VO2 and femoral neck BMD ($R2 = 0.29$, $p = 0.048$) and total BMD ($R2 = 0.32$, $p = 0.036$) in the HLM group. These relationships were insignificant in the TA group ($R2 = 0.03$, $p = 0.58$; $R2 = 0.003$, $p = 0.84$). Trending correlations ($p < 0.10$) were seen between VO2max and BMD (FN, LS and total) in HLM, but not in TA participants.
CONCLUSION: The results indicate that higher RP VO2 is related to greater BMD in HLM but not in TA. Since higher RP VO2 was strongly associated with greater speed at RP ($p < 0.0001$), this could facilitate increased accumulation of osteogenic bone stress during chronic training in HLM. Its possible that TA do not see the same changes in BMD with RP VO2 because of training regimen differences, but further investigation is needed. These findings provide a basis for future research to understand the complexities contributing to BMD in endurance athletes.
REFERENCES
1. Mudd, et al. J Athl Train. 2007
2. Wilks, et al. Bone. 2009
3. Scofield, et al. Curr Sports Med Rep. 2012

## DOES THE NUTRITIONAL VALUE OF THE PALEO DIET MEET THE RECOMMENDATION FOR PROFESSIONAL ATHLETES?

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INTRODUCTION: Paleolithic nutrition is based on the principles of evolutionary biology with a focus on the moderate carbohydrate options available to hunter–gatherers. The relatively small amount of carbohydrates in the Paleo diet is increasingly used by athletes with the aim of using fat during exercises and saving carbohydrate reserves. The purpose of the study was to evaluate the nutritional value of the isocaloric Paleo diet according to recommendations dedicated to professional athletes.
METHODS: The food rations were prepared for nine professional handball players considering the isocaloric model of the Paleo diet (PD) based on individual assumptions. The following energy share of macronutrients was adopted: 20-30% protein, 35-40% fat and 30-35% carbohydrates. A total of 504 daily food rations were created and then prepared by the catering company for 8 weeks for each athlete. The nutritional value of the Paleo diet applied by athletes was compared to the recommendations for ones according to various position stands.
RESULTS: In relation to the recommendation for athletes the Paleodiet distinguished by a higher content of protein (24,22%, but not in g/kg of body mass: 2,82g/kg), fats (40,52%; 2,06g/kg of body mass), saturated fatty acids (15,76%), cholesterol (1018,16mg), fiber (59,86 g/d) and lower amount of carbohydrates (35,13%; but sufficient in g/kg of body mass: 4,23g/kg), sucrose (13,09%), polyunsaturated fatty acids (5,44%). The PD is characterized by an adequate content of sodium and vitamins: K, B1 and higher (exceeding the RDA/AI) content of minerals: phosphorus, iron, magnesium, zinc, copper, potassium, manganese, selenium, and vitamins: A (higher than UL), E, C, niacin, vit. B2, B5, B6, B12, and folic acid but lower than RDA/AI amount of minerals: calcium, and vit. D.
CONCLUSION: The analysis of the content of macro- and micronutrients in the Paleodiet, considering the increased energy needs of athletes, allows it to be considered a diet with high nutritional value. The carbohydrate content is close to the lower limit of the recommendation, and the fat content is slightly higher than the upper limit of the recommendation. Recommendations for polish population have been implemented. The Paleodiet is characterized by a high content of vitamin D, which should be considered an exceptionally beneficial feature of the diet. The results allow to justify the use of the PD by athletes as an effective method of nutrition with a low risk of deficiencies in most nutrients. A properly composed PD can be considered as a strategy for athlete representatives of disciplines that do not require high availability of carbohydrates (e.g., team sports).

### CAFFEINE DOES NOT INCREASE PERSISTENT INWARD CURRENTS IN HUMAN TIBIALIS MUSCLE

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INTRODUCTION: Neuromodulation is a fundamental part of normal motor command. Several neurotransmitters play a role in neuromodulation. Specifically, serotonin and noradrenaline facilitate persistent inward currents (PIC) in motoneurons. PIC amplify and prolong synaptic input allowing motor units to fire at higher frequencies, as observed during normal motor behaviour. Caffeine is a methylxanthine known to increase the release of noradrenaline, enhance the concentration of serotonin, and increase self-sustained firing in human motor neurones. Self-sustained firing is a characteristic of PIC activity. Thus, we aimed to evaluate if the consumption of caffeine could influence estimates of PIC (measured through the paired motor unit technique) in human tibialis anterior muscle.
METHODS: In a crossover, double-blind design, 6 participants were asked to visit the laboratory on two occasions. For each visit, participants performed isometric submaximal triangular contractions (20% of their maximum force) with their tibialis anterior muscle. Surface electromyography (EMG) was recorded from a 64-channel electrode matrix over the muscle. EMG signals were decomposed into single motor unit discharge events and then converted into instantaneous discharge rates. ?Fs were calculated for pairs of motor units using a fifth order polynomial fit. All testing measurements were performed before and 60 min after consuming 6 mg · kg-1 of either a placebo (PLA) or caffeine (CAFF).
RESULTS: No differences were observed for ?F between PLA and CAFF (p = 0.07; ?2 = 0.04). ?F pre-post supplement consumption was 4.62 (95%CI: 2.83 ? 6.40) to 4.22 pps (95%CI: 2.78 ? 5.65) for CAFF and 4.33 (95%CI: 2.98 ? 5.68) to 5.01 pps (95%CI: 3.71 ? 6.31) for PLA.
CONCLUSION: Our findings show that an acute dose of 6 mg · kg-1 of caffeine was unable to modify estimates of PICs amplitude of lower-threshold motoneurons from healthy humans tibialis muscle.

## Conventional Print Poster

### CP-AP04 Plyometrics / HIT

### IMPACT OF ACUTE HEAT EXPOSURE ON THE CRITICAL POWER CONCEPT AND TIME TO EXHAUSTION DURING A HIGH-INTENSITY INTERVAL TEST IN MEN AND WOMEN

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INTRODUCTION: The effect of heat on interval exercise is, up to now, not well documented, in contrast to sprint and endurance exercise. The aim of this study was to investigate the impact of acute heat exposure on the determination of the Critical Power Concept parameters and the recovery kinetics during a high-intensity interval test (HIIT) in a physically active male and female population.
METHODS: Twelve men (V̇O2peak: 58.2 ± 5.2 ml.min-1.kg-1, age: 25.4 ± 3.3 years, height: 1.82 ± 0.05 m, body mass 74.3 ± 9.1 kg) and twelve women (V̇O2peak: 41.2 ± 5.3 ml.min-1.kg-1, age: 26.4 ± 3.4 years, height: 1.69 ± 0.05 m, body mass 61.9 ± 5.5 kg) performed three constant load tests between 2 and 15 min to establish critical power (CP) and the curvature constant (W'), both in 18°C (TEMP) and 36°C (HOT) with 40% relative humidity. Afterwards, three HIIT were executed., one in TEMP based on CP and W' determined in TEMP (HIIT-1) and two in HOT, of which one based on CP and W' determined in TEMP (HIIT-2) and one in HOT (HIIT-3), respectively. HIIT consists of three work bouts (WB) to exhaustion, separated by 5 min active recovery, respectively at the intensity equal to the individual theoretical time to exhaustion (TTE) in 4 min based on CP concept (P4) and 90 % of individual gas exchange threshold (90%GET).
RESULTS: CP was lower in HOT compared to TEMP in men (267 ± 29 vs. 249 ± 30 W; p < 0.001) and women (187 ± 30 vs. 176 ± 29 W; p < 0.001), while W' was higher in men (20.0 ± 3.1 vs. 22.7 ± 4.5 kJ; p = 0.026) and women (12.8 ± 1.6 vs. 14.3 ± 2.6 kJ; p = 0.032). P4 was slightly lower in men (350 ± 32 vs. 344 ± 32 W; p = 0.055) and women (240 ± 32 vs. 235 ± 35 W; p = 0.044). Predicted TTE at WB1 was only correctly estimated (i.e., 240 s) in HIIT-1 in men (235 ± 38 s; p = 0.651 ) and women (226 ± 32 s; p = 0.165). TTE was different in HIIT and WB, regardless of sex of the participants (p = 0.008).
CONCLUSION: This study showed that acute heat exposure affected the determination of CP and W', using multiple constant load tests, in an opposite direction. The hyperbolic relationship was skewed with acute heat exposure, as short trials (2-5 min) were less impacted, in contrast to long trials (12-15 min). It has been shown that the use CP concept during interval exercise in heat needs special attention. Even though CP and W' are determined in HOT, TTE in HIIT was still diminished compared to TEMP in both men and women.

### EFFECTS OF 5-WEEKS OF 30-S ALL-OUT SPRINT INTERVAL TRAINING ON CONSTANT SEVERE DOMAIN EFFORT PERFORMANCE, NEUROMUSCULAR FUNCTION AND GLYCOLYTIC RESPONSES.

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INTRODUCTION: All-out efforts performed during sprint interval training (SIT) require a high demand of neuromuscular system as well as glycolytic pathway [1-2] and it is expected that chronically an improvement in physiological parameters and performance. However, some studies have reported reduction on the time to exhaustion for an equalized exercise intensity (ie., 115%@iVO2max) [3]. Thus, the study aimed to investigate the effects of 5-weeks of SIT on glycolytic pathway, neuromuscular function and time to exhaustion in a severe-domain effort.
METHODS: In the baseline moment (A1), 14 healthy men underwent a cycling graded exercise test to determine the respiratory compensation point (RCP) and an until exhaustion effort test at severe-domain (150% of RCP). Neuromuscular assessment by twitch interpolation technique were performed before and immediately after the severe-domain effort. In addition, muscle biopsies of vastus lateralis were also performed to measure the glycogen content, content (Western Blotting) and activity of enzymes hexokinase II (HK), glycogen phosphorylase (Gphos), phosphofructokinase (PFK), and lactate dehydrogenase (LDH), and muscle tissue buffering capacity. After A1, the participants were randomized into training group (TG; n=8) and control group (CG; n=6). The TG performed 5-weeks of the SIT (4-6 all-out sprints of 30-s; workload:0,70 Nm·kg-1; rest:4-min) while control group remained out of regular training programs. After 5-weeks (A2), the same

measurements performed at A1 were repeated. A two-way ANOVA for repeated measurements were used to detect changes between moments and groups. Significant main effects were followed-up by SIDAK post-hoc. Significance was set at $p<0.05$.
RESULTS: There was no difference in time to exhaustion at 150% of RCP for any group or moments ($p=0,66$; $F=0,20$). No significant interaction was observed for any neuromuscular outcomes (i.e., peak force; force evoked by doublet high-frequency, low frequency, and single stimulus; voluntary activation; and m-wave amplitude, and root mean square of electromyography) ($p=0,19$; $F\geq0,14$). The pre-effort glycogen content increased significantly for TG from baseline to post training (+27,3%; $p=0,03$), however there is no difference for content when measured after exhaustion ($p\geq0,56$; $F\leq0,36$). The content of HK, GPhos and LDH increased for TG (+56,3%; +12,2%; +20,4% respectively; $p<0,05$). The enzymatic activity of HK, LDH and PFK during A2 pre-effort increased only for TG when compared pre-effort in A1 (+22,4%; +21,2%; +57,6%, respectively; $p\leq0,04$), however there is no significative difference in the delta percentage during exercise ($p>0,06$;$F>3,38$). In addition, there was no difference for delta percentage buffering capacity ($p=0,93$;$F=0,01$).
CONCLUSION: Although 5-weeks of SIT to improve the glycolytic enzymatic content and activity, the time to exhaustion at 150% of RCP did not improve, as well as the neuromuscular function.
[1] Buchheit & Laursen (2013), [2] Malta et al. (2018), [3] Milioni et al. (2019)

**EARLY NEUROPLASTICITY INDUCED BY HIGH-INTENSITY INTERVAL TRAINING IN RATS WITH CEREBRAL ISCHEMIA**

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INTRODUCTION: Among its multiple benefits, endurance-training regimens might promote cerebral plasticity, or neuroplasticity, after stroke while optimal exercise parameters, such as intensity and duration of sessions, remain to be defined. Cognitive and sensorimotor functions partially depend on cortical actions of neurotrophic factors. Indeed, the brain-derived neurotrophic factor (BDNF) and/or insulin-like growth factors (IGF-1) could promote neuronal survival by modulating the expression of anti-apoptotic factors and pro-apoptotic factors. The neurotrophic factors could also influence GABAergic activity by interacting with potassium-chloride-cotransporter 2 (KCC2), a neuronal chloride extruder, and sodium-potassium-chloride-cotransporter 1 (NKCC1), a chloride intruder. These two chloride cotransporters play a crucial role in synaptic transmission and functional recovery after stroke.
When individualized, the high-intensity interval training (HIIT) is a time-efficient and secure endurance training regimen during the critical period of stroke rehabilitation (i.e., first weeks in rodents and first months in human post-stroke). To improve the translational relevance of training protocols, we use common physiological parameters of exercise intensity in humans and rodents, such as the speed associated with lactate threshold (SLT) and maximal speed (Smax), to distinguish low- from high-intensities and individualize running speed, as recommended in clinics. However, the early influence of individualized HIIT on sensorimotor/cognitive disorders as well as on the neuroplasticity processes (neurotrophins, apoptosis and cation-chloride cotransporters) remains poorly investigated in rodents.
This study is thus designed to assess the effects of individualized HIIT over a 2-week training on neurotrophic factors, key markers of apoptosis and cation-chloride cotransporters in both cerebral cortices in rats with cerebral ischemia, along with cognitive/sensorimotor functions and endurance performance.
METHODS: Rats with a 2-h cerebral ischemia performed HIIT (long intervals; 4min) for 2 weeks. Incremental exercise tests and sensorimotor tests were performed at day 1, 8, and 15 (D1, D8, and D15) and cognitive tests at D15. Molecular analyses (Western blot and ELISA) were achieved in both ipsi- and contralesional cortices at D17.
RESULTS: HIIT early promote expression of cortical neuroplasticity markers in both ipsi- and contralesional cortices. HIIT induces gains in endurance performance in a time-dependent manner and slight improvements in mechanical forepaw sensitivity. However, no effect on cognitive functions was found.
CONCLUSION: HIIT alone is effective to stimulate neuroplasticity in both hemispheres and to improve endurance capacities, but when HIIT is alone, it remains insufficient to enhance cognitive and sensorimotor functions after stroke suggesting that combination between HIIT and other rehabilitation strategies should be investigated.

**MONITORING OF JUMPS WITH AN AD-HOC INERTIAL SYSTEM**

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INTRODUCTION: The height and time that an athlete is able to jump can be a clear indicator of both their physical ability and the state of fatigue. An electronic system has been designed, based on Inertial sensors, where the data are collected and processed using an ad-hoc developed application running on a smartphone. The main motivation for this development has been to achieve a wearable system capable of monitoring jump performance accurately, achieving the highest possible portability while maintaining a low-cost design, which would represent a considerable improvement with respect to the methods currently used [1].
METHODS: In a preliminary system evaluation, three subjects of similar complexion participated in this study, being the technique performed the countermovement jump (CMJ). Data was collected with both a force platform as a gold standard (Kistler 9260AA6) and the inertial system simultaneously.
The developed system consists of an inertial measurement unit that includes a microcontrolled 3-axis accelerometer with a sampling frequency of 200 Hz and configured in the range of +-16g. It is connected to a smartphone through the low energy Bluetooth protocol thanks to the BM78 module. It also has a lithium-polymer battery of 450 mAh that provide an autonomy higher than 3 hours and an SD card that allows data storage. The total weight of the system is 47 g, which is almost unnoticeable to the athlete. For data processing, an algorithm has been developed to detect the most characteristic points of acceleration and obtain both the time the jump duration and the height reached, and has been implemented in a smartphone application.
RESULTS: A statistical analysis was carried out to verify the level of agreement of the data reported by the force platform and the system developed, both with the flight time and the jump height, being the results obtained satisfactory, as a good correlation of the data can be found (linear regression is 1,04x-0,01 and R2 factor 0,91 in the first case, and 1,1x-0,03 with R2 factor of 0,91 in the second one) and the high repeatability of the measurements has also been checked. If error percentages are calculated in absolute value, the average would be 1,53% and 3,63% respectively, which is a rather small value.
CONCLUSION: From this preliminary evaluation, it can be concluded that the proposed system presents promising capabilities. Work is currently conducting a validation trial with a larger number of more differentiated subjects, and the system is expected to be applied in field trials.

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REFERENCES:
[1] A. Magnúsdóttir, B. Porgilsson, B. Karlsson, "Comparing three devices for jump height measurement in a heterogeneous group of subjects", Journal of Strength and Conditioning Research, 2014
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**INTRASESSION AND INTERSESSION RELIABILITY OF A LOW-COST JUMP TOOL**

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INTRODUCTION: The vertical jump is linked to lower body power, an essential physiological characteristic in many athletic skills. The 'gold standard' for measuring vertical jump employ costly equipment such as force platform or high-speed motion cameras. Portable, useful, and accessible low-cost equipment are currently available for practitioners. The purpose of this study was to investigate the intrasession and intersession reliability, and usefulness of a single-beam laser jump equipment for measurement of jump performance.
METHODS: Three experimentation sessions between 0600-0800 hrs, separated by 24 h, at the training facility were participated by seven male and five female world class poomsae athletes. Athletes executed a standardised warm-up, succeeded by three trials of hands-on-waist countermovement jump (CMJ). Rest interval in between trials is 60 s. Athletes were encouraged to jump and land at a specified area, ensuring similar contact of the foot between the laser during take-off and landing. Additional trial was carried out for an unsuccessful jump execution or any CMJ discrepancy of > 5 cm across trials. CMJ was acquired from a single-beam laser equipment connected to a mobile application (Jump Pro, Mobi Pro, Philippines), using the flight time equation. The average CMJ height of three trials was used for analysis. Relative reliability was established using intraclass correlation coefficient (ICC), interpreted as poor (< 0.5), good (0.7-0.9), and excellent (>0.9). Absolute reliability was identified through typical error as coefficient of variation (%CV), expressed as good if %CV < 5%. Comparison of smallest worthwhile change (SWC) (computed by 0.20 mutiplied by between-subject standard deviation) and typical error (TE) was used to establish usefulness, interpreted as marginal (TE > SWC), ok (TE = SWC), or good (TE < SWC). The reliability spreadsheet by Hopkins (2015) was used for calculating reliability and SWC.
RESULTS: Intrasession values are as follows: Day 1 (CMJ: 44.7 ± 1.40 cm; ICC = 0.96; %CV = 3.16); Day 2 (CMJ: 42.8 ± 0.78; ICC = 0.99; %CV = 1.80); and, Day 3 (CMJ: 42.9 ± 1.01 cm; ICC = 0.99; %CV = 2.38). Intersession values displayed ICC = 0.98, %CV = 3.57, TE = 1.21 cm, and SWC = 1.41 cm.
CONCLUSION: This study investigated the intrasession and intersession reliability of CMJ performance using a low-cost tool. Results revealed excellent relative reliability and good absolute reliability for CMJ across all sessions. CMJ intersession relative reliability was excellent, with good absolute reliability. The usefulness of low-cost jump tool was also deemed good. In conclusion, the low-cost jump tool is reliable and useful for measurement of intrasession and intersession countermovement jump performance.

## Conventional Print Poster

### CP-MH08 Ageing and strength

**AGE-RELATED CHANGES IN THE SKELETAL MUSCLES OF THE EXTREMITIES OF THE MIDDLE-AGED AND ELDERLY**

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INTRODUCTION: The goal of this study was to look into the characteristics of changes in limb muscle mass, strength, and quality in healthy middle-aged and older persons aged 40-69 years.
METHODS: The study included 900 healthy middle-aged and older adults aged 40 to 69 years. Questionnaires were used to gather basic information; The nylon tape ruler was used to determine body form, and the dual-energy X-ray absorptiometry scanner DXA was used to determine body composition. Researchers used an electronic grip strength meter and a motor function analyzer to test grip strength and squat strength. Skeletal muscle mass was calculated using the ratio of limb muscle mass (kg) to height squared (m2). For the calculation of muscle mass, the strength index of the corresponding limb such as grip strength or squat strength (kg) is used divided by the skeletal muscle mass of that limb (kg). When evaluating differences across groups, SPSS 11.0 was used, and multiple comparisons and ANOVA were used.
RESULTS: (1) In middle-aged and older adults, there was a gradual loss of limb muscle mass. (2) Men and women showed different incremental age-related changes in skeletal muscle mass, with men aged 60-69 years showing a degree of decline in skeletal muscle mass of the limbs compared to those aged 40-49 years ($P < 0.05$); however, the difference between men and women was not significant, and the rate of change in all parts of the muscle was lower than that of men. (3) The decrease in skeletal muscle mass in the right upper and lower limbs was slightly greater than in the left upper and lower limbs ($P < 0.05$). (4) Grip strength levels in the 60-69 age group were around 15% lower than in the 40-49 age group, but squat strength dropped by about 30%. (5) In the 60-69 age range, lower limb muscle quality fell by more than 20% in both men and women, but upper limb muscle mass declined by just 10% to 15%. The right limb had slightly more muscle mass than the left ($P < 0.05$), but there was no statistical difference between males and females.
CONCLUSION: (1) Skeletal muscle mass declines faster in men than in women as they age, but there are no gender differences in skeletal muscle quality. (2) Most peoples right limb has more skeletal muscle mass and muscle strength than their opposing side. (3) Skeletal muscle mass is higher in all lower limbs than in the upper limbs, but the rate of age-related skeletal muscle mass degradation may be higher in the lower limbs.

**IMPACT OF EXERCISE HABITS DURING MIDDLE AGE ON MUSCLE MASS AND AEROBIC CAPACITY AT OLD AGE**

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INTRODUCTION: The impact of regular exercise habits at middle-age on muscle mass and function at old age remains inconclusive. While regular exercise likely represents a primary source of health-enhancing PA, the physical demand of occupation needs to be considered. Additionally, PA level at old age should be taken into account in order to elucidate true associations between past exercise behaviors and muscle mass and function at old age. Therefore, the aim of the study was to examine the impact of regular exercise habits during middle age years on muscle mass and physical function at old age, while considering occupation and objectively assessed PA level at old age.
METHODS: Self-reported leisure-time physical activity (PA) during middle age years [35-65 years] and present accelerometer-derived PA level were assessed in a population of community-dwelling older women (65-70 years; n=117). Participants who accumulated at least 600 MET-min of PA per week during middle age years were classified as physically active. Skeletal muscle mass index (SMI), aerobic fitness and maximal isometric arm and leg strength were determined. Analyses of differences in muscle mass and physical function between physically active and inactive at middle age were adjusted by present PA, adiposity level, and the physical demand of former occupation (sedentary vs manual).
RESULTS: Participants accumulating at least 600 MET-min of exercise-related activities during middle-age years had higher aerobic fitness ($P<0.01$) and SMI ($P<0.05$) at old age compared to their less active peers. Notably, these beneficial impacts were driven by exercise habits during late middle-age period [50 to 65 years], and remained significant after further adjustment by the physical demand of former occupation and present PA behavior at old age. Finally, middle-age engagement in exercise-related activities had no influence on maximal arm and leg isometric strength at old age.
CONCLUSION: Our findings highlight the importance of engaging in regular PA of at least moderate intensity during middle age years in order to promote benefits at the level of muscle mass and aerobic fitness. This clearly supports the potential of PA in delaying aerobic capacity impairment and the occurrence of clinically manifest sarcopenia at old age.

**MULTIMODAL AGILITY TRAINING DOES NOT AFFECT HANDGRIP STRENGTH IN HEALTHY OLDER ADULTS**

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INTRODUCTION: Handgrip strength is considered as an important vitality surrogate indicator for general fitness, cognitive status and frailty in older adults. A meta-analysis of our group revealed that handgrip however does not notably reflect adaptations from whole body resistance training. Compared to selective health-related strength, balance and endurance exercise for seniors that can sum up to more than 500 weekly minutes of exercise, multimodal exercise training approaches seem to be more functional and related to relevant tasks of daily activity (e.g., stop and go, change in direction, cutting and reactive and decision making demands). As rate of force development (RFD) of handgrip strength and maximum handgrip strength (Fmax) are related to mobility in the elderly, it is aimed to analyse the relation between handgrip strength (Fmax and RFD) and motor performance assessed via the agility challenge for the elderly (ACE). Finally, our RCT aims at analysing the effects of such a multimodal agility training approach on handgrip strength in healthy older adults.
METHODS: Healthy older adults (N=79, age 72.2±4.8 years, weight 77.4±15.1 kg, height 169±10 cm) were randomly assigned to either an intervention (IG, n=39) or control group (CG, n=40). IG took part in multimodal agility training (strength, coordination, start-stop movements and change of directions, dual task and decision making tasks) twice a week for one year. Total training volume was 90 sessions and adherence ranged between 56-91%. CG continued participating in their normal behavioural sportive and daily activities. Handgrip strength (Fmax and RFD) was assessed pre and post with a hand dynamometer in a stable standing position and was computed using the software IsoTest. Time to complete ACE parcourse was assessed in pre and post measurements.
RESULTS: Of the recruited participants n=51 completed pre and post measurement for handgrip strength. Repeated measurements ANOVA (IG vs. CG) x (pre vs. post) for maximum handgrip strength revealed no significant group x time interaction ($F(1,31.9734)=0.0002$, $p= .98$). Repeated measurements ANOVA for handgrip strength RFD revealed also no significant group x time interaction ($F(1,29.0061)=2.8617$, $p= .10$). For correlation analysis n=66 completed the measurements for handgrip strength and ACE. Spearman correlation for ACE and Fmax HGS ($r(64) = - .367$, $p = .005$) and for RFD ($r(64) = -.487$, $p < .001$) was found to be negative.
CONCLUSION: A one-year multimodal agility training does not affect handgrip strength in healthy older adults. This could be due to the non-specific exercises for handgrip strength, as already concluded in the meta-analysis of our group. Motor performance is weakly associated with Fmax and RFD handgrip strength in healthy older adults. Handgrip seems not specific and sensitive to a multimodal whole body training, nevertheless it could reveal more information when study participants suffer from diseases as frailty, cognitive impairment or are at a high risk for falling.

**PHYSIOLOGICAL AND PSYCHOLOGICAL RESPONSES TO A PROGRESSIVE ACUTE SESSION OF SLED-PUSH EXERCISE AMONG OLDER ADULTS: PRELIMINARY FINDINGS**

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INTRODUCTION: Sled-pushing is a functional full-body compound exercise defined as weighted or resisted sprint training. This study aimed at reporting preliminary results of the acute effect of a motorized wheeled sled-push exercise among older adults on physiological and psychological parameters compared to a walking session.
METHODS: This preliminary analysis included 18 older adults (Mean±SD; age: 68.9±4.9 years; BMI: 25.9±4.3 kg/m2; 56% women) that were randomly allocated into either the sled-push (SLP; n = 9) or walking (WKG; n = 9) group. We assessed: heart rate (HR) using a HR monitor with chest strap, rate of perceived exertion (RPE) using the Omni scale, and enjoyment using the Physical Activity Enjoyment Scale (PACES). The exercise protocol involved participants pushing a motorized wheeled sled 6 times on a 30-meter course with 2-minute rest periods in between. The exercise of the SLP was based on normal average speed pushing the sled with the motor disconnected (i.e., no resistance). Normal average speed was then used to create three different exercise intensity/speed zones: subnormal (75 and 85%), normal (100%), and supranormal (125%); with the 100 and 125% speed being completed twice each and the average used for the analysis. Data were collected during all 2-minute rest periods. An online metronome connected via Bluetooth to a speaker was used to pace and monitor

speed. The WKG condition performed the same task but without the sled. Data were analyzed using Mixed-Factor ANOVAs and independent t test with significance level set at p <.05, with holm correction.
RESULTS: Mixed-factor ANOVA revealed no statistically significant speed by group interactions on HR (F = 2.874, p = .071, ηp2 = .152) or RPE (F = 0.954, p = .396, ηp2 = .056); but there was a main effect for speed/intensity on HR (F = 6.282, p = .005, ηp2 = .282) and RPE (F = 16.514, p = <.001, ηp2 = .508); and a main effect for group on HR (F = 17.237, p = <.001, ηp2 = .519) and RPE (F = 19.408, p = <.001, ηp2 = .548). HR for the SLP group was higher than the WLK group for all speeds (Subnormal: 109.6±15.1 vs 86.3±15.9 bpm; Normal: 115.2±27.3 vs 83.9±14.8 bpm; Supranormal: 131.3±20.1 vs 89.6±16.4 bpm). Similar pattern was observed for RPE (Subnormal: 4.8±1.7 vs 1.7±0.7; Normal: 6.0±2.2 vs 2.1±0.9; Supranormal: 6.7±2.9 vs 3.1±1.5). No significant difference was observed for enjoyment between the SLP (5.16±1.38) and WLK (5.07±1.06) group; t(16) = .167; p = .869, d = .073).
CONCLUSION: The acute sled-push session demonstrated an intensity driven modality that may have potential to elucidate positive adaptations in the cardiovascular system of older adults as indicated by a linear increase in HR and RPE as the intensity of the exercise was increased. Overall activity enjoyment was high (5 out of 8) and similar between both activities. This is a positive finding since enjoyment has been associated with exercise participation and adherence.

## COMPARISON BETWEEN 10 VS. 20% VELOCITY LOSS DURING VELOCITY-MONITORED RESISTANCE TRAINING ON STRENGTH, POWER, AND FUNCTIONAL CAPACITY IN OLDER ADULTS

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INTRODUCTION: Recent studies demonstrated the effectiveness of 10 and 20% velocity loss (VL) during velocity-monitored resistance training (VMRT) on the improvement of strength and functional capacity in older adults [1, 2]. Nevertheless, to our best knowledge, no study examined the differences between 10 vs. 20% VL in the same intervention on older adults strength, power, and functional capacity. Therefore, in this study, we compared the effects of 10 vs. 20% VL on strength, power, and functional capacity in older adults.
METHODS: Eighteen community-dwelling older adults (75.5±11.2 years; 28.1±5.0 BMI) were randomly assigned into two groups: VL of 10% (VL10, n=10) or 20% (VL20, n=8). The participants performed a 10-week VMRT program (two sessions per week) using the leg press and chest press at 40-65% of 1 repetition maximum (1RM). In all training sessions, each repetitions mean velocity was monitored using a linear velocity transducer. At pre-test, mid-test (week 5), and post-test, the maximum dynamic strength (1RM) and peak power (PP) were estimated through a progressive loading test in the leg press and chest press. In addition, the 10-m walking (T10) time, 5-repetition sit-to-stand (5STS) time, and 1-kg medicine ball throw (MBT) distance were assessed at pre and post-test.
RESULTS: We did not observe significant differences between groups on strength and power measures at pre, mid, and post-test. Both groups significantly improved the 1RM and PP leg press from pre to mid-test (VL10: 11±6.0 kg and 40.2±42.6 W; VL20: 8.9±4.0 kg and 32.8±19.1 W), but neither group significantly improved these outcomes from mid to post-test. In the 1RM and PP chest press, there were no significant improvements in both groups at any time point. Regarding the functional capacity outcomes, we did not observe significant differences between groups at pre and post-test. Both groups significantly improved the 5STS time (VL10: -1.3±0.9 s; VL20: -1.4±0.9 s), but only the VL20 significantly improved the T10 time (VL10: -0.2±0.4 s; VL20: -0.3±0.3 s). Finally, no group significantly improved the MBT distance after the intervention.
CONCLUSION: Our results showed that VL10 and VL20 produced similar lower-limb strength and power gains after five weeks of VMRT, which remained stable until the end of the intervention. In addition, both groups improved the 5STS time, while only the VL20 group improved the T10 time. These results suggest that VL10 and VL20 are equally effective in increasing lower-limb strength and power and the ability to rise from a chair, while VL20 might yield better results than VL10 to improve walking performance.
[1] Marques, D. L., et al. Novel Resistance Training Approach to Monitoring the Volume in Older Adults: The Role of Movement Velocity, Int. J. Environ. Res. Public Health (2020).
[2] Marques, D. L., et al. Velocity-Monitored Resistance Training in Older Adults: The Effects of Low-Velocity Loss Threshold on Strength and Functional Capacity, J Strength Cond Res (2021).

## PHYSICAL FUNCTION AND HEALTH-RELATED QUALITY OF LIFE IN OLDER MEN AFTER 10-WEEKS POWER TRAINING – ANY ASSOCIATIONS?

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INTRODUCTION: A meta-analysis by Hart and Buck1 support the promotion of resistance training in improving health-related quality of life (HRQL) in older adults. However, in a study by Katula et al.2 it was concluded that high velocity power training may positively influence multiple levels of quality of life more than traditional strength training. In a recent study Sunde et al.3 found that physical function and HRQL-physical were strongly linked, and interventions improving physical function might improve HRQL-physical. The objective of the present study was therefore to investigate the effect of 10-weeks power training on physical function and HRQL, in addition the association between these variables at baseline and with training-induced improvements in older men.
METHODS: Forty-nine elderly men (67.7±5.3yrs, 83.4±10.5kg, mean±SD) completed a 10-weeks biweekly power training intervention. Physical function was assessed as Leg-press power (Keiser Air300), Sit-to-stand power (MuscleLab force plate), Timed-up-and-go time, Stair-climbing-time (15 steps), and Grip strength. HRQL was assessed by the Short Form health survey questionnaire (SF-12). Paired sample T-test and Wilcoxon signed rank test were used to analyse changes from pre to post. A stepwise linear regression was used to examine associations between physical function and HRQL. Alpha level of 5% was chosen for statistical significance.
RESULTS: At baseline, grip strength was positively associated with both the physical (R2=0.14, p<0.01) and mental (R2=0.19, p<0.01) component of HRQL. After the training period, the participants increased physical function measured as Grip strength (2.0±2.5 kg [5.4%], p<0.001), Leg-press power (40.2±68.0 W [4.2%], p<0.001), Timed-up-and-go time (-0.7±0.20 sec [-1.6%], p<0.017), and Stair-climbing time (-0.2±0.3 sec [-5.2%], p<0.001), in addition to an increase in HRQL-physical (6.5 [median] [7.9%], p<0.01) and HRQL-mental (3.5 [median] [4.2%], p=0.04). Additionally, changes in Grip strength were positively associated with changes in HRQL-physical (R2=0.06, p=0.04).
CONCLUSION: The current study revealed significant improvements in physical function in older men after 10-weeks power training. These changes were accompanied by increase in physical and mental components of HRQL. Furthermore, Grip strength at baseline was positively associated with both components of HRQL. Whereas changes in Grip strength were positively associated with changes only in the physical component of HRQL. However, caution should be taken when interpreting these associations. Future studies should therefore investigate

the effect of power training including exercise and non-exercise groups to determine how physical function may affect HRQL in older adults.

1. Hart and Buck, Health Promot. Perspect., 2019
2. Katula et al., Health Qual. Life Outcomes, 2008
3. Sunde et al., Eur. Geriatr. Med., 2021

**TO EXPLORE THE EVALUATION METHOD OF LOWER LIMB SKELETAL MUSCLE STRENGTH IN HEALTHY MIDDLE-AGED AND ELDERLY PEOPLE**

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INTRODUCTION: This study aims to explore the evaluation indexes and measurement methods of skeletal muscle strength of lower limbs in healthy middle-aged and elderly people aged 40 to 69 years, so as to evaluate the muscle strength quality of lower limbs in healthy middle-aged and elderly people.
METHODS: The subject was divided into 6 groups according to the changing rules of strength quality (40-49, 50-59, 60-69 years) and gender. There were 150 people in each group, with a total of 900 people. Firstly, circumference and body fat were measured, then lower limb muscle strength was measured using three METHODS: muscle function analyser (MES), longitudinal jump meter and lower limb muscle strength meter.
RESULTS: (1)Through mathematical analysis, 5 male and 6 female indicators reflect the lower limb strength of the middle-aged and elderly. (2) Among the three methods, MES has a significant advantage in evaluating lower limb muscle strength.(3)Lower limb circumference and whole body circumference have greater influence on lower limb muscle strength, which is greater than waist and abdomen circumference, while female lower limb muscle strength is significantly lower than that of male (P<0.05). (4)The total muscle strength of the lower limbs was measured by MES and lower limb muscle strength measurement, respectively. The total muscle strength of normal circumference men was significantly greater than that of women on the total muscle strength, left and right muscle strength(p<0.05).(5)The correlation coefficient between MES, lower limb muscle strength meter and lower limb circumference were greater. The circumference*gender has a significant effect on the muscle strength of the lower extremities. The greater the circumference, the higher the muscle strength of the lower extremities in men. (6)there is no significant advantage in the relationship between the vertical jump height measured in the vertical jump meter and the body fat rate.
CONCLUSION: (1)The indexes reflect lower limb strength better and there is a positive correlation between lower limb muscle strength and circumference for all three tests, especially lower limb circumference. However, MES and the lower limb muscle strength meter reflects lower limb muscle strength better than the vertical jump height of the vertical jump meter.(2)There is a correlation between body fat percentage and lower limb muscle strength.(3)Lower limb muscle strength measured by the MES was the best fit to different circumferences and body fat percentage, the lower limb plyometric fit was not significantly different from the former, and the longitudinal hopper was the worst fit.

**INCREASES IN MUSCLE MASS, STRENGTH, AND PHYSICAL PERFORMANCE FOLLOWING RESISTANCE EXERCISE TRAINING DO NOT DIFFER BETWEEN OLDER AND ELDERLY ADULTS**

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INTRODUCTION: Aging is associated with the loss of muscle mass and strength. Resistance exercise training can be applied effectively to increase muscle mass, strength, and physical performance in older adults (65-75 y). However, it has been speculated that elderly people (>=85 y) are less responsive to the benefits of exercise training. This study compares the impact of prolonged resistance exercise training on muscle mass and function in older (65-75 y) versus elderly (>=85 y) men and women.
METHODS: We subjected 17 healthy, older (65-75 y) females and males (OLDER; n=13/4 (f/m); 68±2 y; 26.9±2.3 kg·m-2) and 12 healthy, elderly (>=85 y) females and males (ELDERLY; n=7/5 (f/m); 87±3 y; 26.0±3.6 kg·m-2) to 12 weeks of supervised whole-body resistance exercise training (3x/wk). Prior to, and after 6 and 12 weeks of training, quadriceps and L3 muscle cross sectional area (CSA; CT scan), lean body mass (DEXA scan), strength (1RM tests), physical performance (TUG and SPPB), quality of life (SF-36), and instrumental activities of daily living scale (IADL) were assessed. Pre- versus post-intervention data were analyzed using repeated-measures ANOVA with time as the within-subjects factor and age group as the between-subjects factor, using an alpha level of 0.05. Data are reported as means±SD, and n2 (partial eta squared) was used to estimate effect sizes.
RESULTS: Twelve weeks of resistance exercise training resulted in a 10±4 and 11±5 % increase in quadriceps CSA (from 46.5±10.7 to 51.1±12.1 and from 38.9±6.1 to 43.1±8.0 cm2, respectively; P<0.001; n2=0.67), a 2±3 and 2±3 % increase in whole-body lean mass (from 40.5±8.0 to 41.3±8.7 and from 37.7±5.0 to 38.3±5.2 kg, respectively; P=0.001; n2=0.22), and a 38±20 and 46±14 % increase in 1RM leg extension strength (from 53±25 to 71±31 and from 36±13 to 52±20 kg, respectively; P<0.001; n2=0.77) in the OLDER and ELDERLY groups, respectively. No differences in the response to exercise training were observed between groups (time x group, all P>0.60; all n2<=0.012). In accordance, physical performance on the SPPB and TUG improved (both P<0.01; n2>=0.22), with no differences in the exercise response between the OLDER and the ELDERLY groups (time x group, P>0.15; n2<=0.07).
CONCLUSION: Prolonged resistance exercise training increases muscle mass, strength, and physical performance in older adults, with no differences between older and elderly adults. The adaptive response to resistance exercise training is preserved in the oldest of old.
Supported by ANID - FONDECYT - Chile (Grant Number 11180949). Clinical trial registration: NCT04999501. Contact: gabriel.marzuca@ufrontera.cl

## 16:15 - 17:30

### Plenary sessions

### PL-PS02 Interorgan cross-talk and network physiology of exercise: dynamic perspectives for understanding and optimizing kinesiology

#### NETWORK PHYSIOLOGY OF EXERCISE: BEYOND MOLECULAR AND OMICS APPROACHES

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*INEFC BARCELONA*

During the last century, Exercise Physiology has been deeply influenced by reductionism and classical cybernetics. The reductionist research approach has produced a lot of information, but has provided a limited understanding of exercise-related phenomena. An inductive analytic mode of inquiry, reflected by the redundant expression "Effects of" has characterized the field which, inevitably, has evolved towards Molecular Biology, Genetics and OMICS technologies. Although such biology branches are subjected to dynamical approaches, recent specialities like Molecular Exercise Physiology keep focused on questionable non-dynamic group pooled statistical inferences.
Inspired by the new field of Network Physiology and Complex Systems Science, Network Physiology of Exercise emerges to transform the theoretical assumptions, the research program and the practical applications of Exercise Physiology. The cybernetic Control Theory is replaced by Dynamic Systems Theory, the centralized control of the Central Nervous System by a multilevel self-organization of body functions, and the static regulatory mechanisms by dynamic mechanisms with synergetic properties. The inductive analytical research, generalizing from group inter-individual inferences to intra-individual phenomena, is replaced by an inductive/deductive research based on intra-individual time series analysis techniques. Considering the organism as a multilevel complex network system, Network Physiology of Exercise goes beyond molecular and OMICS approaches, mostly focused on bottom-up inferences from molecular data to the physiology of the entire person. It centres the research efforts on investigating the nested dynamics of the vertical (among levels) and horizontal (e.g. among organs) physiological network interactions. The embededness of lower network levels in upper levels, the circular causality (bottom-up, top-down) among levels acting at different timescales, and the emergence of nonlinear network phenomena are some of its genuine expected contributions.
Network Physiology provides a wide range of data analysis techniques that have the potential to be utilized as novel evaluation tools to investigate dynamic interactions among physiological systems under exercise settings. These techniques can lead to the development of new network-based biomarkers (e.g., cardio-respiratory interactions, inter-muscular interactions and cortico-muscular interactions) able to identify how different key organ systems coordinate and synchronize as a network during exercise, and track how these network interactions change in response to different physiological states and exercise interventions. The use of such network-based biomarkers may open exciting horizons on exercise testing, improve the understanding of exercise-related phenomena and contribute to enrich Basic Physiology and diverse fields such as Sports Medicine, Sports Rehabilitation, Sport Science or Training Science.

#### MOLECULAR TRANSDUCERS OF PHYSICAL ACTIVITY CONSORTIUM (MOTRPAC): MAPPING THE DYNAMIC RESPONSES TO EXERCISE

TRAPPE, S.

*BALL STATE UNIVERSITY*

Exercise provides a robust physiological stimulus that evokes cross-talk among multiple tissues that when repeated regularly (i.e., training) improves physiological capacity, benefits numerous organ systems and decreases the risk for premature mortality. However, a gap remains in identifying the detailed molecular signals induced by exercise that benefit health and prevent disease. The Molecular Transducers of Physical Activity Consortium (MoTrPAC) was established to address this gap and generate a molecular map of exercise. Preclinical and clinical studies will examine the systemic effects of endurance and resistance exercise across a range of ages and fitness levels by molecular probing of multiple tissues before and after acute and chronic exercise. From this multi-omic and bioinformatic analysis, a molecular map of exercise will be established. Altogether, MoTrPAC will provide a public database that is expected to enhance our understanding of the health benefits of exercise and to provide insight into how activity mitigates disease.

# E-poster not debated

## PP-UD01

### E-poster not debated

#### Biomechanics

**FEATURES OF INCLINED ADJUSTMENT OF ALPINE SITTING SKIS RELATIVE TO TURN WIDTH: COMPARISON WITH STANDING SKIS**

SUGAJIMA, Y., KATO, T., KOEDA, M.

*ASAHI UNIVERSITY*

INTRODUCTION: Ski turns require a force to point inside the turn (centripetal force), which allows the skier to tilt the body inside the turn. With standing skis (STA), the movement of various joints of the lower limbs plays an important role in the inclined operation. However, with skis operated from a seat (SIT), 1), 2) depending on the difference in tools and range of motion, the inclined operation during sit turns is considered different from STA. Evaluating this difference is meaningful in understanding the turn technique of skiing as universal skiing regardless of disability or not.

This study aimed to clarify the characteristics of SIT by comparing the inclined adjustment of SIT and STA for turn width using two-dimensional motion analysis and seat pressure distribution analysis, to evaluate the ski turn technique universally.

METHODS: Eight skilled male alpine skiers participated in this study; two sitting skiers and six standing skiers. Participants turned at four cones on the fall-line (FL) at intervals of 8 m and skied 3-5 trials with two different turn widths. The narrow turn (N) was assumed to be about 1.5 m from the cone, and the wide turn (W) was twice the width of N. Each trial was videotaped from the lower FL, and the second and third turns of each trial were analyzed. Then, the turn width (Wid), time (TT), speed (Spe), tempo (Tem), inward tilt angle (IA) at the maximum turn amplitude and inner outrigger extension angle (EA) were calculated. In SIT, the seat pressure distribution was measured using a seat pressure sheet, and the centre of the seat pressure (COP) was calculated. Each index was statistically compared between N and W, and between SIT and STA.

RESULTS: The following results were obtained;

(1) Wid was not different between SIT and STA in both N and W. SIT had longer TT than STA, and Spe and Tem were lower. In addition, IA was larger in SIT.

(2) There was a negative correlation between Wid and Spe in both SIT and STA. There was no correlation between Spe and IA in STA, but there was a relationship in SIT.

(3) In the seat pressure distribution of SIT, there was a high correlation between IA and COP in the left and right directions (COPx).

CONCLUSION: SIT had longer TT than STA and Spe and Tem were also lower at the same turn width. From these results, SIT showed that the IA was enlarged and turned by the incline, which appeared to be supported by the displacement of COPx. In STA, the fact that Spe did not correlate with IA is considered inherent in movement that not only tilts the upper body, but also involved in the inclined movement of various joints of the lower limbs.

REFERENCES:

1） Sugajima et al., Jap J Adapted Sport Sci, 2017

2） Sugajima et al., Jap J Adapted Sport Sci, 2021

**ACUTE EFFECT OF IMPROVED HIP RANGE OF MOTION ON MAXIMUM HIP ANGLE IN POLE VAULTING: A PILOT STUDY**

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*CHUKYO UNIVERSITY*

INTRODUCTION: A previous study reported that the lower back was the most common location of injury among collegiate pole vaulters. In addition, low back pain occurrence was associated with low hip flexion and extension range of motion among collegiate pole-vaulters and decathletes. Thus, large maximum hip flexion and extension range of motion is considered effective low back pain prevention. Moreover, we found that there was a significant positive correlation between range of motion and the maximum joint angle during pole vault in hip extension. However, it is unclear whether the improvement in hip flexion and extension ROM changes their hip joint angle during vaulting. The purpose of this study was to clarify the acute effects of interventions in hip flexion and extension range of motion for pole vaulters on the maximum hip joint angle during pole vaulting.

METHODS: Seventeen male pole vaulters who underwent the same interventions for hip range of motion were included. We measured both active and passive hip flexion and hip extension ROM in participants lying on a bed and recorded video of pole vaulting motion at a rate of 240 fields/s pre and post interventions. The maximum hip joint angle during the pole vault from the touchdown of the last step of the run-up to the pole straightening was calculated from videos taken pre- and post-intervention and then compared. We used three types of self-massages to improve hip flexion and extension range of motion and active straight leg raise exercises. We completed the program in approximately 25 min on an experimental day and all interventions were monitored by the examiner.

RESULTS: No significant differences between pre- and post-intervention hip range of motion were observed. No significant improvement in maximum hip joint angles was observed post-intervention. The magnitude of change in active hip flexion range of motion and the maximum hip flexion angle during pole vaulting pre-and post-intervention was significantly correlated ($p=0.002$, $r=0.687$). No significant correlations in the changes of other joitnts were observed between the ROM and maximum joint angle.

CONCLUSION: The magnitude of change in maximum hip flexion angle on takeoff leg during the pole vaulting was not significantly correlated with the change in passive hip flexion range of motion, but there was a significant positive correlation with the change in active hip

flexion range of motion. In order to change the vaulting motion to prevent injuries or improve, active ROM may need to be changed instead of passive ROM, and coaches and athletic trainers should keep assessing and improving active ROM. However, it is difficult to consider that an active ROM is greater than the passive ROM, and it is deemed necessary to acquire a large passive ROM as a basis.

### ASSOCIATION BETWEEN ELASTOGRAPHY-ASSESSED MUSCLE MECHANICAL PROPERTIES AND HIGH-SPEED DYNAMIC PERFORMANCE

EMA, R.

*SHIZUOKA SANGYO UNIVERSITY*

INTRODUCTION: Clarifying the muscular factors that contribute to performance improvement can be beneficial for athletes and coaches. One study (1) found that the medial gastrocnemius shear wave modulus, an indicator of passive mechanical properties, was associated with the drop jump height. In contrast, the shear modulus of the rectus femoris was not significantly correlated with the countermovement jump (CMJ) height (2). Thus, the relationship between passive muscle mechanical properties and performance during stretch-shortening cycle (SSC) exercise remains unclear. Also, performance during explosive exercises involving only concentric muscle contractions can also be associated with passive muscle mechanical properties, but no consensus has been reached among previous studies. It is possible that the association between passive muscle mechanical properties and performance is clearer for exercises that have a time restriction for generating force. The present study examined the relationships between the resting muscle shear modulus and dynamic performance during the SSC and explosive exercises.

METHODS: We measured the jump height during three types of vertical jumps [squat jump (SJ), CMJ, and rebound jump (RJ)] and the multi-joint leg extension power at three velocities (low, moderate, and high) of 30 healthy women. Using ultrasound elastography, the resting shear modulus of the vastus lateralis was assessed in the sitting position as an index of passive muscle mechanical properties.

RESULTS: The shear modulus was positively correlated with RJ height and multi-joint leg extension power at moderate and high velocities ($r = 0.435–0.563$, $P < 0.05$). The magnitudes of correlations were interpreted to be moderate based on the proposal by Guilford (3). There was no significant correlation between the shear modulus and SJ height, CMJ height, and multi-joint leg extension power at low velocity. Contact time (i.e., the time under force exertion against the ground) during RJ (161 ± 19 ms) was 19% of that during CMJ (869 ± 171 ms).

CONCLUSION: These results suggest that passive muscle mechanical properties play an important role in high-speed SSC and dynamic explosive exercises, although the contribution to the performance would not be high.

REFERENCES:

1. Ando et al. J Electromyogr Kinesiol 2021;58:102549

2. Akkoc et al. Med Ultrason 2018;20:170–176

3. Guilford JP. McGraw Hill 1942.

### THE EFFECTS OF DIFFERENT BALL MASS ON THE INSTEP KICK MOTION OF ELEMENTARY SCHOOL CHILDREN IN SOCCER

TAGO, T.

*TOKUSHIMA BUNRI UNIVERSITY*

INTRODUCTION: This study was to establish guidelines for proper selection of soccer balls for elementary school students by conducting a kinematic analysis of the form displayed by students of a youth soccer team when kicking two types of balls with differences in mass—a size 4 ball and size 3 ball .

METHODS: Ten youth soccer team players aged 8-11 years, who all kicked using their right foot, were included in this study. On a youth soccer pitch, the participants were asked to perform an instep kick with full strength to hit a stationary soccer ball toward a target 8 m away. Two types of balls were used in the experiment—a size 4 ball weighing 360 g (hereafter, normal) and a size 3 ball weighing 300 g (hereafter, light). The unit vector from the right superior anterior iliac spine to the left superior anterior iliac spine was defined as the xpelvis, the unit vector from the midpoint of the left and right sacrum to the right superior anterior iliac spine as the spelvis, and the unit vector from the midpoint of the left and right sacrum to the left superior anterior iliac spine as the tpelvis. The unit vector zpelvis was determined from the cross-product of the spelvis and tpelvis, and the unit vector ypelvis was determined from the cross-product of the zpelvis and xpelvis. The pelvic coordinate system was defined as the coordinate system with xpelvis, ypelvis, and zpelvis as the axes. As a kinematic calculation item, the angle of fore and aft inclination of the fuselage was calculated. The angle from the midpoint of the left and right hip joints projected on the YZ-plane to the vector projected toward the Y-axis and the vector from the midpoint of the left and right hip joints to the upper edge of the sternum was used as the torso flexion angle of the torso body.

RESULTS: Based on the finding that the average light-to-normal rebound ratio value was 1.077, participants with light-to-normal ratios lower than the average were placed in the SG group and those with ratios larger than the average were placed in the WG group. In the SG and WG groups, the forward–backward tilt angle became smaller after the ball impact, and there was a tendency to lean forward, with the WG group leaning forward more than the SG group. In addition, a substantial forward-leaning was observed in the WG group Normal, indicating a considerable difference before and after the ball impact.

In the SG group, there was no difference between Normal and Light in the angle difference between the forward and backward tilt of the torso before and after the impact. In the WG group Normal, the forward tilt was large, and there was a considerable difference from that of the SG group.

CONCLUSION: In the WG group, the forward tilt of the torso after ball impact was greater in Normal. However, this was thought to be owing to the difference in the mass of the ball, which was reflected in the kicking form, and also suggested that the kicking motion was far from the original kicking form.

### SHORT-TERM INFLUENCE ANALYSIS OF DIFFERENT WEIGHTS' INSTEP WEIGHTS ON 50 METERS SPEED AND RUNNING TIME

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*ESCOLES UNIVERSITARIES GIMBERNAT I TOMAS CERDA*

INTRODUCTION: Instep wearable resistances at running trainings(1) change mechanical parameters modifying muscle activity(2), ground plantar support and run biomechanics; changes could reduce lower limb's impairment risk produced by abnormal stepping during the

race(3). Instep weights show positive effects on the race, due to the influence of the instep specific placement without decreasing inter-muscular coordination nor altering running technique(2)(4)(5).

Objective: to analyze if instep weights use during warm-up for 50-meter running series could significantly modify race times in sprinters and hurdlers and evaluate genders differences.

METHODS: 30 semi-professional sprinters ran 6 consecutive 50-meter series at maximum speed (15 minutes resting between series) with or without instep weights, randomized into three groups: no-weight, Ascending (50, 100, 150, 200g load cadence) or Descending (200, 150, 100, 50g load cadence). 1st and 6th series were run without weight. Weight devices: Power Instep(R). Total and partial times and speed were collected as well as gender and anthropometric variables. Variables were statistically analyzed and compared. This study was approved by Universitat Autònoma de Barcelona Research Ethics Committee (CEEAH-UAB, number 4987).

RESULTS: Instep weights were always safe and well tolerated. Total race time between 1st and 6th series increased in all groups. In women, all groups' race times were longer in the 6th than in the 1st race. Instead, men in Ascending group decreased their race time an average of 667ms (SD=19.03) in the 6th race compared to the 1st (p=0.48), while Descending and no-weight worsened their running time 490ms (SD=13.76).

CONCLUSION: Instep load was safe and well tolerated (50 to 200g). Improvements obtained in Ascending group men in the last series (without weight) were statistically non-significant due to the small sample size, but magnitudes observed could be considered important in some elite sports contexts: using increasing instep loads in men during 50-meter series at maximum speed in training or competition warm-ups could slightly increase final race speed a few hundredths of a second. Different muscle stimulation(2) and adjustments to positive biomechanical changes(2) during warm-up with ascending loads could slightly modify race parameters to a small but significant speed increase.

Conclusion: Instep weights are safe and well tolerated as a warm-up technique in short distance runners. Upward weight cadence instep load in men during warm-up could positively modify 50-meter race time in sprinters and hurdlers, but larger studies are needed; if confirmed these results could be important in a professional sports context where hundredths of a second separate success from failure.

REFERENCES

1) Feser et al., Eur J Sport Sci. 2020

2) Cos Morera et al., FTP18 Congress proceedings, 2018

3) Colomar et al., PloS one, 2020

4) López et al., Journal of Human Sport and Exercise, 2018

5) Macadam et al, Strength and Conditioning Journal, 2019

## BIOMECHANICAL PREDICTORS OF THE PITCHING KINETIC CHAIN AND PERFORMANCE AMONG ADOLESCENT BASEBALL PITCHERS

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*NATIONAL TAIWAN NORMAL UNIVERSITY*

INTRODUCTION: The pitching mechanic consisted of kinetic chain for energy transferred from the striding foot to the throwing arm. Ground reaction forces (GRFs), pelvic and trunk pitching kinematics play an integral role in energy transfer from the lower to the upper extremities and influence sports performance. This study was aimed to distinguish the pitching motion pattern between different ball speeds in adolescent baseball pitchers. To analyze the variables associated with pitch velocity from their biomechanical factors in the kinetic chain, and its ability to predict pitching performance in teenage pitchers.

METHODS: A total of 30 male teenage players (age 14.1±0.6 years; height = 173.5±5.5 cm; weight = 65.8±12.4 kg) were right-handed overhand baseball pitchers. In this study, a motion analysis system with 6 cameras (Motion analysis crop, 250Hz) was used to calculate for evaluate the pitching kinematics. One force plate (Kistler, 2500Hz) collected GRFs from the stride leg and used a pocket radar to collect the ball speed. After warm-ups, pitchers threw 5 fastballs on a custom-made pitching mound, assessed for segment rotation angle, angular velocity, and sequence via motion capture to investigate their pitching motion pattern. Besides, they were divided into 3 groups according to the average ball speed that they performed in the pitching experiment: High speed (HS), Middle speed (MS), and Low speed (LS). A one-way ANOVA and Tukey post-hoc analysis compared the GRFs kinetic data and pitching kinematic data between groups. The Pearson correlation coefficient examined the variables relations between ball speed. Last, a stepwise multiple regression model determined the contribution of the overall variables that could predict the pitch velocity in teenagers.

RESULTS: Five biomechanical variables showed a significant difference between groups in our study. The knee flexion angles at maximal external rotation (p=.011) and ball release (BR) (p=.007) that HS, and MS were significantly smaller than LS. The vertical pitching GRFs at BR, HS and MS were significantly larger than LS (p=.015). The maximal shoulder-hip separation angle (p=.017) and time% between max pelvis and trunk rotation velocity (p=.024), HS was significantly higher than LS. Those 5 variables also showed a significant correlation between ball speed (p<.05). When all variables were entered into a stepwise multiple regression analysis, vertical pitching GRFs at BR and maximal shoulder-hip separation angle accounted for 45% of the variance in ball speed (p=.008).

CONCLUSION: Our study found that the GRFs and shoulder-hip separation angles would significantly influence the energy kinetic chain transmitted from the lower to the upper extremities and pitch velocity among adolescent players. We suggest teenage pitchers require adequate lower limb strength and appropriate pelvic and trunk control to adequately transfer energy from the kinetic chain, elevating their performance.

## THE INFLUENCE OF BACK SQUAT AND COUNTERMOVEMENT JUMP EXERCISES WITH AND WITHOUT ELASTIC BAND RESISTANCE ON SUBSEQUENT JUMP PERFORMANCE

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*1: UOD , 2: ECU , 3: UOT , 4: D.U.TH , 5: ASPETAR , 6: UON*

INTRODUCTION: Preconditioning the muscle by performing maximal or near maximal voluntary contractions using elastic bands (EB) in combination with free-weight resistance (FWR) can increase subsequent force production and performance. However, such improvements are often reported after limited or no warm-up (1) and the impact of different conditioning contractions at different loads requires further investigation. Therefore, the aim of the present study was to examine the acute effects of conditioning EB exercises (back squat and countermovement jump) following a comprehensive warm-up on subsequent countermovement jump (CMJ) height performance.

METHODS: Fifteen active men (age = 21.7 ± 1.1 y, height = 1.8 ± 0.1 m, mass = 77.6 ± 2.6 kg) volunteered for the study and completed four conditions (EB50%, EB85%, FWR50%, FWR85%) in a randomised order each separated by 48 h. During each trial, participants performed a comprehensive warm-up of 5 min cycling, 10 continuous unloaded squats, 5 continuous CMJs at ~70% of perceived maximum, followed by maximal jumps performed every 30 s until 3 jumps were within 3% of maximum jump height. Participants then performed 5 repetitions of either EB- or FWR-loaded CMJs at 50% 1-RM or 3 repetitions of either EB- or FWR-loaded back squat at 85% of 1-RM (35% of load generated from elastic resistance during EB). CMJs were then performed 30 s, 4 min, 8 min, and 12 min later.

RESULTS: No change in any variable was found after both FWR warm-up conditions ($p > 0.05$). Significant increases ($p < 0.05$) in CMJ height (4.6-8.0%) and peak power (3.1-5.1%) were observed in the EB50% condition at 30 s and 4 min; no changes were found at 8 min and 12 min. CMJ height (5.6-6.5%) and peak power (4.4-6.0%) were also significantly increased in the EB85% condition at 30 s, 4 min and 8 min; no changes were found at 12 min.

CONCLUSION: The lack effect of the free-weight conditioning contractions suggests that the comprehensive task-specific warm-up routine mitigated any further performance augmentation. However, the improved CMJ performance following the use of EB is indicative that specific alterations in force-time properties of warm-up exercises may further improve performance. The use of heavy squat lifts or loaded CMJs with elastic band resistance result in similar increases CMJ performance following a comprehensive warm-up, although the heavier loading resulted in a more prolonged improvement in performance indicative of an intensity-dependent effect.

REFERENCES:

1. Blazevich & Babault (2019). Front Physiol. 1;10:1359.

### EFFECTS OF A SHORT STRETCHING PROTOCOL AND THE DENTAL OCCLUSION ON SPINE: A PILOT STUDY

PATTI, A., GIUSTINO, V., FIGLIOLI, F., BELMONTE, G., GENUA, D., MESSINA, G., THOMAS, E., BATTAGLIA, G., BELLAFIORE, M., PALMA, A., BIANCO, A.

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INTRODUCTION: A good balance and postural control are fundamental for a good performance of both simple daily tasks and more complex movement patterns. The purposes of this study were threefold: a) to evaluate the effects of a short stretching protocol on the spine; b) to evaluate the effects of dental occlusion on the spine; c) to analyze the possible suggestions that may emerge from an instrumental perspective that can reproduce spine images on a monitor using an infrared camera (ToF cameras).

METHODS: Twenty-three subjects were enrolled for the study. They were analyzed using light detection and ranging technology (LiDAR) called Spine 3D (Sensormedica, Guidonia Montecelio, Rome, Italy): an innovative and non-invasive three-dimensional optoelectronic detection system that allows an accurate assessment of vertebrae alignment. We evaluated the sample to 1) baseline; 2) with different mandible positions using a wax bite between the teeth; 3) after a short stretching protocol. A paired t-test was used to determine differences. Pearsons correlation coefficient was used to evaluate the correlation between the parameters. Cohens d was used to measure effect size.

RESULTS: The Person analyses showed some correlations. Particularly interesting are the correlations between trunk inclination parameter vs sagittal imbalance parameter (R=0,97), and cervical lordosis parameter vs lumbar lordosis parameter (R=0,87). After the stretching protocol, our results showed a significant difference in the trunk imbalance parameter ($p<0,05$, -0,46). The dental occlusion showed a significant effect on the trunk inclination parameter ($p<0,05$, d=0,49) and on the sagittal imbalance parameter ($p<0,05$, d=0,48).

CONCLUSION: Our data show an influence of the stretching protocol limited to trunk imbalance. On the other hand, the influence of dental occlusion on trunk inclination and the sagittal imbalance parameters are particularly interesting. Considering these results, Spine 3D can objectively contribute to ameliorating spine-related skeletal muscle disorders without an invasive approach.

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REFERENCES:

1. Marin L, Lovecchio N, Pedrotti L, et al. Acute Effects of Self-Correction on Spine Deviation and Balance in Adolescent Girls with Idiopathic Scoliosis. Sensors (Basel). 2022;22.

2. Ohlendorf D, Seebach K, Hoerzer S, Nigg S, Kopp S. The effects of a temporarily manipulated dental occlusion on the position of the spine: a comparison during standing and walking. Spine J. 2014;14:2384-2391.

### CORRELATION BETWEEN SNPE (SELF NATURAL POSTURE EXERCISE) PERFORMANCE AND MUSCULOSKELETAL PAIN

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INTRODUCTION: This study aims to analyze the correlation between the SNPE (Self Natural Posture Exercise) motion performance and musculoskeletal pain region in patients with musculoskeletal pain at ages of 20s and 40s.

METHODS: The subjects were 77 adult women with chronic musculoskeletal pain for more than 3 months (32.8±6.6 yrs, 21.7±2.9 kg/m2). Movement performance was evaluated by taking front and side pictures during performing SNPE number 1 movement. In the frontal, the acromion and the anterior superior iliac spine were marked to measure the balance of the shoulder and pelvis. The angle formed by the line connecting the left and right points of the affected area and the horizontal line starting from the left point was measured. In the side, a reference point was marked on the tip of the big toe, and a reference line was created that passed the reference point perpendicular to the floor. The angle between the reference line and the line connecting from the reference point to the knee, chest, and chin, respectively, was measured. When the value of measurement was high, it was considered as a poor performance. In addition, in order to measure the position of the shoulder, a line passing through the chest perpendicular to the floor was created, and then the angle with the line from the chest to the acromion was measured. The lower each measurement value, the higher the performance was judged. Musculoskeletal pain was assessed by pressure pain threshold (PPT) using an algometer for upper trapezius (UT), lower trapezius (LT), erector spinae muscles (ES), gluteus (GT), gastrocnemius (GN), iliotibial tract (IT), pectoralis major (PM), and rectus femoris (RF). It was judged that the lower the measured value, the greater the pain. Using the measured values, the correlation between performance and pain in each area was confirmed.

RESULTS: The relationship between performance of shoulder balance and PPT in UT ($r=.329$, $p<.01$), LT ($r=.339$, $p<.01$), ES ($r=.388$, $p<.01$), GT ($r=.507$, $p<.01$), GN ($r=.267$, $p<.05$) was significant. A relationship between performance of pelvic balance and PPT in UT ($r=.242$, $p<.05$), GT ($r=.342$, $p<.01$), GN ($r=.237$, $p<.05$), PM ($r=.240$, $p<.05$), RF ($r=.231$, $p<.05$) was significant. A relationship between performance of chin position and PPT in LT ($r=.236$, $p<.05$), between performance of chest position and PPT in IT ($r=.242$, $p<.05$) and PM ($r=.286$, $p<.05$), and

between performance of shoulder position and PPT in UT (r=.344, p<.01), LT (r=.616, p<.01), ES (r=.646, p<.01), GT (r=.475, p<.01), GN (r=.392, p<.01), IT (r=.494, p<.01), PM (r=.350, p<.01), RF (r=.236, p<.05) was significant. A relationship between performance of knee position and PPT was not significant.

CONCLUSION: The results direct us to identify the musculoskeletal pain regions which is related to the SNPE number 1 movement. This can be used as a useful reference data to provide an effective exercise program during SNPE exercise instruction for the improvement of chronic musculoskeletal pain.

## THE RELATIONSHIP OF BACKSWING PHASE MOVEMENT SMOOTHNESS AND SWING PERFORMANCE IN COLLEGIATE GOLFERS

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INTRODUCTION: Past studies have shown that the swing length and extent of torso rotation in the backswing phase do not affect a golfers clubhead speed (1). Golf swings can achieve more consistent clubhead speed with a short backswing with minimal rotation (2). The performance of the back swing seems to have a significant impact on golf performance. The analysis of sport biomechanics can offer insight into the quality of a movement as it is being executed through the jerk parameters (3). The quality of the movement will improve with maturity, resulting in a smoother movement (3). This study was aimed to investigate the correlation between backswing phase movement smoothness and swing performance.

METHODS: In this study, 30 Division I collegiate golfers were recruited as the study participants. All the participants in this study demonstrated their swings for analysis, performing 10 swings with the same 7-iron. A TrackMan Launch Monitor was used to collect the participants' swing performance parameters. In this study, log dimensionless jerk (LDLJ) was one of the parameters for assessing movement quality, and the formula was defined by positional changes and must include a time-dependent closed interval. The formula is as follows Balasubramanian et al., 2015 (4).

RESULTS: The trunk LDLJ values during the backswing demonstrated moderate correlations with ball parameters ball speed and smash factor and with club parameters club speed, attack angle, low point, swing plane, and face angle.

CONCLUSION: The LDLJ parameters in this study provide clear data and statistical results that verify that the quality of the upswing directly affects the swing performance parameters; therefore, this study further investigated the possible reasons for the upswing's effect on the swing fluency. This effect may be related to a golfer's physical limitations. The research of Gulgin (2014) into golfers' physical limitations and golf swing faults found that the three most likely swing faults caused by golfers' physical limitations are hip extensions, loss of posture, and slide. Golf swing faults occur in the pelvic and trunk movements; physical limitations may cause the golf swings to exhibit jerk movements in the pelvis and trunk during the upswing, which then affect the ball parameters and club parameters of the swing performance. However, how physical limitations affect the fluency of the golf swing requires further study.

## EFFECT OF BALL INCLUSION IN UNILATERAL JUMP TEST ON LOWER LIMB NEUROMUSCULAR ASYMMETRY IN BASKETBALL PLAYERS

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INTRODUCTION: Vertical jump (VJ) is one of the most prevalent acts performed by basketball players (1). Many of these jumps are unilateral and these could lead basketballs players to develop asymmetric neuromuscular adaptations of the lower extremities (2).Traditional jump tests are too static, since players need to constantly adjust their actions in dynamic environments (3). This study aimed to compare the movement variability of basketball players while they performed unilateral drop jump (UDJ) with the same exercise while catching a ball (UDJB). Movement variability was measured using Sample entropy (SampEn).

METHODS: Twelve amateurs basketball players (n=12, 7 females, 5 males, mean ± SD: age 22.3 ± 2.3 years old, height 1.73 ± 0.11 m, weight 67.6 ± 11.3 kg) were tested for drop vertical jumps from a 30-cm high platform and landing on a single leg with (UDJB) or without (UDJ) catching a ball. The acceleration of basketball players was measured using an inertial measurement unit (WIMU, Realtrack Systems, Almeria, Spain). Data was analysed using paired t-test and inter-limb asymmetry (4).

RESULTS: There were significant differences (p = 0.045) between limbs in UDJ condition and 18.68 % of inter-limb asymmetry. However, with the inclusion of the ball, (UDJB) no difference was found (p = 0.477) and inter-limb asymmetry was reduced to a 6.77%.

CONCLUSION: Were found significant differences between legs in UDJ condition, with the movement variability being lower with the right leg. However, when introducing the ball, the coordination challenge of the task increases, specially for the right leg and the differences in movement variability between limbs disappear. In basketball, when shooting with one hand the support falls on the opposite leg, this probably makes the ball affect less on the left leg as all players were right-handed. Therefore, the introduction of the ball equalises the coordinative challenge of the unilateral jumping task between limbs, increasing the unpredictability of the task, more similar to what happens in dynamic environments such as basketball.

References

1. Ziv G, Lidor R. Vertical jump in female and male basketball players-A review of observational and experimental studies. J Sci Med Sport [Internet]. 2010;13(3):332–9. Available from: http://dx.doi.org/10.1016/j.jsams.2009.02.009

2. Hewit JK, Cronin JB, Hume PA. Asymmetry in multi-directional jumping tasks. Phys Ther Sport [Internet]. 2012;13(4):238–42. Available from: http://dx.doi.org/10.1016/j.ptsp.2011.12.003

3. Travassos B, Araújo D, Vilar L, McGarry T. Interpersonal coordination and ball dynamics in futsal (indoor football). Hum Mov Sci [Internet]. 2011;30(6):1245–59. Available from: http://dx.doi.org/10.1016/j.humov.2011.04.003

4. Bishop C, Read P, Cscs D, Chavda S, Turner A, Cscs D. Asymmetries of the Lower Limb : The Calculation Conundrum in Strength Training and Conditioning. :27–32.

### TIME COURSE OF CHANGE IN MUSCLE ACTIVITY DURING A MAXIMAL INTERMITTENT SQUAT PROTOCOL PERFORMED ON AN INERTIAL MACHINE

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INTRODUCTION: Exercise induced muscle damage (EIMD) appears when subjects exercise at a very high intensity, particularly if they are non-trained or non-familiarized with the proposed workouts (1). Albeit both concentric and eccentric exercises can induce muscle damage, it is recognized that EIMD is much more sensitive to eccentric contractions (2). Nowadays, inertial machinery proved its efficacy to improve muscle force and power thanks to its impact on morphological and neural factors (3). We aimed to study fatigue induced changes of muscle activity among knee extensors and flexors when performing 10x10 (ser x rep) dynamic squats (Sq10x) on an inertial machine.

METHODS: Thirty-three adults performed a Sq10x with an inertial load of 1270 Kg/cm2. Three submaximal repetitions were allowed to accelerate the inertial disc before each series The recovery time in between the 10 series was 3 min. Muscle activity was assessed with sEMG recording at 2000 Hz by analyzing the root mean square values (EMGRMS) in the vastus medialis (VM), vastus lateralis (VL), rectus femoris (RF), biceps femoris (BF) and semitendinosus (ST). Force and power were measured during the Sq10x. Before and after the Sq10x, maximal force of knee flexion and extension were measured isometrically in a seated position and knee flexed at 90º. EMGRMS was normalized with baseline maximal voluntary contraction. All signals were synchronized by an external analog-to-digital converter (Power 1401; -CED-). Offline analysis was done with the Spike2 Software. A multivariate analysis of variance was performed to study the changes of the RMS and dynamometric signals across the Sq10x. The series 1 and 2 (beginning) were compared with the series 9 and 10 (ending).

RESULTS: The force decrement of knee flexion and extension measured after Sq10x in comparison to baseline ($p \leq 0.001$) endured even after 10 min of recovery ($p \leq 0.001$). During the eccentric contractions EMGRMS of VL and VM decreased significantly ($p \leq 0.043$) at the ending of the Sq10x. Moreover, an interaction effect (ser x rep) confirmed a higher decrement of EMGRMS throughout the within series' repetitions from the beginning to the end of the Sq10x, in these two muscles ($p \leq 0.05$). EMGRMS of the BF increased significantly ($p \leq 0.048$) during the last two series of the Sq10x. No significant changes were observed across the Sq10x during the concentric contractions for all muscles, except for the VM ($p \leq 0.049$).

CONCLUSION: Whereas the VM (chiefly) and VL were confirmed as prime movers, getting into a fatigue state during the Sq10x, the BF could be considered as a synergist "rescuer" thanks to its increased EMGRMS. Moreover, if during the first two series the participants were able to maintain their level of activation across all the repetitions, the opposite was observed during the last two series.

REFERENCES

1.Illera-Domínguez, et al. (2018). Frontiers in Physiol, 9: 1-12.

2.Schoenfeld, B. J. (2012). J Strength Cond Res: 1533-4287.

3.Spudic, D., et al. (2021). Int J Environ Res Public Health, 18

## Coaching

### ADOPTION, IMPLEMENTATION AND MAINTENANCE FOLLOWING A YOUTH INJURY PREVENTION WORKSHOP IN GRASS-ROOT COACHES FROM 3 EUROPEAN COUNTRIES

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INTRODUCTION: The purpose of this study was to explore the effectiveness of a workshop in terms of knowledge gain, attitude towards and confidence of grass-root coaches to deliver movement competency training to youth participants. Additionally, using the RE_AIM framework, adoption, implementation and maintenance was determined following the youth injury prevention workshop for grassroot coaches.

METHODS: Knowledge, attitude towards and confidence to deliver injury prevention was explored before and after a workshop in 238 grassroot coaches from three European countries (Spain, United Kingdom and Czech Republic). The pre-post workshop questionnaires were analysed using Wilcoxon signed-rank tests and the effect size was calculated using rank-biserial correlation [rB]. An online follow-up questionnaire (six month after the workshop) was completed by 61 coaches (27% follow-up) and examined adoption, implementation and maintenance of the youth injury prevention programme. Follow-up data was analysed using Bayesian binomial (dichotomous variables) and multinomial (categorial variables) tests.

RESULTS: Statistically significant ($p < 0.05$) and large ($rB > 0.5$) positive effects on knowledge gain, attitude and confidence towards injury prevention were found post the workshop. Follow up Bayesian analysis indicated extreme evidence (Bayesian factor > 100) for adoption of the programme (88.5%), weekly implementation (71.4%) and maintenance (83.9%).

CONCLUSION: A bespoke 2 hours workshop can increase knowledge and confidence of grassroot coaches to deliver youth injury prevention programmes. Importantly the workshop resulted in significant adoption, implementation and maintenance of the injury prevention programme. As such appropriately delivered injury prevention workshops should be included in national governing bodies coaching awards or as continuing professional development (CPD) events for those who coach youth sport.

### A PRACTICAL REPORT ON THE COACHING OF "ANY RUSSIAN WENDESWING WITH 360° TURN AND 3/3 TRAVEL(ROTH)" OF POMMEL HORSE OF IN ARTISTIC GYMNASTICS

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INTRODUCTION: Gymnastics involves a huge number of element, and coaches and gymnast need to be familiar with the structure and coaching methods of those elements. Arkaev (2004) points out the importance of knowledge of "how to teach", and shows specific practice stages training devices(Additional equipment) (p.381-389). It is extremely important to develop training devices for effectively learning the technique and to present the rationale for using it.

"Any Russian wendeswing with 360° turn and 3/3 travel (Roth)" in pommel horse is called "Roth", which is performed as an advantageous element by many top gymnasts today. The coaching method of how to master this element has not been scientifically clarified. The purpose of this study was to verify the effectiveness of the new coaching method developed to effectively master this element.

METHODS: The author has coached “Roth” for 10 gymnasts. The coaching process and the process of modifying the coaching method based on the experience are divided into two phases: 1) Showing the details and intent of coaching method development, 2) Accumulation of practical knowledge related to coaching gymnasts and utilization of the teaching method based on the experience. The process is shown below.

RESULTS: The coaching practice revealed a learning process by new practice method. In the process from the start of practice to the acquisition of technique, he was able to effectively acquire it by using the balance beam as an additional equipment. Specifically, he learned the techniques related to hand movement and weight transfer, which are important in the movement of the element, using the balance beam. When this practice was performed, it was found that if the weight was applied too much to the head or the lower leg during the turning motion, the body would fall. In next stage, he performed this element on the pommel horse without pommel(pommel removed). By succeeding in each of the above steps, it became rational to learn this technique.

CONCLUSION: In this study, we presented step-by-step based on coaching practice and analyzed the kinesthetic sensation of each step for the acquisition method of "Russian 360 ° turning movement (3/3)" in pommel horse. In this case, it was found that by incorporating another apparatus -balance beam- into the training, it was possible to effectively learn how to touch hands and how to move weight.

Through these, effective findings were obtained for the guidance of “the russian wendeswing movement”, which is important for the Roth of pommel horse movement.

## AN EXPLORATORY STUDY EXAMINING THE RELATIONSHIP BETWEEN SESSION RATE OF PERCEIVED EXERTION AND HEART RATE DURING JUDO SPECIFIC CONDITIONING IN FEMALE JUDOKA.

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INTRODUCTION: This study aimed to investigate the relationship between athlete rating of perceived exertion (session-RPE and heart rate training load using Edwards TL method) as methods of assessing internal training loads during judo specific conditioning. Assessment of the intensity and loading of training is useful to tailoring adaptive training programmes, and something particularly important in judo where the demands of weight making can mean restrictions in caloric intake to meet the demands of training.

METHODS: 6 female judo athletes (24.6 + 2.5 years; 161.3cm + 2.9 height; 61.5kg + 5.9 weight) performed 5 judo specific training sessions lasting 45-60 min. The internal training load was quantified through the session-RPE (CR 0–10) and the Edwards TL methods, as suggested elsewhere. All data were collected immediately following the session.

RESULTS: The Pearson’s linear correlation was used to verify the relationship between session-RPE and HR methods ($p < 0.05$). A significant positive correlation was found between session-RPE and HR method during Judo specific conditioning ($r = 0.77$; $p < 0.001$).

CONCLUSION: Results from session-RPE and HR suggest that training load monitoring using either method provides useful insights into the overall load of the session. However, we suggest exploring the use of mood monitoring also. Although the relationship is positive and significant only 59% of common variance was found suggesting 41% could be explained by other variables. Of possible candidates, we suggested mood could be useful to assess as it can provide a lens through which people use to interpret inner states, and therefore, a player who is tense might report higher RPE than when feeling calm for the same session. This provides coaches with the option to use session RPE for the planning and programming training load where access to other equipment is limited. Further evidence is needed on how other variables such as mood may influence such self report measures.

## ARE ICE HOCKEY PLAYERS BECOMING FASTER AND STRONGER? A NINE-YEAR TREND STUDY OF THE SWISS U18 MEN’S ICE HOCKEY NATIONAL TEAM

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INTRODUCTION: Physical performance, including speed, power, strength, and endurance are considered critical success factors in elite ice hockey. Several studies have shown overall improvements in these qualities among elite-male ice hockey players over the years 1979–2005 (e.g. Quinney et al., 2008). The last decade has received less attention to date. Anecdotal evidence suggests that today’s players are faster, stronger, and more agile than players were 10 years ago. However, there are no data confirming this claim so far. The aim of this study was therefore to examine physical and physiological changes among the Swiss U-18 men’s ice hockey national team over the years 2011–2019.

METHODS: The data used for this longitudinal trend study were collected as part of the annual off-season testing procedures. These include countermovement jump relative peak power output (CMJ_rel_peak_power), 30m-off-ice Sprint time (30m-Sprint), Yo-Yo intermittent recovery test level 1 (Yo-Yo-IR1), and anthropometric measures (body mass and body size). 306 athletes (17.0±0.3 years) were tested over 9 years. To quantify changes over time, test results were divided into 3 time periods: period 1: 2011–2013 (N = 99), period 2: 2014–2016 (N = 105), period 3: 2017–2019 (N = 102). One-way ANOVAs followed by Bonferroni post-hoc tests were performed to assess differences in the testings between the time periods. For all pairwise comparisons, effect sizes (Cohen’s d) were calculated.

RESULTS: One-way ANOVA revealed significant differences in CMJ_rel_peak_power, 30m-Sprint time, and Yo-Yo-IR1 between at least two time periods (all p’s <0.05). No differences between time periods were observed in anthropometric measures. Although not reaching significance level, post hoc tests revealed superior levels of CMJ_rel_peak_power (mean percentage difference %Mdiff = +3.2%, $p = 0.06$, $d = 0.33$) and 30m-sprint time (Mdiff = -0.7%, $p < 0.64$, $d = -0.21$) for time period 2014-2016 in comparison to 2011-2013. Significant differences were observed between time periods 2014-2016 and 2017-2019 for 30m-Sprint time (%Mdiff = -1.1%, $p < 0.05$, $d = -0.33$) and Yo-Yo-IR1 (%Mdiff = +12.7%, $p < 0.05$, $d = 0.64$) and between time period 2011-2013 and 2017-2019 for CMJ_rel_peak_power (%Mdiff = +4.8%, $p < 0.05$, $d = 0.48$), 30m-Sprint time (%Mdiff = -1.7%, $p < 0.05$, $d = -0.51$), and Yo-Yo-IR-1 (%Mdiff = +8.1%, $p < 0.05$, $d = 0.64$).

CONCLUSION: This study identified small to moderate positive development in physiological fitness parameters over time, while body mass and body size remained unchanged. From the observed trend in the data, we can infer that off-ice fitness test performance has increased over the last 9 years in our sample of youth elite male ice hockey players. In conclusion, our data support the common perception that ice hockey players are becoming faster and stronger. Moreover, today’s players possess more stamina than their predecessors.

Reference:

Quinney et al. (2008). Appl. Physiol. Nutr. Metab.

### EXPLORING THE KEY ATTRIBUTES OF FORMER RACEHORSES CONSIDERED TO HAVE THE POTENTIAL FOR A SUCCESSFUL SECOND CAREER IN DRESSAGE

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INTRODUCTION: Each year, approximately one quarter of the British racehorse population retire from racing and potentially start second careers. A key strategic aim of the British Horseracing Industry is to maximise racehorse welfare and quality of life following their retirement from racing. Despite this, few studies have evaluated what factors underpin successful second careers in former racehorses. Exploratory research has recognised dressage as the main discipline that horse owners compete their former racehorse in [1]. This study therefore aimed to explore what key attributes in former racehorses, owners associated with a successful second career in dressage.

METHODS: A 29-question online survey was shared to existing former racehorse owners through social media channels, including but not limited to, racehorse specific Facebook groups. The survey gathered demographic data on former racehorses including level and success attained in dressage, and asked owners to comment on personality and behavioural attributes that make former racehorses' suitable candidates for dressage, as well as to identify challenges of competing former racehorses in dressage. Data were exported to Microsoft Excel and analysed using frequency analysis and thematic analysis, using a grounded theory approach.

RESULTS: A total of 113 former racehorse owners completed the survey (Margin of Error: 9.16%). Respondents predominately competed their former racehorses at sub-elite level dressage, with horses on average achieving tests scores between 60-70%. Respondents selected dressage as their former racehorse's main discipline, as it was considered a solid foundation for all other second careers, and they felt it mentally and physically develops the horse, while being enjoyable for both horses and owners. Former racehorses' athleticism, "natural talent" and willingness to learn were key attributes which were identified as essential for competitive success in dressage. However, respondents recognised when competing a former racehorse, that patience was required throughout former racehorse re-education, and that individuals' "quirks" and dressage judges' perceived preference for a warmblood conformation could present challenges within this discipline.

CONCLUSION: Former racehorse athleticism, natural talent and willingness to learn were key attributes owners recognised enhanced potential for a successful second career in dressage. Applying these results across the industry to support former racehorse transition could help facilitate successful, long-term rehoming and second career success.

References:

1. Evans, S, et al., Retraining of Racehorses: Attributes Associated with Successful Post-Racing Careers. International Society for Equitation Science Conference 2021: Advancing Equestrian Practice to improve Equine Quality of Life.

## Disabilities

### ASSESSMENT OF BODY COMPOSITION AND STRUCTURE OF ATHLETES WITH SPINAL CORD INJURY

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INTRODUCTION: Spinal Cord Injury (SCI) - paralegic and tetraplegic (CSCI) dysfunction frequently determines and generates other deficits and disorders. Spinal Cord Injury results in physiological changes that reduce whole-body metabolism, resulting in neurogenic obesity via adipose tissue accumulation. Adipose tissue has been implicated in the release of proinflammatory adipokines that lead to chronic and systemic inflammation. Some scientific researches suggests these adipokines contribute to the pathogenesis of metabolic diseases which often accompanies obesity. That is why it is important specifically to create compensatory processes among persons with spinal cord injury who have sedentary life. Sport and physical activity is widely accepted necessary component for healthy individual, especially for a person with spinal cord injury . The purpose of this study was to compare several body features and indexes regarding their changes in the aspect of age and time of injury. It was assumed that main factors which differentiate body structure and composition of the people who had spinal cord injury are sports activity, type of injury, time since injury and age.

METHODS: The study group consisted of 43 Caucasian males aged 25 - 40 years (34.6 ± 2.8 years), who had experienced spinal cord injury. Conducted research was divided into three groups: G1 - wehler rugby players (CSCI), G2 - handbike (CSI) and G3- control group URK - no sports (sedentary life). All subjects were measured for body height, waist and hip circumference, thigh, calf and shoulder, all indicated in centimeters. Body mass (BM) was expressed in kilograms (MENSOR Chair of EC type P3 150 K). Body fat content was measured with the use of Abdominal Fat Analyzer ViSCAN Tanita AB-140 utilizes BIA. In addition, during the research there was conducted thorough interview concerning sports activity and duration of injury.

RESULTS: BMI calculated according to the standards of the general population indicated that 85% of participants fell within the norm (BMI <25), while according to BAI standards it was only 48%. Both the Body Mass and BMI depended inversely proportional from the time since injury, so that, the longer time since the injury, the lower Body Mass and BMI were. Similar correlation was observed for limb circumference. Furthermore, research revealed significant statistical differences in the study group regarding the body structure and composition depending by the age they had experienced injury.

CONCLUSION: Our research indicates that age moderately influences some characteristic of body structure and composition of individuals with SCI, specifically CSCI. We find that the elder the individual is at the time of injury, the greater the impact it has on characteristic of body structure and composition. In our opinion, this is important for the preparation of intervention programs for people with SCI in the form of sports activity.

### PHYSICAL FITNESS AND BONE DENSITY IN ADOLESCENTS WITH DIFFERENT LEVEL OF VISUAL IMPAIRMENT

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INTRODUCTION: Lower habitual physical activity in children and adolescents with visual impairment (VI) have unfavourable effect on their general health such as physical fitness and bone quality. Our aim was to demonstrate the physical fitness and bone density in adolescents with VI and to analyze of the relationships between physical fitness tests, body structure and bone characteristics.

METHODS: Children and adolescents with different level of VI (N=38) provided anthropometric, physical fitness (field and laboratory treadmill tests) and bone data (DEXA).

Differences between genders and subgroups (low vision vs blindness) were tested with Student's t-tests. The relationships between variables were analyzed using Pearson linear correlation. Linear regression models were used to explain the variation in BMD and BMC.

RESULTS: Body height, weight, body mass index (BMI), absolute measured VO2peak of children with low vision were similar as that of children with blindness despite the fact that the blind adolescents were older than the participants with low vision. Estimated relativeVO2 was significantly lower in children with blindness (43.84±4.42 vs 35.08±5.23 ml/kg/min; p<0.001) than in children with low vision. Standing long jump was poorer in blind girls than in girls with low vision (156.00±15.9 vs 118.57±35.2 cm; p=0.0034). Blind boys had higher handgrip strength than blind girls (35.97±9.97 vs 24.24±4.74 kg; p=0.003) and children with low vision (boys: 24.63±5.01, girls: 22.56±4.78 kg; p=0.001).

Bone mineral density (BMD) and bone mineral content (BMC) did not differ in subgroups, however Z-score of total body BMD was significantly lower in children with blindness. Z-score-means in L1-L4 lumbal spinal region were similar in both low vision and blind participants, the values of them were negative. The general linear regression model revealed significant relations of BMD (r2=0.538; p=0.0001) and BMC (r2=0.698; p=0.048) with BMI and handgrip strength test.

CONCLUSION: Individuals with VI have generally lower physical fitness level and decreased bone health. Body mass index and handgrip strength were good predictors of bone mineral density and bone mineral content. Bone health could estimate with this simple fitness test and body parameter without the need for expensive DEXA measurements.

## IS THE VISUAL IMPAIRMENT ORIGIN A PERFORMANCE FACTOR? ANALYSIS OF INTERNATIONAL LEVEL PARA SWIMMERS AND PARA ATHLETES

LE TOQUIN, B.

*INSEP*

INTRODUCTION: The aim of this study was to investigate the effect of congenital and acquired visual impairments on the international performance of Para swimmers and Para track and field athletes

METHODS: We collected results from visually impaired Para athletes competing in Para swimming or Para athletic events at all IPC-labelled competitions between 2009 and 2019. The dataset contained 20689 events results. Impairment origin was collected from the International Paralympic Committee (IPC) website. We separated impairment origin into two groups to distinguish those with a congenital impairment from those with an acquired impairment. In visual impairment sport classes (11-12-13), the performance level and the age performance relationship were investigated according to the impairment origin

RESULTS: In classes 11 and 12, peak performance was achieved earlier by male and female swimmers with a congenital impairment compared with those who had an acquired impairment ($p < 0.05$). No differences were present in class 13 or in any class in Para athletics ($p > 0.05$).

CONCLUSION: A similar performance level was observed among the two sport disciplines for each class ($p > 0.05$). This study demonstrated that impairment origin can influence the performance pathway among visually impaired swimmers.

## RELATIONSHIP BETWEEN THE TRAINING LOAD AND SLEEP IN PARALYMPIC POWERLIFTING ATHLETES

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INTRODUCTION: Since high-performance athletes often experience high physical and psychological demands (1), achieving optimal recovery in the training process is important in improving physical and cognitive performance (2,3). This study aims to compare the sleep parameters during the days with and without training of Paralympic powerlifting athletes, and to analyze the relationship between the training load and sleep of the same day.

METHODS: Actigraphy was used to analyze the sleep parameters of 11 Paralympic powerlifting athletes for 14 days (7 days without and with training) while Ratings of Perceived Exertion (RPE) analysis was used to assess training load. In addition, the Horne and Östberg chronotype questionnaire and the Epworth sleepiness scale were applied.

RESULTS: Athletes show a morning and indifferent chronotype and low daytime sleepiness. Sleep onset latency (SOL) was lower (average 5.3 min faster), and total sleep time (TST) and sleep efficiency (SE) were higher (TST averaged 169 min and SE 7 % higher) on training days compared to non-training days. In addition, the TST of the night before the training days was positively correlated with the RPE of the following day, as well as the training volume was negatively correlated with the SE of the same day.

CONCLUSION: It is concluded that positive effects of Paralympic powerlifting training were observed in increasing TST, SE and decreasing SOL on training days. These results point to the positive effects of this type of training in improving the sleep of athletes with physical disabilities. In addition, a good nights sleep the day before training can favor a greater effort in training the next day. Therefore, it is recommended to guide athletes to sleep more before training with more intense loads.

1.Silva A, et al. (2012). Br J Sports Med, 46(2), 150-154.

2.Silva A, et al. (2019). International journal of sports physiology and performance. 2019;15(5):671-676.

3.Roberts SSH, et al. (2019). British journal of sports medicine. 2019;53(8):513-522.

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### POST-OPERATIVE EXERCISE TRAINING IN PATIENTS WITH METASTATIC COLORECTAL CANCER – THE POET STUDY

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INTRODUCTION: Surgical treatment of liver metastases in colorectal cancer (CRC) patients has become a mainstay in the CRC treatment and has significantly improved survival rates (Xu et al., 2018). However, 50-75% of the patients experience a relapse in less than two years following metastatic tumor resection (De Jong et al., 2009).

CRC patients with liver metastasis, due to the high probability of relapse, undergo multiple rounds of surgery and adjuvant chemotherapy treatment which results in substantial physical deconditioning. Retrospective data indicate that physical activity increases progression-free survival rates in metastatic CRC (mCRC) patients (Meyerhardt et al., 2006). The objectives of this randomized controlled trial (RCT) are to investigate the effects of structured exercise training, applied in an early setting post-surgery and in a dose-response fashion, on:

Primary:

• Peak oxygen consumption (VO2peak)

Secondary:

• Recurrence-free survival (RFS), time-to-recurrence (TTR) and overall survival (OS)

• Overall physical fitness, inflammatory status and immune function.

• Patient reported outcomes.

METHODS: Sixty-six mCRC patients will be randomized 1:1:1 to either 1) 150 min/week of exercise (2 times /week), 2) 300 min/week of exercise (4 times/week) or 3) standard of care. Exercise training will start after discharge from surgery for resection of liver metastasis and will continue for 6 months. Training will consist of both aerobic and resistance exercise and will be partly center-based and partly home-based. The following assessments will be performed before the surgery and at 3, 6, 9, 12 months after initiation of exercise training: VO2peak, maximal strength, body composition, functional capacity, quality of life, fatigue. Blood samples will be collected at the same time points for assessment of immune function, inflammatory status and circulating tumor DNA as a marker of disease progression. CT scans performed every 3 months as standard of care will be used for detention of tumor recurrence.

RESULTS: NA

CONCLUSION: Six months of supervised, combined aerobic and resistance exercise training are expected to increase VO2peak in mCRC patients, improve physiological outcomes, inflammation status and immune function and delay tumor recurrence.

### EFFECT OF DIFFERENT TYPE OF TRAINING ON MUSCLE FUNCTION AND PHYSICAL CAPACITY IN CHRONIC HEMODIALYSIS PATIENTS

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INTRODUCTION: Decreased exercise capacity due to muscle weakness and exercise intolerance reduces the ability to perform activities of daily living in patients with end-stage kidney disease. Data on exercise type in dialysis population and its muscle effects are scarce. We aimed to determine the impact of training type (strength, resistance and mixed) on cardiovascular performance, muscle function (strength-speed parameters for quadriceps (QUAD) for right (QUAD_R) and left leg (QUAD_L), electrophysiological function of quadriceps (QEMG) in patients on hemodialysis maintenance.

METHODS: Eighty six dialysis patients underwent claster randomisation and were assigned to an exercise intervention groups: A - controlled endurance training during haemodialysis using rotors, B - controlled force training (resistance) , C - Tai Chi training on non dialysis days. Intervention lasted 6 months, 3 times a week (A, B) and 2 times a week (C) for 60 minutes. The outcome measures were spiroergometry (VO2/VO2max), strength of the lower limbs (dynamometry) and electromyographic examination (superficial electromiography). Values at the baseline and 6 months later were compared.

RESULTS: 45 patients completed intervention period and were analysed. Mean age in group A was 64±12y (n-16), in B was 60,5±10y. (n-15) and in C  68,5±9y. (n-14). Patients did not differ markedly between groups in term of sex, BMI, dialysis vintage and comorbidities.

After 6 months of training, VO2 and VO2max increased significantly only in group B (resistance training) 12.7 % for VO2 and 12.9% for VO2max but not in A and C group. Regarding force torque of quadriceps (QUAD) in isometric conditions the highest peak values were measured in group B (resistance training), namely increase by 13.6% ($p=0.0004$) for QUAD_R and 14% ($p<0.0001$) for QUAD_L. In group A (endurance) were not significat changes in strenght observed (3.2% in QUAD_R and 3.7% in QUAD_L). In group C (Tai Chi group) strength has increased by 7% ($p<0.05$) for QUAD_R and 6.8% ($p<0.05$) for QUAD_L.

In terms of changes in electrophysiological function of right (QEMG_R) and left (QEMG_L) quadriceps , there were increases: for group A by 10.5% ($p<0.0001$) and 9.6% ($p<0.05$); B 9.7% ($p=0.0002$) and 20.1% ($p=0.0001$); for C by 4.5% and 6.2% for R and L, respectively.

In groups B and C significant increases in static force moments was associated with increases in electrophysiological action (%QEMG), but in group A increase in EMG activity did not correspond with rise in muscle force.

CONCLUSION: Differences in muscle strength and functions were observed after 6 months of various type of exercise intervention in dialysis patients. Resistance training during dialysis showed the largest improvement in cardiorespiratory function and isometric leg muscle strength.

## Health and Fitness

### THE OPTIMAL WAKE-UP TIME FOR PEAK PERFORMANCES IN THE MORNING

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INTRODUCTION: Sports performances display a circadian rhythm; many individuals perform better in the afternoon than in the morning. Therefore, for a morning match, it is very important to take the essential steps to improve performances. Therefore, the purpose of the present study was to verify the optimal wake-up time in the morning for peak performances.

METHODS: The participants were 14 male college baseball players (age=21.1±0.6 yr, height=176.2±6.4 cm, weight=76.4±6.8 kg) who came to the laboratory by 9:30 a.m. The performance test started at 10:00 a.m. and was conducted thrice, with the time elapsed after waking up being changed each time. These times were set as 1, 2.5 and 4 hours after waking up (1H, 2.5H, and 4H, respectively; the waking-up time was 9:00 a.m., 7:30 a.m., and 6:00 a.m., respectively). The sitting trunk flexion (STF), simple and choice reaction times (RT and CRT, respectively), grip strength (GS), back strength (BS), vertical jump height (VJ), and the time of the pro-agility test (PAT) were measured.

RESULTS: There were no significant differences in body temperature, heart rate and blood pressure at pre-exercise among three experiments. The BS at 1H was significantly higher than that at 4H ($p<0.05$), and the PAT at 1H was significantly slower than that at 4H ($p<0.05$). The other parameters did not change with the variation in the elapsed time. However, there were differences among parameters or individuals in the time when peak performance was observed. Six or seven participants showed peak value of muscle strength at 1H, while only two peaked at 4H. Eleven participants peaked at 4H in the PAT. Three participants peaked at 1H in VJ, while seven peaked at 2.5H. In other measurements, the peak time was evenly distributed. Additionally, a few participants showed peak performances at 1H in many parameters, while others at 2.5H or 4H, or evenly.

CONCLUSION: Our data shows that muscle strength can be exerted even shortly after waking up, but a certain period of time is required for agility. The participants underwent early morning baseball training (6:00 a.m.-8:30 a.m.) 1-2 times per week; they often slept until just before the start of training to maintain sleep time. They might have, therefore, shown good performance even at 1H, as they were accustomed to exercising immediately after waking up.

Though we could not indicate the optimal wake-up time for a match in the morning, it might be effective to set the wake-up time based on the individual patterns of peak performance.

### THE EFFECTIVENESS OF A 12-WEEK EXERCISE PROGRAM TO RELIEVE SYMPTOMS DURING MENOPAUSE

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INTRODUCTION: In menopause, women face a number of negative changes due to the reduced hormone secretion. A well-structured exercise program can delay these negative symptoms, and do a lot against osteoporosis, muscle loss, and obesity, but it also has a positive effect on mental health and general physical well-being. The aim of the study was examining the effectiveness of a 12-week exercise program specifically designed for this age group based on physiological and psychological measurements.

METHODS: In the first phase of the study (baseline data and first measurements) a total of 21 female participated, during the 12-week exercise program the dropout rate was less than 10%, so we included a total of 19 female to the evaluation, where the mean age was 52.5 ± 2.91 years. The training program was carried out between June-October 2021. Due to the COVID-19 pandemic the trainings were executed both face-to-face and online. Participants attended 2x1 hours of resistance training were per week and 1x1.5 hours endurance training (i.e. cycling, walking) per week. The resistance training was executed with various strength training tools as well as with participants' own weight. The fitness test contained a flexibility test (sit and reach), a 2-minute step test, and the handgrip measurement. The body composition was measured with a TANITA BC-545N bio-impedance scale. The Physical Self –Description (PSD) was measured with the short version of PSDQ (Marsh et al., 2010). The sympthoms of menopause were asked by a self-developed questionnarie. Descriptive statistics (means and standard deviations) calculated for each variable. The Student´s t-test (one sample) was used to calculate physical fitness level differences before and after the intervention, Wilcoxon test was used to analyze the PSDQ data and Spearman Rank Order Correlation was used to see connections in menopause symptoms, before and after the intervention.

RESULTS: Significant improvement was detected in all fitness tests (flexibility, handgrip and 2-minute step test). Although the mean body weight decreased, it did not reach the significance level of 69.19 ± 11.37 kg vs. 68.84 ± 11.21 kg; and BMI also showed a only decreasing trend (25.87 ± 4.32 vs. 25.58 ± 4.29). Mean values of bone mass, muscle mass, visceral fat, and body fat did not change significantly between the first and second measurements, but e.g. body fat% was reduced in 36% of participants. The self-description of the women changed significantly over the 12 weeks: more than half of the self-assessment questions showed significantly better median values at the second measurement.

CONCLUSION: Our results are in line with earlier findings indicates that postmenopausal women who engage in the comprehensive exercise program, benefit by maintaining a healthy body as well as a good mental health.

### PREFERENCE PATTERNS FOR EXERCISE/SPORTS ACCORDING TO NUMBER OF PEOPLE PARTICIPATING

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INTRODUCTION: When people attend university, exercise or sports involve many people in PE classes or club activities. However, after graduation, people decide on their own if they want to exercise or play sports. For instance, some people jog by themselves. Others do radio calisthenics together with many other people in a neighborhood park. However, jogging can be done also with two or more other people and radio calisthenics can be done alone at home. Thus, this study examined whether preference patterns for exercise/sports according to the number of people participating exist or not and, if they do exist, what those patterns are.

METHODS: Subjects were 1,333 Japanese aged from their teens to middle age. They were asked three questions about the degree to which they want to exercise or play sports 1) alone, 2) with a few other people, and 3) with many other people. Answers were obtained on a 4-point scale from 1: very much to 4: not at all. Quantification Theory Type Three (QTTT; factor analysis using binary data) was applied to the data and configurations showing mutual similarities of responses and person patterns were obtained. The patterns were studied from positional relationships in the configurations.

RESULTS: A two-dimensional plot obtained using QTTT was adopted because the accumulated ratio of eigenvalues up to two dimensions was 39.55%. The plot of the category weights of the alternatives of questionnaire items generated three clusters: 1) "Want to exercise or play sports very much;" 2) "Sometimes" or "Not so much;" and 3) "Never." That is to say, a fine classification by the number of people exercising or playing together with that originally assumed was not found, and they were categorized into those who actively wanted to play all kinds of sports, those who did not, and others with medium characteristics regardless of the number of people participating. Based on a two-dimensional plot of sample scores showing the similarities among individuals, the following seven clusters were found in which respondents gradually changed their preference from completely dislike to completely like: 1) three-dislike group (96, 7.2%); 2) two-dislike and one moderately-like group (55, 4.1%); 3) two-moderately-like and one-dislike group (115, 8.6%); 4) three-moderately-like group (402, 30.2%); 5) two-moderately-like and one-like group (256, 19.2%); 6) two-like and one-moderately-like group (173, 13.0%); and 7) three-like group (102, 7.7%). In addition, three additional clusters with extreme preference patterns were also found: 8) two-dislike and one-like group (29, 2.2%); 9) two-like and one-dislike group (37, 2.8%); and 10) all combinational pattern of like, dislike and moderately like (68, 5.1%).

CONCLUSION: There was no difference in sports preferences according to the number of people together with whom sports were played, and there was a tendency that those who liked/disliked sports liked/disliked all kinds of sports regardless of the number of people participating.

## 1-H NMR URINARY METABOLOMIC ANALYSIS IN ELDER SUBJECTS AFTER A HIP FRACTURE REDUCTION MAY PROVIDE VALUABLE INFOR-MATION FOR PATIENT CHARACTERIZATION. A PRELIMINARY INVESTIGATION.

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INTRODUCTION: At the time of precision and personalized medicine, the importance of patient characterization to identify patient needs is crucial in order to provide the best available and cost-effective treatment. In this study, we used urine metabolomics to explore a possible characterization of elder patients who experienced hip fracture reduction and to explore the possibility of forecasting patient outcomes.

METHODS: Overnight urine specimens were collected in 33 elder patients after hip fracture reduction during their stay at the hos-pital. The specimens were analyzed with 1H NMR spectroscopy. We performed a metabolomics study regarding frailty evaluation and the results obtained at the Functional Independence Measure (FIM) and Short Physical Performance Battery (SPPB). We also investigated whether the categorization of the patients could predict their performance in FIM and SPPB one year later

RESULTS: The main metabolic variations concerned 10 identified metabolites: paracetamol derivatives (4 peaks: 2.15 ppm; 2.16 ppm; 7.13 ppm and 7.15 ppm); hippuric acid; acetate; acetone; dimethylamine; glycine; alanine; lactate; valine and TMAO. The urinary levels of these identified metabolites were significantly higher in frail persons (frailty score ≥ 3) with weak score of FIM and low score of SPPB compared to non-frail patients at baseline and after one year.

CONCLUSION: Our findings reveal that patients with increased levels of urine metabolites associated with metabolic, inflammatory, renal disorders presented clear signs of frailty, impaired physical capacity, and poor physical performance. Metabolomics could be a valuable tool to further characterize patients with frailty syndrome.

## 12 WEEKS OF WALTZ DANCE ON CARDIOVASCULAR RISK FACTORS AND BONE METABOLISM IN POSTMENOPAUSAL CHINESE WOMEN: A RANDOMIZED CONTROLLED TRIAL

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INTRODUCTION: In postmenopause, estrogen withdrawal along with sedentary lifestyle could contribute to the increased risk of cardiovascular disease and fracture in women. The energy consumption recommended by the American College of Sports Medicine to improve female health has been exhibited for many years. In this study, we aimed to investigate the improvement effect of waltz dance which meets current energy consumption recommendations on cardiovascular risk factors and bone metabolism in postmenopausal women of 12 weeks.

METHODS: Twenty six community-dwelling sedentary postmenopausal women aged 45-65 years were recruited and randomly divided into the waltz dance group (WEG, n = 14, BMI: 25.57±2.47 kg/m2) and the control group (CG, n = 12, BMI: 24.47±2.92 kg/m2). WEG completed 12-week waltz dance exercise training, the dance sessions of approximately 105 minutes were performed 3 days a week. Body composition, maximal oxygen consumption, lipid profile, serum bone metabolic markers (osteocalcin), bone mineral density (BMD) and bone mineral content (BMC) were measured before and after the intervention.

RESULTS: During the intervention, the energy consumption of waltz dance was 1624kcal to 2000kcal each week. After 12 weeks of waltz dance, the body weight (-1.96±1.70%, $P<0.01$) and body fat percentage (-1.60±0.71%, $P<0.01$) in WEG were significantly reduced. The TG was significantly lower than before (1.23±0.72 mmol/L VS 1.61±0.86 mmol/L, $P<0.05$), and the HDL-C was significantly higher than before in WEG (1.53±0.40 mmol/L VS 1.08±0.36 mmol/L, $P<0.01$). Moreover, the VO2max in WEG was significantly improved (27.79±3.09 mL/kg•min VS 22.43±3.41 mL/kg•min, $P<0.05$). As expected, the intervention improved BMD (+1.2%, $P<0.05$) and BMC (+2.4%, $P<0.05$) in the WEG, but had no impact on serum osteocalcin (1.13±0.47 VS 1.09±0.43, $P>0.05$).

CONCLUSION: A 12-week waltz dance intervention is effective in reducing risk factors of cardiovascular disease and improving bone health in postmenopausal women. This suggests waltz dance could be adopted as an interesting exercise for women to improve health in senior community.

## PHYSICAL ACTIVITY, EATING AND SLEEPING HABITS IN BRAZILIAN ADULTS AT THE BEGINNING AND ONE YEAR AFTER THE PANDEMIC

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INTRODUCTION: Social isolation is one of the strategies to prevent the contagion and transmission of the coronavirus (COVID-19), but the impacts of this new routine and lifestyle need to be understand. Therefore, the aim of this study was to analyze physical activity [1], sleep [2] and eating habits [3] of adults at the onset of the pandemic and one year after the COVID-19 pandemic.

METHODS: Cross-sectional study with 135 participants in first moment and 57 participants in second evaluation, divided by age group, comprising the sample. The group consisted of both sexes, enrolled in a physical activity program in a school community. An online questionnaire with 26 questions was applied about eating habits, sleep and physical activity, in addition to protective behaviors against COVID-19.

RESULTS: The distribution of participants the questionnaire by age groups were: 18-29 years (n=18; 9.3%), 30-40 years (n=37; 19.3%), 41-50 years (n=52; 27%), 50-60 years (n=53; 27.6%), 61-70 years (n=25; 13%). One year after the pandemic, 68.5% of the participants met the World Health Organization Physical Activity Recommendation, unlike the beginning of the pandemic, 52.7% did not meet the recommendation ($p<0.001$; $x2=6.89$). After a year of pandemic, participants became more active. At the beginning of the pandemic 78.1% occupied their time in more sedentary activities, such as watching television and spending a long time in front of the computer or cell phone and then 21.9% at the end of the first year ($p<0.01$; $x2= 5.61$). As for eating habits, 96.5% of the group responded that they took care of their diet after one year of the pandemic, at first only half (50.3%) of the participants did ($p<0.001$; $x2=37.99$). And, regarding the number of meals, 19.7% of the participants did not control the number of meals they had per day at the beginning of the pandemic and one year after this number went to 80.3% ($p<0.001$; $x2= 12.99$). In 68.7% of the participants declared that they slept an adequate number of hours, however 67.7% said that they slept poorly. There was no significant difference between onset and one year after the pandemic in terms of sleep habits.

CONCLUSION: One year after the start of the pandemic, most program participants were motivated by their physical activity and eating habits. Only the sleep habit did not improve, which can be concluded is that having more sleep is good for health, but it does not ensure quality, since the stress and frustration caused by the pandemic has overcome the possible positive effects of quarantine.

## HYBRID-TYPE, MULTICOMPONENT INTERVAL TRAINING IMPROVES CARDIORESPIRATORY FITNESS AND BODY COMPOSITION IN MIDDLE-AGED OVERWEIGHT AND OBESE ADULTS: A 1-YEAR DOSE-RESPONSE RANDOMISED CONTROLLED TRIAL

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INTRODUCTION: The rising prevalence of overweight and obesity is a major public health challenge negatively affecting more than one in two adults worldwide [1]. Regular exercise is a fundamental component of a comprehensive strategy for preventing, managing and treating obesity [2]. Particularly, a hybrid-type, multicomponent interval training programme (DoIT) has been reported as an effective exercise approach for improving a wide spectrum of musculoskeletal fitness indices [3]. This study examined the dose-response effects of a 1-year DoIT on cardiorespiratory fitness and various body composition parameters in previously inactive overweight and obese adults in a gym setting.

METHODS: Ninety-seven middle-aged (44.8 ± 5.2 years) overweight and obese individuals (31.2 ± 5.7 kg/m2) (66% female) were randomly assigned to the following groups: (i) no-intervention control (CON, n=29), (ii) DoIT performed once weekly (DoIT-1, n=24), (iii) DoIT performed twice weekly (DoIT-2, n=23) and (iv) DoIT performed thrice weekly (DoIT-3, n=21). DoIT was a time-efficient, intermittent-based, multicomponent exercise protocol using progressive loaded fundamental movement patterns with prescribed work-to-rest intervals (1:3 to 2:1) in a circuit format (2–3 rounds). Cardiorespiratory fitness (CRF), somatometric parameters [body mass (BM), waist circumference (WC), waist-to-hip ratio (WHR)] and body composition [body fat percentage (BF%), fat mass (FM), fat-free mass (FFM), trunk fat percentage (TF%)], resting metabolic rate (RMR), bone metabolism [whole-body and regional (femur) bone mineral density (BMD) and bone mineral content (BMC)] were assessed at baseline, 6 months and 12 months following intervention.

RESULTS: CON increased all somatometric (1.8%–2.2%, $p<0.001$) and body composition variables (0.5%–4.3%, $p<0.001$). In somatometric measures, all DoIT groups reduced BM (1.8%–5.2%), WC (3%–6.6%), WHR (1.1%–6.6%) at post training compared to baseline ($p<0.001$). In body composition, all DoIT groups reduced BF% (1.5%–4.5%), FM (5%–15%) and TF% (0.4%–1.8%) while increasing FFM (1%–2.4%), whole-body and femur BMD (0.4%–2.2%) as well as BMC (0.1%–1.8%) at post-training ($p<0.001$). All DoIT groups exhibited superior increases than CON in CRF (18%–23%, $p<0.001$).

CONCLUSION: These findings suggest that a multicomponent exercise approach incorporating bodyweight drills and resistance-based alternative modes performed under real-world conditions may improve cardiorespiratory fitness and several body composition indicators, but not widely in a dose-dependent manner in previously inactive, middle-aged overweight and obese adults. The results of this study will enable physicians and exercise professionals to follow more efficient exercise prescription guidelines for this popular and effective exercise modality.

References:

1. Collaboration NCDRF. Lancet. 2017; 390(10113): 2627–2642.
2. Oppert et al. Obes Rev. 2021; Suppl 4: e13273.
3. Batrakoulis et al. Eur J Sport Sci. doi: 10.1080/17461391.2021.2025434

### THE CHARACTERISTICS OF GENERAL MALAISE/INDEFINITE COMPLAINTS IN JAPANESE CHILDREN AS EXAMINED BY LATENT CLASS ANALYSIS

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INTRODUCTION: We refer to subjective symptoms showing that physical conditions are something wrong despite that there is no disease causing it to be a general malaise/indefinite complaint (GMIC). It is said that GMIC consists of a feeling of tiredness, dizziness, headaches, palpitation, diarrhea, and others, and a disorder of the autonomic nervous system is involved. Since irregular menstruation, as well as psychological stress, a change in environment, and accumulation of fatigue, is thought to be associated with it, it is said that it is often seen in adult females. Even in advanced countries, it is caused by a deficiency of vitamins or essential nutrients or degraded physical fitness. Although it is often found in adults, it is appearing in children now and is considered to be similar to a life-related disease. However, its actual situation has not been made clear yet. Thus, this study examined the characteristics of GMIC in Japanese children using latent class analysis.

METHODS: 192 Japanese elementary school boys/girls aged 11 or 12 years in F-city were asked to answer a questionnaire survey about their GMIC, i.e., how often do they feel 1) Heavy head, 2) Sleepy, 3) Irritated, 4) Stomach aches, 5) Heavy and tired, 6) Intestinal disorders such as constipation and diarrhea, 7) Headaches, and 8) Lack of motivation, based on using the alternatives of a) Never, b) 1 or 2 days/week (ds/w), c) 3 or 4 ds/w, d) 5 or 6 ds/w, and e) every day. Latent class analysis was conducted using poLCA in R, which utilizes an EM algorithm. The optimal number of classes was obtained using AIC.

RESULTS: Since the AICs in 1 to 4 classes were 2417, 3184, 3113, and 3124, respectively, the 3-class solution was adopted of which the AIC was the minimum. The first class was interpreted as “Healthy children without any GMIC” because they answered with “No” for all questionnaire items, except that they answered with “1 or 2 ds/w” for “Sleepy” and “Stomach aches.” The results of the answers where they responded with “1 or 2 ds/w” for all items, except for answering with “No” for “Intestinal disorders,” allowed us to interpret the second class as the group with slightly GMIC. The third class answered with “every day” for “Heavy and tired,” “Heavy head,” “Irritated,” “Lack of motivation,” and “Sleepy” and “5 or 6 ds/w” for “Headaches,” and this class was thought to be a typical GMIC. However, this GMIC class responded with “No” or “1 or 2 ds/w” for “Stomach aches” and “Intestinal disorders.” That is, it is thought that typical GMIC in Japanese children is characterized not by disorders of the digestive organs, but by a shortage of active vitality or irritation. Again, the number of students included in each class was 42.2% in the “Healthy children group,” 47.9% in “Slightly-healthy children group,” and 10.35 in the “GMIC group.”

CONCLUSION: The rate of Japanese GMIC was approximately 10%, of which the main characteristics were not disorders of digestive organs, but a shortage of active vitality or irritation.

### EFFECTS OF CONCURRENT EXERCISE TRAINING ON PHYSICAL, PHYSIOLOGICAL AND PSYCHOPATHOLOGICAL PARAMETERS IN ADULTS WITH TREATMENT-RESISTANT DEPRESSION: TRACE-RMD STUDY

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INTRODUCTION: Treatment-resistant depression (TRD) is defined as those who do not remit to major depressive disorder with pharmacological treatment. Concurrent exercise training (i.e. a combination of aerobic and resistance exercise in the same session) could be an efficient no-pharmacological treatment strategy for improving physical (cardiorespiratory fitness and body composition) and mental health (psychopathological variables). This study aimed to determine the effectiveness of a concurrent exercise program on physical, physiological, and psychopathological parameters in adults with TRD.

METHODS: Participants (n=13, 69.2% women, 57.3±13.7 yr old) with TRD undertook a supervised exercise program (concurrent training, 2 days/week). All variables were assessed pre-and post-intervention (12 weeks). A cardiopulmonary exercise test was performed to determine the cardiorespiratory fitness through the peak oxygen uptake (VO2peak). Waist circumference and body mass index determined the body composition. The depression symptoms and severity of the disease were assessed with the Montgomery Depression Rating Scale (MDRS) and Clinical Global Impression (CGI-G), respectively.

RESULTS: Following the intervention, there was not a significant (P>0.05) change decrease in body mass (Δ=-5.7%), body mass index (Δ=-0.7%), and waist circumference (Δ=5.4%). Likewise, cardiorespiratory fitness in, both, V̇O2peak (L·min-1, Δ=11.5%), V̇O2peak (mL·kg.1·min-1, Δ=12.3%), showed no significant (P>0.05) changes. However, in psychopathological variables, participants improved with lower values in both MDRS (Δ=-27.21%, P=0.02) and CGI-G (Δ=-25.32%, P=0.01).

CONCLUSION: The beneficial effects on psychopathological variables in patients with TRD after concurrent exercise should lead to consider exercise as a coadjuvant program in their treatment.

### TREATMENT WITH CONCURRENT EXERCISE IN PATIENTS WITH RESISTANT MAJOR DEPRESSION (TRACE-RMD): PHYSICAL, PHYSIOLOGICAL AND BIOCHEMICAL PRELIMINARY BASELINE OUTCOMES

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INTRODUCTION: Functional dysfunctions in people with resistant major depression (RMD) are frequent and severe, and their importance contrasts with the absence of drugs to alleviate these deficits. Associated risk factors are unhealthy lifestyle including sedentarism, social and economic factors, and the side effects of treatments. Exercise programs, which were initially developed as interventions aimed at improving physical health in early stages or mild symptomatology, have shown that they can also improve the symptoms of this disease in more advanced stages. Therefore, the aim of this study was to determine some key physical, physiological and biochemical markers of health status in adults with RMD.

METHODS: The current baseline study comprised a total of 15 participants (67% women, 57.7±13.8 yr old) enrolled in the TReAtment with Concurrent Exercise in patients with Resistant Major Depression study (TRACE-RMD). Body composition included body mass index (BMI), bioimpedance analysis, and waist circumference. Peak oxygen uptake (VO2peak) through the cardiopulmonary exercise test determined the cardiorespiratory fitness (CRF). After an overnight fast a blood sample was collected to determine the biochemical profile.

RESULTS: The studied population showed obesity according to BMI (30.0±4.8 kg·m-2), and taking into account the fat mass percentage (36.1±9.8%) and high metabolic risk considering the waist circumference (99.9±12.5 cm). Poor cardiorespiratory fitness (18.8±8.6 mL·kg-1·min-1) and 26.7% of patients were smokers. Regarding participants' biochemical profile high-density lipoprotein cholesterol (HDL-C) presented optimal values (>40 mg/dL). However, low-density lipoprotein cholesterol (125.93±44.0 mg/dL), cholesterol ratio (total cholesterol, TC/HDL-C=4.1±1.4), and C-reactive protein (5.34±5.9 mg/L) were, instead, upper to optimal values according to the Adult Treatment Panel III. There were normal TC (180.1±58.5 mg/dL), glucose (107.6±50.0 mg/dL) and hepatic enzymes (aspartate transaminase=19.1±4.1 U/L and alanine transaminase=22.92±10.9 U/L) values. According to Wildman Modified criteria, participants were classified as metabolically abnormal obese (i.e., obese and ≥2 cardiometabolic abnormalities).

CONCLUSION: Patients suffering from RMD present an unhealthy profile, with a low CRF, obesity, and high cardiometabolic risk. These results strongly suggest that targeting key behaviors such as improving CRF through exercise will contribute to getting a healthier population.

## A STUDY OF CARDIOVASCULAR RISK PREDICTION METHODS DURING EXERCISE IN PEOPLE AGED 45-55 AND 56-65 YEARS

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INTRODUCTION: The purpose of this study was to investigate the factors associated with the occurrence of cardiovascular risk during exercise in people aged 45-55 years and 56-65 years, finally to construct a prediction formula for exercise risk in people aged 45-55 years and 56-65 years to provide some theoretical reference for the prevention of cardiovascular risk during exercise in adults of different ages.

METHODS: 206 subjects were divided into 45-55 years old group (group A, N=80) and 56-65 years old group (group B, N=126). The flow of this study was divided into the following 2 phases: basic test phase and exercise test phase. Basic test phase: This phase was conducted in the early morning, and subjects sat quietly for 10-20 min before the test, and physiological and biochemical indexes were measured, and breakfast was consumed uniformly after the basic test. The exercise test phase: Perform a GXT with power bicycle (60rpm, initial load of 25W, increasing 25W every 3 minutes). The changes in the ECG were monitored by a 12-lead ECG tester and the ST-segment depression values were recorded during the exercise. The cardiovascular risk during exercise was determined by the presence of an ECG ST-segment value of ≥0.1 for more than 1 minute. Finally, the indexes with higher correlation between the ECG ST-segment values during exercise in group A and group B were explored by Correlation Analysis, and the prediction formula of cardiovascular risk during exercise in different age groups was constructed by Bayesian discriminant analysis and multiple regression analysis.

RESULTS: 1. The incidence of cardiovascular risk was 55% for 45-55 years and 41.3% for 56-65 years.

2. The ECG ST-segment values during exercise were significantly correlated with CIMT, WHR and SBP in the 45-55 years old group, and prediction equations were constructed as shown below.

Y=-0.174X1-0.15X2-0.002X3+0.278; R=0.640, R2=0.360

Y: the ST-segment hypotension value during exercise, X1: CIMT; X2: WHR; X3: SBP

3. The ECG ST-segment values during exercise were significantly correlated with LDL, PA and PWV values in the 56-65 years old population, and prediction equations were constructed as shown below.

Y=-0.05X1+0.2*10-5 X2-0.54*10-4X3-0.022; R=0.556, R2=0.309

Y: the ST-segment hypotension value during exercise; X1: LDL; X2: PA; X3: the mean left- and right-side PWV values

CONCLUSION: 1. The degree of cardiovascular risk during exercise in people aged 45-55 years can be predicted by a cardiovascular risk prediction formula constructed from indicators responding to the degree of obesity, the degree of atherosclerosis and vascular elasticity.

2. The degree of cardiovascular risk during exercise in people aged 56-65 years can be predicted by a cardiovascular risk prediction formula constructed from indicators responding to the degree of lipid metabolism and vascular sclerosis and physical activity level.

## INTERMITTENT FASTING ON PROMOTING METABOLIC HEALTH: CURRENT STATUS, HOTSPOTS AND FUTURE PROSPECTS

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INTRODUCTION: Intermittent fasting (IF), an eating pattern that cycles between periods of eating and fasting, has received considerable interest as strategies to ameliorate chronic diseases and promote metabolic health. It also has many potential long term health benefits. However, the specific mechanisms and strategies of IF for metabolic amelioration are still unclear. Therefore, a systematic review was conducted to focus on its effects on promoting metabolic health, involving global status, research hotspots and its future prospects.

METHODS: Cite Space software was used to visually analyze 703 publications in Web of Science core database from the period 2010-2022. Literature categories, research hotspots, the most prolific research by country and journal were analyzed separately.

RESULTS: Publication outputs increased smoothly year by year with a sharp rise from 142 to 251 in 2020 that reached the highest volume of all time. Approximately 73% of the research came from five countries: United States (36.42%), China (10.38%), Australia (9.82%), United Kingdom (8.96%) and Germany (7.40%). The most popular disciplines were Nutrition, sports science, endocrinology and metabolism, accompanied by multi-discipline intersections, showing a trend of diversification. Nine of the top ten most-published journals were medical that affiliated to United States with a large range of impact factor spans from 3.24 to 47.728. The first controlled feeding trial achieved the highest citation shown that IF contributes benefits independent of weight loss such as improvement of insulin sensitivity and oxidative stress. "Insulin resistance", "circadian clock", "childhood obesity", "time-restricted feeding", "glycogen", "oxidative stress" and "exercise" were demonstrated as major hotspots. "Body composition", one of the most widely used research outcomes, and "gene expression", one of the most common keywords of mechanism study, sustained both high frequency and centrality. Detected by the citation burst, the frequencies of the appearances of keywords "time-restricted feeding", "dysfunction" and "appetite" dramatically surged in the period between 2020 and 2022. TRF has been proved to substantially reduce the desire and capacity to eat at night, therefore help curb food intake and, in turn, facilitate weight loss and metabolic dysfunction.

CONCLUSION: The present study provides a further understanding of the trends in promotion of metabolic health by IF. Based on the aforementioned statement, the future research directions can be concluded as 1) personalized regimens for children, adolescents, women and the elderly; 2) to uncover promising targeted fasting therapeutic approaches for chronic diseases and cancer, and understanding the underlying mechanisms; 3) safety and dose-response relationship of different regimens in personalized populations.

### EFFECTS OF RECREATIONAL ACTIVITIES COMBINED WITH JAPANESE TRADITIONAL GAMES ON COGNITIVE FUNCTION IN ELDERLY PEOPLE

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INTRODUCTION: In Japan, the number of elderly people (aged 65 and older) with dementia is increasing. Because dementia is an incurable broad category of brain disease, early detection as well as early intervention regimens are imperative countermeasures. In addition, it would be wise to emphasize on dementia prevention at the age of 60 or less which would be beneficial even for high susceptibility individuals. In this study, we investigated the effects of recreational activities combined with Japanese traditional games (JTG) on cognitive function (focused on memory function) in elderly people.

METHODS: Forty subjects aged 65 to 85 years old were enrolled in the present survey. Twenty-five subjects performed recreational activities combined with JTG (JTG group). The control group consists of 15 individuals not being engaged in either recreational activities nor JTG (Co group). The subjects in the JTG group were asked to participate in 90-minute recreational activities combined with JTG. The intervention was set once every two weeks for one year (total participation=24). Before and after the one-year-long intervention, each group was assessed by cognitive evaluation tests including word memory test divided into short-term memory (STM) and long-term memory (LTM), kanji conversion symbol test (KCS), and animals' names recalling test (ANR).

RESULTS: The results demonstrated that the STM score, LTM score, KCS score, ANR score, and the total scores in the post-intervention of the JTG group was higher than those in their pre-intervention ($P<0.01$- $P< 0.001$), but not in the Co group. The STM score, LTM score and total scores of post-intervention in the JTG group was significantly higher ($P<0.05$ - $P<0.001$) than those in the Co group.

CONCLUSION: These results suggest that the intervention regimen used in this study is an effective method in improving the cognitive function of elderly individuals. Furthermore, we suggest that an intervention program, including recreational activities and JTG, could to some extent prevent cognitive decline in elderly people.

### ENERGY CONSUMPTION OF WALKING AND RUNNING AT DIFFERENT INTENSITIES IN THE ELDERLY

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INTRODUCTION: The improvement of physical activity level can effectively prevent and improve metabolic diseases and promote health in the elderly. However, it is not clear that how much energy is expended by different types of exercise for different populations. In this study, walking and running at low, medium and high exercise intensities were selected and energy consumption was measured to observe the energy consumption and post-exercise recovery.

METHODS: 15 male and female subjects aged 60-70 who met the inclusion criteria were recruited from the surrounding communities of Haidian District, Beijing. The subjects went to the lab to accomplish 3 different speeds of walking and running on a treadmill. During the 4.2km/h, 5.6km/h, 6.4km/h of walking and running, the participants wore a gas metabolism analyzer (Cortex3B-R2) and a Polar watch to measure energy expenditure and heart rate. Each speed lasted for 6 minutes, after each level of exercise the participants rested until the heart rate, oxygen uptake and respiratory quotient recover to the quiet level. Excessive post-exercise oxygen consumption (EPOC) was also tested in the rest period after each level of exercise. The differences between different intensities within groups were tested by one-way ANOVA, and the differences between groups were tested by independent samples T test. $P<0.05$ was considered statistically significant.

RESULTS: The energy consumption of walking and running in males and females were different under different intensities. There were no differences in energy consumption between men and women during exercise at 4.2km/h (4.94±1.44kcal/min VS 4.23±0.20kcal/min, $P>0.05$). There were significant differences in energy consumption between men and women during exercise under the intensity of 5.6km/h and 6.4km/h(5.6km/h:6.08±1.31kcal/min VS 5.10±1.24kcal/min; 6.4km/h:7.45±1.01kcal/min VS 6.09±0.25kcal/min, all $P<0.05$). There were no differences in EPOC between men and women under different intensities ($P>0.05$). The total energy consumption（exercise plus EPOC）of men is higher than that of women under three intensities. There were significant differences in total energy consumption between men and women at 6.4km/h (38.21±6.86kcal VS 32.51±6.80kcal, $P<0.05$), but there were no gender differences in total energy consumption at 4.2km/h and 5.6km/h (4.2km/h:23.49±9.13kcal VS 21.04±5.82kcal; 5.6km/h:30.93±7.63kcal VS 26.46±6.08kcal, all $P>0.05$).

CONCLUSION: For 60 to 70 elderly people, the exercise energy consumption and total energy consumption gradually elevate with the increase intensity of walking and running, but EPOC does not show the same increasement. Elderly male experience more energy expenditure than women both during walking and running.

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### EFFECT OF AEROBIC EXERCISE COMBINED WITH HIGH PROTEIN DIET ON MYOCARDIAL HYPERTROPHY IN RATS

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INTRODUCTION: It is known that aerobic exercise (AE) induces cardiac hypertrophy accompanied with an increase in left ventricular mass and cavity, and that high protein dietary intake (HPD) partly prevents myocardial weight loss associated with prolonged bed rest. However, the effects of the combination of AE and HPD on the myocardial remodeling are still unclear. The aim of this study was to examine the effect of the combination of AE and HPD on myocardial hypertrophy in rats.

METHODS: Twenty-four 10-week-old male Wistar rats were divided into four groups based on the presence of AE and HPG interventions; AE+HDP, AE only, HDP only, and no interventions. After a total of 8 weeks of exercise protocol, hearts were removed. Next, the samples were embedded in paraffin wax and the blocks were then serially cut into transverse 5-µm-thick sections and stained with hematoxylin and eosin for cardiac morphological analysis. Two-way analysis of variance was used to analyze the effects of AE and HPG, and the interaction between AE and HPG.

RESULTS: Cardiac cross-sectional area showed the main effect of AE ($F(1,23) = 20.76$, $p < 0.01$), the main effect of HPD ($F(1,23) = 8.75$, $p < 0.01$), the interaction effect of AE and HPD ($F(1,23) = 5.32$, $p < 0.05$). Left ventricular cavity area showed the main effect of AE ($F(1,23) = 128.30$, $p < 0.01$), the main effect of HPD ($F(1,23) = 131.38$, $p < 0.01$), and the interaction effect of AE and HPD ($F(1,23) = 37.33$, $p < 0.01$). Left ventricular wall cross-sectional area showed the main effect of AE ($F(1,23) = 13.42$, $p < 0.01$) and the interaction effect between AE and HPD ($F(1,23) = 12.64$, $p < 0.01$), but not the main effect of HPD ($F(1,23) = 0.04$ , $p = 0.85$). Left ventricular myocardial fiber cross-sectional area showed the main effect of AE ($F(1,23) = 137.96$, $p < 0.01$) and the main effect of HPD ($F(1,23) = 14.94$, $p < 0.01$), but not the

interaction effect between AE and HPD (F (1,23) =1.56, p=0.23), which was thus considered to be an additive effect. Left ventricular myocardial fiber short diameter showed the main effect of AE (F (1,23) =54.65, p < 0.01) and the main effect of HPD (F (1,23) =8.44, p < 0.01), but not the interaction effect between AE and HPD (F (1,23) =0.05, p=0.83), which was thus considered to be an additive effect.

CONCLUSION: The present morphological findings revealed that the combination of AE and HPD had the synergic or additive effects on eccentric myocardial hypertrophy with an increase in left ventricular cavity and wall thickness in rats. It is suggested that the combination of exercise and nutritional therapy is effective in promoting the physiological cardiac hypertrophy.

**CAN PHYSICAL FITNESS ATTENUATE THE IMPACT OF HIGHER BODY MASS INDEX AND ADIPOSITY ON INFLAMMATION IN WOMEN WITH SYSTEMIC LUPUS ERYTHEMATOSUS?**

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INTRODUCTION: Higher body mass index and adiposity represent independent contributors to the systemic low-grade inflammatory state often observed in patients with systemic lupus erythematosus (SLE). This study assessed the role of physical fitness in the association of body mass index and adiposity with inflammatory markers in women with SLE.

METHODS: A total of 77 women with SLE were included in this cross-sectional study. Body mass index (kg/m2), waist-to-height ratio, and body fat percentage were obtained. Fasting blood samples were obtained and the concentration of relevant inflammatory markers (C-reactive protein, interleukin 6, and leptin) were assessed in serum. Cardiorespiratory fitness was estimated with the 6-minute walk test, range of motion with the back-scratch test, and muscular strength with handgrip dynamometry.

RESULTS: Cardiorespiratory fitness attenuated the association of body mass index and body fat percentage with interleukin 6 (all, P<0.05). Range of motion attenuated the association of body mass index with interleukin 6 (P<0.05) and the association of body fat percentage with C-reactive protein (P<0.05). These interactions indicated that higher fitness was associated with a lower increase in inflammation per unit increase of body mass index or adiposity. Muscular strength showed a non-significant trend to attenuate the association of body fat percentage with interleukin 6 (P=0.057) but potentiated the association of body fat percentage with leptin (P<0.05).

CONCLUSION: These findings suggest that higher levels of cardiorespiratory fitness and range of motion might attenuate the impact of higher body mass index and adiposity on inflammation in women with SLE. The role of muscular strength requires further investigation.

**KNOWLEDGE, ATTITUDES AND PERCEPTIONS OF TYPE 2 DIABETES MELLITUS AND THE ROLE OF EXERCISE INTERVENTIONS.**

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INTRODUCTION: Regular exercise has shown to have a positive effect on Type 2 Diabetes Mellitus (T2DM) but is underutilised in developing countries. Self-management of T2DM in South Africa (SA) is sub-optimal, with exercise reported to be the least employed modality of self-management. Health care professionals such as biokineticist can play a vital role in the treatment of T2DM by using exercise as a treatment modality. The aim of this study was to identify the knowledge, attitudes and perceptions (KAP) of T2DM and exercise interventions and to explore participants' awareness and acceptance of the role of biokineticists in the management of T2DM in KwaZulu Natal, South Africa.

METHODS: A quantitative, cross-sectional, purposive study design was used. Participants with T2DM who were receiving treatment from the Wentworth public hospital completed a validated questionnaire. Participants' knowledge was evaluated by true/false questions, and their attitudes and perceptions on a five-point Likert scale. Data was analysed using descriptive and inferential statistics ($p \leq 0.05$).

RESULTS: Reported adherence to prescribed diabetes medication by participants (n = 150) was high, at 96%. However, only 60% of participants reported exercising regularly; 47.3% followed a recommended diet for T2DM; and 32.7% took appropriate care of their feet. Responses given by the participants regarding their knowledge and perceptions indicated good insight into the role of exercise in the management of T2DM (94.7%). There was low awareness of the field of biokinetics, with 74% of participants admitting no knowledge of 'biokinetics'. However, after receiving information on the role of the biokineticist in T2DM, 92% of participants were willing to work with a biokineticist to manage their T2DM.

CONCLUSION: There was low reported adherence to exercise, diet and foot care among participants, despite good knowledge about, and attitudes to, the modalities of T2DM self-management. Majority of participants (92%) expressed a willingness to work with a qualified health care practitioner such as a biokineticist to manage their T2DM.

**EFFECTS OF SNPE ON PHYSICAL FITNESS, ISOMETRIC STRENGTH AND ROM OF THE LOWER EXTREMITY IN ADOLESCENT CHEERLEADING ATHLETES**

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INTRODUCTION: SNPE (Self Natural Posture Exercise) is an exercise mode that helps restore musculoskeletal function and relieve pain by using exercise tools and belts. The purpose of this study is to analyze the effect of SNPE training on physical strength, lower extremity muscle strength, and ROM in sports cheerleading athletes.

METHODS: A total of 22 participated; Exercise Group (EG: n=11, 15.9±2.0 yrs, 159.2±7.1 cm, 54.6±16.2 kg), and Non-Exercise Group (NEG: n=11, 15.9±2.5 yrs, 158.2±8.1 cm, 53.5±9.2 kg). EG underwent SNPE program consisting belt and tool exercises 60 min per session, 5 times a week, for 6 weeks. The exercise intensity was raised every 2 weeks by repetition and sets. Physical fitness (grip strength, back muscle strength, standing long jump, backward flexibility and sitting flexibility), isometric strength (knee- extension, and flexion, ankle- plantar and dorsi flexion, foot-inversion and eversion) and ROM (hip- external and internal rotation, ankle- plantar and dorsi flexion) of the lower were measured before and after SNPE training. Data analysis was performed using ANCOVA.

RESULTS: As the results of physical fitness, grip strength was increased in EG than NEG (23.8±0.6 vs 21.8±0.6 kg, p<0.05). The right (15.6±0.8 vs 11.8±0.8 N, p<0.01) and left (15.4±4.2 vs 11.5±3.2 N, p<0.05) knee flexion, right (23.0±1.0 vs 8.6±1.0 N) and left (22.2±1.3 vs 8.5±1.3 N) knee extensionp (p<0.001), right (11.1±0.7 vs 7.9±0.7 N, p<0.05) and left (10.7±0.7 vs 6.9±0.7 N, p<0.01) plantar flexion, right (11.7±0.7, vs 5.9±0.7 N, p<0.001) and left (11.3±1.1, vs 6.2±1.1 N, p<0.01) dorsi flexion, right (7.6±0.3, vs 4.8±0.3 N) and left (6.8±0.4, vs

3.8±0.4 N) inversion (p<0.001), and right (6.4±0.3, vs 4.2±0.3 N) and left (6.9±0.3 vs 3.8±0.3 N) eversion (p<0.001) in isometric strength of the lower extremity increased in EG than NEG. The right (29.4±2.1 vs 21.3±2.1 degree, p<0.05) and left (27.0±1.6 vs 20.2±1.6 degree, p<0.01) external rotation of hip joint, left internal rotation of hip joint (24.5±1.9 vs 17.7±1.9 degree, p<0.05), right (80.9±1.7 vs 70.0±1.7 degree, p<0.001) and left (78.8±1.3 vs 72.5±1.3 degree, p<0.01) plantar flexion, and right (11.6±0.8 vs 4.7±0.8 degree) and left (9.3±0.8, vs 3.6±0.8 degree) dorsi flexion (p<0.001) in ROM of the lower extremity increased in EG than NEG.

CONCLUSION: SNPE had a positive effect on lower extremity muscle strength and ROM. Program development will be required through continuous research.

### INTRADIALYTIC COGNITIVE AND AEROBIC EXERCISE TRAINING IN HEMODIALYSIS PATIENTS: STUDY PROTOCOL

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INTRODUCTION: Hemodialysis (HD) patients have lower cognitive functioning and reduced physical fitness compared to age-matched healthy individuals. These patients are less physically active and activate their mental functions to a lesser extent than the general population. Clinicians typically do not recognize the declining cognitive performance in these patients; therefore, cognitive impairment is greatly underestimated and not appropriately treated. Cognitive decline is widespread and progresses at a faster and greater rate than in the general population, so preventive and therapeutic interventions are urgently needed.

The primary aim of this research project is to investigate the effect of cognitive training combined with physical exercise on cognitive function, physical performance and frailty indicators in the HD population. Secondly, the project will test the feasibility of using the innovative cognitive platform to apply cognitive training to HD patients.

METHODS: We will conduct a randomized controlled intervention trial to examine the effects of a combined non-pharmacological intervention in the form of intradialytic physical exercise and intradialytic cognitive training on cognitive function, indicators of frailty, and physical performance measures in HD patients. The group of patients receiving the study intervention will be compared to the control group receiving standard HD care. The duration of the intervention will be 12 weeks. We will use sensitive instruments (cognitive domain tests) to assess cognitive functions. The primary outcome of the study at 12 weeks will be performance on the Alertness subtest of the computerized Test of Attentional Performance, which measures one domain of cognitive function, alertness. Secondary study outcomes are: Performance in other domains of cognitive function (executive function, psychomotor speed, information processing efficiency, working memory, attention), physical fitness (10 repetition sit-to-stand test, timed up and go test, handgrip strength test, spontaneous gait speed, Stork balance test), and assessment of frailty (Edmonton Frail Scale). Study outcomes will be assessed at baseline, immediately after the 12-week intervention, and six months after the end of the study without specific further intervention (retention effect assessment).

RESULTS: We hypothesize that the experimental group will achieve significant and clinically meaningful improvements in their cognitive and physical functions and reduce their frailty score compared to the control group.

CONCLUSION: Prevention and treatment of cognitive decline and dementia are one of the most important public health goals. If our hypothesis is confirmed, we would be able to offer an innovative, non-pharmacological, bimodal intervention that is cost-effective, safe, and easy to implement during the intradialytic period, with potential impact on patients important unmet needs and quality of life.

### EXPLORING THE FEASIBILITY AND USER EXPERIENCE OF AN AUGMENTED REALITY APP PRESCRIBING EXERCISE FOR CHILDREN AND YOUNG PEOPLE WITH CANCER

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INTRODUCTION: This study is still ongoing and the following abstract has been composed to reflect the study protocol. Findings will be presented at the time of the conference. An updated abstract will be provided by the 29th of July 2022.

Children and young people with cancer face particular barriers when engaging with exercise, such as cancer and treatment-related side effects, psychosocial treatment burdens and lack of individualised provisions. In recent years, Coronavirus has further exacerbated these difficulties. Therefore, it is vital to explore new technologies as a way to enable remote, individualised exercise rehabilitation for young cancer patients. As part of the Europe-wide FORTEe trial, 16 institutions are exploring the use of exercise for enhancing physical and mental health among young cancer patients. The wider study includes a focus on using technology to support this effort. The present study aims to provide crucial evidence on feasibility and user experience of a novel exercise-focused smartphone augmented reality (AR) app to inform future technology development within paediatric oncology populations.

METHODS: Practical workshops and focus groups with n=65 children and young people aged 9-21 years will be conducted. The 30-minute workshop will encourage participants to engage with the smartphone app and complete a digitally prescribed low-moderate intensity exercise session consisting of bodyweight strength exercises. The subsequent focus group discussions will explore participant experiences, preferences, suggestions for improvement and impressions of potential long-term use.

RESULTS: The user-led and evidence-based development of the AR app is expected to allow participants to engage in meaningful exercise provisions and supportive encouragement via this novel technology. Due to the innovative nature of the AR app, study findings are expected to provide vital indications for further improvement.

CONCLUSION: The findings of this study will contribute to the future development of this technology to support exercise rehabilitation for young people with cancer. Evidence from this research plays an important role in enhancing clinical care pathways for patients, whilst allowing clinicians to explore novel interventions to support current practice.

### THE EFFECT OF UNIVERSITY FITNESS CLASS ON THE EXERCISE BEHAVIOUR: A PRE-POST STUDY

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INTRODUCTION: Although accumulating physical activity is one of the important factors for health [1], Japanese university students have fewer physical activities in leisure hours compared with other countries [2]. One of the main reasons for few physical activities was a lack of equipment, facilities and knowledge [3]. The fitness class would be the opportunity to get knowledge in exercise and to begin exercise in Japanese university students. Therefore, the present study aimed to investigate the effect of university fitness classes on students' exercise behaviour.

METHODS: Eighteen university students (age, 19±1 years) have participated in the present pre-post study. Participants completed university fitness classes about once a week for five weeks. The fitness class consisted of 30-min lecture (e.g., diet and exercise) and 60-min fitness exercise (e.g., aerobic exercise, resistance training). Participants answered the Diagnostic Inventory of Health and Life Habit version 2 (DIHAL.2) [4] before the first class (pre) and after the final class (post). The DIHAL.2 can assess the physical, mental and social component summaries (PCS, MCS and SCS), exercise behaviour, exercise awareness, nutritional balance, regularity of eating, preference, rest, the regularity of sleep, sleep satisfaction and stress evasion.

RESULTS: The PCS ($t(18)=-3.019$, $p=0.008$), exercise behaviour ($t(18)=-6.262$, $p=0.000$), rest ($t(18)=-4.862$, $p=0.000$) and stress evasion ($t(18)=-2.310$, $p=0.034$) at the post were significantly improved compared with those at the pre. No significant differences were observed for the MCS, SCS, exercise awareness, nutritional balance, preference, regularity of eating, the regularity of sleep and sleep satisfaction.

CONCLUSION: The present study revealed that the university fitness class improved university students' exercise behaviour, which is consistent with some previous studies [5,6]. This may be due to 1) participants getting knowledge that there is fitness training needed no special equipment and facilities and 2) an increase in readiness for exercise. Indeed, the previous study has suggested that the fitness class in university positively affects students' transtheoretical model [7]. Moreover, the PCS and rest at the post were higher than those at the pre. These may result from the increase in university students' physical activities. Therefore, the university fitness class was a chance to improve the university students' exercise behaviour.

**EFFECT OF HABITUAL PHYSICAL ACTIVITY ON PHYSICAL FITNESS AGING AMONG COMMUNITY-LIVING MIDDLE-AGED AND OLDER JAPANESE: A 12-YEAR FOLLOW-UP STUDY**

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INTRODUCTION: Age-related decline in physical fitness is unavoidable even though physical fitness is the one of the most important factors in healthy aging. Physical activity has been considered to preserve physical fitness level. However, it is still unclear whether daily physical activity inhibits age-related decline in physical fitness across middle and late adulthood. The purpose of the present study was to estimate the effect of habitual physical activity (HPA) on physical fitness ageing in men and women through a 12-year longitudinal epidemiological study.

METHODS: Participants were randomly selected community-living men (n = 1,139) and women (n = 1,128) aged 40 to 79 years at baseline, who participated in the National Institute for Longevity Sciences- Longitudinal Study of Aging. They were repeatedly tested over a mean follow-up period of 9.8 years with a mean of 4.9 examinations. Grip strength, sit-and-reach and one-leg standing with eyes closed were examined for physical fitness. HPA at baseline was assessed by multiplying activity intensity rate (metabolic equivalents; Mets) with the total number of time (mins) spent on each activity during leisure time, at work and sleeping per day over the preceding year (Iwai et al., 2000). HPA was categorized in tertiles; highest, middle and lowest. The general linear mixed model was performed for analyses of repeated measures of physical fitness. The models were comprised of fixed effects of HPA (lowest=reference), baseline age, follow-up years, their interactions and covariates (height and weight). Significant probability levels were considered to be less than 0.05.

RESULTS: The main effect of HPA was significantly positive for grip strength in both men ($F=3.21$, $p=0.041$) and women ($F=3.20$, $p=0.041$), and for sit-and-reach only in men ($F=3.33$, $p=0.036$). The main effect of HPA for one-leg standing was also significant in men ($F=6.84$, $p=0.001$), but the effect was negative. The interaction terms, HPA×age×follow-up years were significant for grip strength in men ($F=3.48$, $p=0.031$) and sit-and-reach in women ($F=3.87$, $p=0.021$). Predicted trajectory substituting baseline age and HPA level indicated that the slopes in highest HPA were markedly less steep after 68 years of age for grip strength in men, and 59 years of age for sit-and-reach in women comparing to those in lowest HPA.

CONCLUSION: Twelve-year longitudinal data showed that habitual physical activity might affect the age-related decline in physical fitness over time, especially muscle strength in older men and flexibility in older women.

References:

Iwai, N., et. al.: Leisure-time physical activity and related lifestyle characteristics among middle-aged Japanese. Japan Lifestyle Monitoring Study Group. J Epidemiol, 10(4), 226-233, 2000

**THE EFFECT OF AN ONLINE TRAINING PROGRAM IN CHILDREN WITH OBESITY**

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4. Dep. of Pediatrics, "Vittore Buzzi" Children's Hospital. 5. Ped. and Adolescent Unit, Dep. of Int. Med. and Therapeutics, Uni. of Pavia.INTRODUCTION: COVID-19 pandemic caused a negative change in daily habits, a decrease in physical activity and energy expenditure in
the worldwide population and especially in children. The regular practice of exercise promoted several benefits on fitness performance counteracting the adverse effects of obesity. During COVID-19 restrictions, online training showed the potential to reach a large number of subjects who live in different places counteracting sedentary behavior.
The aim of this study was to determine the functional results of an online supervised combined training adapted to children with obesity. The variation of physical fitness and self-perception was evaluated.

METHODS: 30 children (10 females) with obesity (11.50+1.83 years old) were enrolled in an online exercise training program, implemented three times a week for a 12-week period. The program consisted of a combination of aerobic and free body resistance exercises proposed by a trainer with a recreative approach including circuit games and fabulation. Each training session was developed through the ZOOM platform and lasted around 60 min. Six-minute walking test (6MWT), 5x10 meters run test and standing broad jumps (SBJ) evaluated respectively cardiorespiratory health, speed-agility and muscular strength. Perceived effort during training has been evaluated through the Children's Effort Rating Table (CERT).

RESULTS: Children, after the training period, increased their performance of the 6MWT (mean difference (MD) 53.6 meters; Effect size (d) = 1.064; p-value<.001), of the SBJ (MD=10 meters; d=.865; p-value<.001) and of the 5x10 meters run test (MD= -0.92 seconds; d=0.483; p-value=0.013). Perceived effort did not change before and after the training period (p-

value>.05) in 6MWT (MD=.033; d=.010) and in 5x10 meters run test (MD= .367; d=.155).

CONCLUSION: The online training program improved children with obesity performance keeping the perceived effort of the tests constant. Given the importance of improved physical fitness in children with obesity, further studies should focus on the assessment of the efficacy of an online training program evaluating other outcomes related to obesity.

Ref: Bethea TC, Berry D, Maloney AE, Sikich L. Pilot Study of an Active Screen Time Game Correlates with Improved Physical Fitness in Minority Elementary School Youth. Games Health J. 2012 Feb;1(1):29-36. doi: 10.1089/g4h.2011.0005. Epub 2012 Jan 4. PMID: 26196430; PMCID: PMC5395018.

Lee KJ, Noh B, An KO. Impact of Synchronous Online Physical Education Classes Using Tabata Training on Adolescents during COVID-19: A Randomized Controlled Study. Int J Environ Res Public Health. 2021 Sep 30;18(19):10305. doi: 10.3390/ijerph181910305. PMID: 34639604; PMCID: PMC8507984.

## EFFECTS OF LONG-TERM FOOTBALL TRAINING ON HUMAN BREAST CANCER CELL MIGRATION: A PILOT STUDY

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INTRODUCTION: Breast cancer (BC) is the most common cancer in women worldwide responsible for 685.00 deaths in 2020, with approximately 10% developing metastases within 5 years of early diagnosis (1). Recently, epidemiological studies reported the benefits of a regular training program, mostly aerobic, in cancer prevention; the effects of adapted football training in BC survivors were also evidenced (2,3). The aim of this pilot was to investigate the effects of football training on BC cell migration in in-vitro system.

METHODS: 5 older (> 65 years) long-term football men trained for at least 15 years (VPG) and 5 active untrained subjects (CG) matched for age were recruited from P. Krustrup' s group; blood samples at rest (VPG and CG) and immediately after a football match (VPG) were collected. Human breast adenocarcinoma cells, MCF-7, were cultured to confluence in a medium (EMEM) containing 15% FBS. Cells were starved in 0.5% FBS for 24h, scratched to perform a wound healing assay, and cultured in 5% sera from VPG or CG or FBS (as control) for 72h, respectively; the wound closure percentage was calculated at 72h vs T0 in each group. Data are expressed as mean±SD from three independent experiments. Differences were considered statistically significant at $p < 0.05$. T-test was used for statistical analysis.

RESULTS: Long-term football training significantly reduced the migration of MCF-7 cells in wound healing assays (VPG vs FBS at 72h, $p<0.005$); a significant reduction in the wound closure percentage was also found in VPG compared to CG ($p<0.05$) cultured cells.

CONCLUSION: Our pilot study indicate that long-term football training reduces the migration of BC cells. Ongoing experiments will evaluate the effect of long-term football training on MCF-7 cell invasion and metastases.

References:

1. WHO, 2020

2. Ki-Yong et al (2020) Effects of exercise dose and type during breast cancer chemotherapy on longer-term patient-reported outcomes and health-related fitness: A randomized controlled trial. Int J Cancer 146 :150-160

3. Uth et al. (2020) Exercise intensity and cardiovascular health outcomes after 12 months of football fitness training in women treated for stage I-III breast cancer: Results from the football fitness After Breast Cancer (ABC) randomized controlled trial. Prog. in Cardiovasc Dis. 63: 792-799.

## IMPROVING RESISTANCE TRAINING PRESCRIPTION THROUGH THE LOAD-VELOCITY RELATIONSHIP IN FEMALE BREAST CANCER SURVIVORS: THE CASE OF THE BENCH PRESS EXERCISE

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INTRODUCTION: Breast cancer is the cancer type with the highest incidence in women worldwide, with almost 2.1 million new patients diagnosed every year [1]. Muscular strength during treatment has been reported to be 12% to 16% lower in upper extremities compared to healthy individuals [2]. Resistance training is an effective method to increase muscular strength levels in breast cancer survivors [3]. Movement velocity allows to accurately quantify relative load to prescribe an effective resistance training program [4]. Due to a close relationship has been found between movement velocity and the relative load (%1RM) during a lower body exercise (bilateral leg-press) in breast cancer survivors [5], the aims of this study were to analyze the load-velocity relationship in an upper body exercise (bench press) in female breast cancer survivors and to examine what type of adjustment and velocity variable allows to predict with greater precision the velocities associated with each %1RM.

METHODS: Twenty-four breast cancer survivor's women (age: 50.2 ± 10.8 years, weight: 69.6 ± 15.2 kg, height: 160.51 ± 5.25 cm), as part of the EFICAN project [6], performed an incremental load test until 1RM in the bench press exercise. The mean propulsive velocity (MPV) and the peak velocity (PV), measured using a linear velocity transducer (T-Force System), were analyzed by lineal (LA) and polynomic (PA) regression models.

RESULTS: A very close relationship between MPV and relative load (%1RM) was observed ($R^2 = 0.954$; $p < 0.0001$; SEE = 0.068 m.s-1 by LA and $R^2 = 0.957$; $p < 0.0001$; SEE = 0.067 m.s-1 by PA). Similarly, a high correlation between %1RM and PV was observed ($R^2 = 0.908$; $p < 0.0001$; SEE = 0.141 m.s-1 by LA and $R^2 = 0.928$; $p < 0.0001$; SEE = 0.124 m.s-1 by PA). The MPV of 1RM was 0.15 ± 0.04 m·s-1, whereas the PV at 1RM was 0.38 ± 0.13 m.s-1

CONCLUSION: LA and PA allow to predict the velocities associated with each %1RM and the estimated 1RM with a great precision in bench press exercise in female breast cancer survivors. However, PA showed better accuracy. MPV was considered the most recommended velocity variable to prescribe the relative load during resistance training.

References:

1. Bray F, et al. CA Cancer J Clin 2018;68:394-424.

2. Klassen O, et al. J Cachexia Sarcopenia Muscle 2017;8:305-316.

3. Strasser B., et al. Med & Sci Sports & Ex 2013;45:2080-90.

4. González-Badillo JJ, et al. Int J Sports Med 2010;31:347-352.

5. Díez-Fernández DM, et al. Eur J Sport Sci 2021;27:1-10

6. Soriano-Maldonado A, et al. J Cancer Surviv 2022
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## INVESTIGATE OF POSSIBILITY TO PROMOTE RECOVERY OF MUSCLE HARDNESS AND DELATED ONSET MUSCLE SORENESS (DOMS) BY USING HIGH-CONCENTRATION ARTIFICIAL CO2-HOT SPRING WATER

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INTRODUCTION: In our previous study, experiments in human subjects indicated that flexibility of the body was facilitated by bathing in artificial CO2–hot spring water [1]. Furthermore, near-infrared spectroscopy (NIRS) applied to the human subjects revealed that repeated immersion of the forearm into CO2-water augmented the local muscle O2 consumption and blood flow. These results suggest that a CO2-water bath may promote recovery from muscle fatigue. To inspect this hypothesis, we investigated whether the immersion of extremities including agonist muscles into artificially made CO2-water (CO2 ≥1000 ppm) influences recovery of muscle hardness and soreness in fatigue after resistance exercise.

METHODS: The healthy male college students (n=12) participated in this study (Age 19-26 yrs, height; 173.5±5.0 cm, weight; 64.9±6.9 kg). The subjects performed 100 times calf raise resistance exercises and immersed lower legs into tap-water or artificial CO2-water at 35 °C for 10 minutes after exercise. On exercise day, the hardness of the medial head of gastrocnemius dominant muscle was evaluated 3 times with indentation method, at 5 minutes before, immediately after and 10 minutes after the exercise. Simultaneously, muscle fatigue was assessed using a visual analogue scale (VAS). Perceived pain or soreness was determined using the Talag Scale [2]: (0) No Pain, (1) Dull Vague Ache, (2) Slight Persistent Pain, (3) More than Slight Pain, (4) Painful, (5) Very Painful, and (6) Unbearably Painful. Resistance exercise was performed only on the first day. Lower legs water immersions (tap-water or CO2-water) were performed every 24h for 5 consecutive days after the resistance exercise. Following the exercise day, muscle hardness and soreness were measured before and after lower legs water immersion once a day. Statistical evaluation of the data was done by repeated measures two-way ANOVA using Tukey test for post hoc multiple comparisons, where appropriate. Significance level was set at $p < 0.05$.

RESULTS: Muscle hardness peaked on the third day after the exercise. Muscle hardness on the third day was significantly smaller in CO2-water treatment group than in tap-water treatment group (tap vs. CO2 : 19.0±1.0 vs. 16.2±2.2 tone, $p<0.05$), and the difference between two groups disappeared after the peak day. Muscle soreness of the CO2-water treatment group was significantly smaller than that of the tap-water treatment group, which lasted only for 2 days after exercise, in comparison with 5 days in tap-water group.

CONCLUSION: These results imply that immersion into high concentration CO2-water after the exercise may contribute to rapid recovery from muscle fatigue. In this study, high concentration artificial CO2-hot spring bathing can contribute to the recovery from intense training in athletes, and there is a possibility of improving performance.

REFERENCES:

1. Yamamoto and Hashimoto, J Physiol Sci, 61, S240, 2011.
2. Talag TS, Res Q, 44: 458-469, 1973.

## ASSOCIATION BETWEEN STAGES OF CHANGE MODEL FOR PARTICIPATION IN PHYSICAL ACTIVITY, NEIGHBORHOOD WALKABLE ENVIRONMENTS, AND FRAILTY IN OLDER ADULTS

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INTRODUCTION: Perceived and objectively-assessed aspects of the neighborhood physical environment have been postulated to be key contributors to regular engagement in active habitual physical activity in older adults. However, the association the neighborhood walkability and the participation in physical activity in frail older adults remains unclear. This study examined the associations between the stages of change model for participation in physical activity, frailty and neighborhood walkable environments in older adults.

METHODS: Participants were 126 older adults. Walkability was measured objectively using GIS. We also assessed participants' perceptions of neighborhood, street connectivity, safety (traffic, crime), etc. using a modified version of the Neighborhood Environment Walkability Scale—abbreviated (NEWS-A). Scale scores range from 1 to 4 (strongly disagree, somewhat disagree, somewhat agree, strongly agree). The readiness for physical activity stages of change scale was used to examine readiness to become and stay physically active with five stages: (1) precontemplation, (2) contemplation, (3) preparation, (4) action, and (5) maintenance. Frailty was assessed by an adapted version of the Fried Frailty Phenotype. Using logistic regression, we calculated the odds and 95 CI between physically active odds of any (compared with none) perceived and objectively-assessed neighborhood walkability, respectively.

RESULTS: The data were significantly described by linear regression models which showed that the perceived and objectively-measured environmental factor (access to recreational facilities, connectivity of streets, land use mix, traffic safety, presence of bicycle lane) associate with increasing participants of daily physical activity, theses tendency, however, was found to be higher in the elderly subjects with frailty. Multivariate-adjusted logistic regression analyses predicted that healthy and frail older adults who lived in poorer access to recreational facilities, street connectivity and traffic safety area were, respectively, 1.7-2.0, 1.7–2.2 and 2.2–3.5 times more likely to sustain physically active than those who live better environmental walkability.

CONCLUSION: The factors of the built environment appear to influence duration and frequency of the physical activity in general. In particular, access to recreational facilities, street connectivity and traffic safety was positively influenced physical activity participation in frail older. Therefore a better walkable neighbourhood appears to be a worthwhile investment as it encourages older adults who have frailty living on low walkability and/or income to walk for transportation and safe, and it seems crucial to identify aspects of the built environment that promote active behaviours, like physical activity, across a broad spectrum of older adults as a means to guide these decision makers.

### A POSSIBILITY TO IMPROVE THE PHYSICAL FATIGUE AFTER ARTIFICIAL HIGH CONCENTRATION CO2 HOT WATER IMMERSION IN ATHLETES

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INTRODUCTION: The bathing and sleep processes in physical recovery play an important role in athletes. One of the body recovery is the night sleep. The hot spring water containing high concentration carbon dioxide (CO2 ≥1000 ppm) has long been applied to the patients suffering from cardiovascular diseases in balneotherapy. The purpose of this study is to examine the physical recovery after artificial high concentration CO2-water immersion in athletes.

METHODS: Six healthy college competitive swimmers participated in this study. The subjects performed anaerobic exercise and immersed whole body into tap-water or artificial CO2-water at 38 degrees Celsius for 10 minutes immediately after the exercise. To measure the sleep-wake cycle, accelerometers (FS-760 and 770, ACOS, Japan) was used. The sleep-wake data were analyzed by circadian rhythm analysis software (SleepSign Act2, KISSEI COMTEC, Japan). Sleep variables included time in bed (TIB), sleep period time (SPT), total sleep time (TST), sleep efficiency (SE), and sleep latency (SL). Blood lactate concentration (BLa) was measured by means of Lactate analyzer (Lactate Pro2, LT-1730, Arkray, Japan).

RESULTS: BLa in recovery period was significantly lower in CO2-water immersion than that in tap-water immersion (20min after the exercise 2.4±0.8 vs 2.7±0.5 mmol/L $p<0.05$, 25min after the exercise 1.9±0.6 vs 2.6±0.8 mmol/L $p<0.05$, 30min after the exercise 1.8±0.4 vs 2.4±0.4 mmol/L $p<0.05$,). SL was significantly shorter in CO2-water immersion than that in tap-water immersion (7.8±2.3 min vs 16.5±3.8 min $p<0.05$). SE was significantly higher in CO2-water immersion than that in tap-water immersion (90.3±3.5% vs 83.2±4.6%, $p<0.05$). Therefore, these results suggest that as CO2-water immersion could raise body core temperature enough, this hyperthermia may cause a deep sleep.

CONCLUSION: Sleep after the CO2-water immersion seems to be significantly useful in the physical recovery from fatigue. The rapid decrease in BLa in the CO2-water immersion suggested efficient physical recovery after anaerobic exercise. Therefore, it was suggested that CO2-water immersion is effective for recovery.

### BLOOD PRESSURE RESPONSE TO ISOMETRIC EXERCISE WITH DIFFERENT INTENSITIES

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INTRODUCTION: Resistance exercise (RE) generates a prompt response of the human cardiovascular system. Because of its well-documented long-term benefits, RE has become recommended physical activity. As the cardiovascular system reacts to this type of exercise by immediate changes in blood pressure (BP), general population is usually restricted to lower intensities of 10 to 12 RM for given modalities. Despite of extensive research there are still debates whether blood pressure response depends more on absolute resistance or its value expressed in percent of maximum. Therefore, this study tried to elucidate BP response to isometric exercise is more closely correlated with absolute or relative load intensities.

METHODS: Twenty-five young healthy participants (age: 23.96 ± 2.95y; 11 males, 14 females) performed test of maximal isometric strength on a universal linear leg press (FiTRONiC Diagnostic and Training Systems LTD, Bratislava, Slovakia) at 90-degree. On a different day, they had to resist for 15 seconds to randomly assigned load of 20, 40, 60, 80 % of the maximum test value. Over each period, BP values were measured with a manual sphygmomanometer.

RESULTS: There was a significant difference in BP values between 20 % and 80 % of additional load for systolic BP (SBP) (131.8±10.1 mmHg vs. 166.7±12.7 mmHg; $t=2.011$, $p<0.001$), and for diastolic BP (DBP) (82.04±7.68 mmHg vs. 112.56±12.30 mmHg; $t=2.011$, $p<0.001$). Values of medial arterial pressure (MAP) and additional load correlations were nearly identical in absolute and relative expressions ($R=0.85$; $p<0.001$ vs. $R=0.85$; $p<0.001$, respectively). Similar trend was observed in SBP ($R=0.84$; $p<0.001$ vs. $R=0.84$; $p<0.001$) and for DBP ($R=0.83$; $p<0.001$ vs. $R=0.84$; $p<0.001$).

CONCLUSION: As expected there were strong correlations between BP (SBP, DBP, and MAP) and load intensity expressed. However, both correlations did not differ significantly.

### DEFINITION AND CONTEXT FACTORS OF NURSING HOME RESIDENTS' MOBILITY IN A HOLISTIC VIEW: A DELPHI STUDY

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INTRODUCTION: The importance of promoting mobility in nursing homes is underlined by a growing number of nursing home residents with a decreasing life space mobility. To include hitherto neglected confounding factors of mobility and create a holistic understanding, there is a need for expanding the definition of mobility. Research as well as care practices need to be based on a uniform understanding regarding the definition, context factors and valid assessments of mobility. The present study reports expert ratings from a Delphi study regarding these aspects of mobility.

METHODS: A total of 129 experts of different professional backgrounds (e.g., human movement sciences, medicine, nursing and geriatric science) were invited to a Delphi study via e-mail. Up to N=39 experts participated in each of the three rounds of online questionnaires. In the first round, open-ended questions collected possible definitions, context factors, and assessment tools, which were rated on Likert-scales (1-10) regarding their suitability in the second round. The last round presented a consensual definition as well as top rated context factors and assessment tools from the first two rounds for a final rating of agreement.

RESULTS: Experts agreed to the final version of the mobility definition with 8.9 ± 1.4 out of 10 points. The selected context factors for different categories (health status, cognition and emotion, social and leisure, environmental and residence-internal factors) met broad agreement with 8.4 ± 1.8 points to 8.9 ± 12 points (out of 10 points). The same applies to the top three assessment tools selected from previous rounds' results, which were agreed to with 7 or more points (out of 10) by 81.6 % to 100 % of all experts in the different categories.

CONCLUSION: The conducted Delphi survey confirms the above-stated need for an updated holistic understanding of mobility. As an interdisciplinary group of experts considers various context factors as relevant, this implies the necessity of a more comprehensive

definition regarding mobility. Hence, the present results might serve as a general basis for an updated interdisciplinary and holistic understanding of mobility.

**EXERCISE-MITIGATED, GENDER-BASED DIFFERENCES IN AGING RAT HEART**

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INTRODUCTION: Aging involves unfavorable progressive cardiovascular processes, therefore striving to maintain a physiological heart function is pivotal in old ages. The aim of our current study was to explore the voluntary exercise-evoked cardioprotective effects in aged male and female rats, from protein expression alterations to changes in heart performance.

METHODS: To determine the effects of a long-term voluntary exercise, we divided 20-month-old female and male Wistar rats to control and running groups. Control rats were placed into standard cages, whereas running animals were provided with a running wheel–equipped cage. This protocol was defined as a voluntary exercise model; animals were not forced to exercise but had free access to the wheel 24 h a day. After the 12-week-long experimental period, hearts were either removed for biochemical measurements or mounted into a Langendorff-perfusion system to detect infarct size. Using ELISA method, the following proteins were analyzed from heart: catechol-O-methyltransferase (Comt), endothelin-1 (Esm1), Purkinje cell protein-4 (Pcp4), and osteoglycin (Ogn).

RESULTS: Cardiac expression of Comt and Ogn was reduced as a result of exercise in aged males, whereas Pcp4 and Esm1 showed a marked overexpression. The key result of this study is that exercise enhanced the expression of the Pcp4 protein, a recently described regulator of calcium balance in cardiomyocytes, and suppressed Comt and Ogn protein expression, which has been associated with impaired cardiac function. In addition, as a result of exercise, a significant improvement was observed in the size of infarct elicited by left anterior descending coronary artery occlusion.

CONCLUSION: Our results clearly show that voluntary exercise has proved to be an effective therapeutic tool to improve cardiac function in aged rats with clearly visible sex differences. Exercise-moderated fundamental genetic alterations may have contributed to the functional adaptation of the heart.

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**EFFECTS OF A SINGLE SESSION OF BRAIN YOGA ON BRAIN-DERIVED NEUROTROPHIC FACTOR AND COGNITIVE SHORT-TERM MEMORY**

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INTRODUCTION: This study aimed to evaluate the effects of a cognitive enhancement brain yoga program on short-term memory and serum brain-derived neurotrophic factor (BDNF) levels according to the cognitive state in men aged 20–29 years.

METHODS: Thirty healthy volunteers aged 20–29 years were divided into four groups: brain yoga group, yoga group, combined exercise group, and control group. Seven people were assigned randomly per group. A single-session intervention was conducted over 50 min and consisted of three parts: warm-up, main exercise (brain yoga, yoga, combined exercise, or non-exercise), and cool-down. Serum BDNF levels were measured using enzyme-linked immunosorbent assay, and short-term memory was evaluated using the forward number span test before and after the intervention.

RESULTS: BDNF levels significantly increased within the brain yoga group after the intervention (from 28874.37±5185.57 to 34074.80±7321.12, p=.003), whereas there were no significant differences pre and post-intervention in the other groups. The inter-group comparison showed a significant interaction between the brain yoga group and the combined exercise group (p=.036) but no significant interaction between any of the other groups. Forward number span scores were significantly increased in the brain yoga group (from 9.43±9.83 to 23±7.92, p=.012) and the yoga group after the intervention (from 13.43±9.41 to 24.14±8.45, p=.011), whereas there were no significant changes after the intervention in any other groups.

CONCLUSION: Our findings showed that a single-session, 50-minute brain yoga exercise improved short-term memory and increased serum BDNF levels in healthy men aged 20–29 years and that yoga improved only short-term memory in healthy men of this age group.

**CARDIAC FUNCTION AND HEART RATE VARIABILITY DURING A MULTI-STAGE CYCLING EVENT: A CASE STUDY**

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INTRODUCTION: Due to high cardiac workload, prolonged intense exercise results in an exercise-induced cardiac fatigue (EICF) (1). This phenomenon is characterized by transient cardiac function alterations associated to an increase in the cardiac damage biomarkers after athletes performed this type of sport events whether isolated or repeated over several days (2). The EICF is generally assessed by conventional echocardiography and/or cardiac biomarkers, but these tools are expensive and require highly qualified bio-medical staff. The cardiovascular control by autonomous nervous system (ANS) can be assessed by heart rate variability (HRV) analysis. Due to strong relationship between ANS, HRV and cardiac function, we can consider the interest of the HRV analysis for determined EICF. The objective of the study was to describe the evolution of cardiac function and HRV parameters during a multi-stage cycling event and to determine their relationship.

METHODS: Using a case study approach, this investigation focused on one female athlete who performed the 21 stages of the Tour de France circuit 2018 without any spirit of competition of performance goal. Each morning, she underwent a rest transthoracic echocardiography and a RR recording (5 minutes supine, 5 minutes standing). Cardiac function was assessed by conventional echocardiography, tissue Doppler imaging and speckle tracking techniques. HRV analysis was performed in time and frequency domains. Descriptive analysis of cardiac function and HRV was first performed. Then, correlations between cardiac function and HRV parameters were tested (p<0,05, r=0,8).

RESULTS: Multiple's variations were observed on both diastolic and systolic function parameters (E/A, E/E' mean, LV global longitudinal strain, LVEF, S' mean) of left ventricle. There were also variations on the systolic function parameters of the right ventricle (TAPSE, FAC, RV

longitudinal strain). These variations were not considered as alterations or degradations of the heart function also known as EICF. During the 21 stages, multiple's variations were observed for the HRV parameters such as imbalance of HRV, increase of sympathetic tone and decrease of parasympathetic tone. No significant correlation was found between the HRV and the echocardiophy parameters.

CONCLUSION: Despite HRV imbalance, no evidence of a cardiac fatigue was observed all along the event. This repeated and prolonged endurance exercise seems insufficiently stressful to impair cardiac function, perhaps due to too moderate intensity.

1 Oxborough D, Birch K, Shave R, George K. "Exercise-Induced Cardiac Fatigue"-A Review of the Echocardiographic Literature: Exercise-Induced Cardiac Fatigue. Echocardiography. oct 2010;27(9):1130-40.

2 Middleton N, Shave R, George K, Whyte G, Simpson R, Florida-James G, et al. Impact of Repeated Prolonged Exercise Bouts on Cardiac Function and Biomarkers. Medicine & Science in Sports & Exercise. janv 2007;39(1):83-90.

## EFFECTS OF DIFFERENT TYPES OF EXERCISE ON CEREBRAL BLOOD FLOW AND EXECUTIVE FUNCTION IN YOUNG ADULTS

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INTRODUCTION: Different types of exercise have recently received increasing attention in improving the cognitive and cerebrovascular function of the elderly. However, the cognitive benefits of HIIT and MICT in healthy young adults and their mechanisms have not been fully discussed. Some evidence shows the same effects also apply to a high-functioning population (e.g., young adults), yet whether high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) could improve the executive function (EF) and cerebral blood flow (CBF) is still unknown. Therefore, we hypothesized that both HIIT and MICT could be beneficial to EF compared to the control group in college students. Furthermore, the CBF was related to the improvement of EF.

METHODS: Eighty-two college students with irregular exercise habits were recruited from Tsinghua University to receive 12-weeks interventions three times a week. They were randomly divided into HIIT (10 minutes warm-up + [100% VO2max running for 1 minute + 50% VO2max fast walking for 1 minute] *10 times + 10 minutes cool down, 40 minutes totally, n=29), MICT (10 minutes warm-up + 70-75% VO2max running for 20 minutes +10 minutes cool down, 40 minutes totally, n=31) and control group (health education for 40 minutes, n=22). EF was tested by trail-making test (TMT), and CBF velocity (Transcranial Doppler, EMS-9WA) was tested before and after 12-week interventions. To avoid distractions, all the tests of participants were performed in the morning. We also controlled these participants' education level, birthplace (rural or city), age, and body mass index as covariates. A mixed-effect model was used to detect changes between the treatments as well as effect sizes expressed as t values. A p-value of 0.05 or less was considered significant.

RESULTS: The systolic and mean velocity of CBF (Vs and Vm) were negatively correlated with the total time of the TMT. Vs ($t = -2.60$, $p < 0.05$) was associated with the total time of TMT after controlling for other variances. Furthermore, MICT group improved significantly after 12 weeks intervention compared with the control group ($t = -2.01$, $p < 0.05$), and HIIT group has a significant edge effect compared with control group ($t = -1.99$, $p = 0.05$); Vm ($t = -2.29$, $p < 0.05$) associated with the total time of TMT after controlling for other variances. Furthermore, MICT group improved significantly after 12 weeks intervention compared with control group ($t = -2.04$, $p < 0.05$), and HIIT group has a significant edge effect compared with control group ($t = -1.95$, $p = 0.06$). The pulsatility index, resistance index (PI and RI) and ratio of systolic and diastolic CBF velocity (S/D) of these participants were significantly associated with the improved accuracy of TMT after interventions ($t = 2.14$, $p < 0.05$; $t = 2.16$, $p < 0.05$; $t = -2.13$, $p < 0.05$). However, there were no difference in these three groups.

CONCLUSION: As hypothesized, the 12-week of MICT and HIIT intervention, to some extent, could increase the EF of young adults, which associated with the improvement of the systolic and mean velocity of CBF. MICT was found to be better than HIIT in the improvement of EF in young adults. Future studies were needed to enlarge the sample size and duration of the intervention to confirm this conclusion.

## 8-WEEK RESISTANCE TRAINING MODULATES SOD1 AND PIRE1/IRE1 RATIO IN THE ELDERLY

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INTRODUCTION: Aging is been related to changes in redox balance, low-grade inflammation and a decreased endoplasmic reticulum (ER) unfolded protein response (UPR). Regular physical activity has been proposed as a successful intervention in the elderly, and resistance training has been shown to offset the inflammatory response, balance redox homeostasis and ameliorate the UPR. This work aimed to investigate the effects of a resistance exercise program on oxidative status, UPR and inflammation biomarkers in PBMCs of elderly subjects.

METHODS: Thirty healthy elderly subjects (22 trained; 8 controls) volunteered in an 8-week resistance training protocol. Basal data were also analyzed in a group of eleven young subjects. The expression of the anti-aging protein Klotho and oxidative stress markers (catalase, GSH, lipid peroxidation, NRF2, protein carbonyls, ROS, SOD1, and SOD2), and the activation UPR IRE1 arm and TLR4/TRAF6/pIRAK1 pathway, were evaluated prior to and following training.

RESULTS: No changes in HSP60 and Klotho levels, and TLR4/TRAF6/pIRAK1 pathway activation were found with training. Although most oxidative markers remained unchanged, a reduced SOD1 expression was found in the trained group compared to the controls. Moreover, an attenuation of the reduced pIRE1/IRE1 ratio induced by aging was observed.

CONCLUSION: Although SOD1 is considered as a major cytoplasmic antioxidant enzyme that metabolizes superoxide radicals to molecular oxygen and hydrogen peroxide, thus providing a defense against oxygen toxicity (Nojima et al., 2015), the H2O2/ROS-dependent reversible oxidation/reduction could drive to SOD1 oxidation leading to the formation of non-native disulfides that cause the formation of insoluble SOD1 multimers and aggregates, contributing to the cytotoxicity and resulting in ES stress and UPR activation (van Dam & Dansen, 2020). Moreover, during aging there is an inability to handle protein folding, accumulation, and aggregation due to a progressive failure of the chaperoning systems (Naidoo et al., 2014), as well as a decline in UPR components (Ogborn et al., 2014; Paz Gavilán et al., 2006). Therefore, the 8-week resistance training program could be able to reduce the aging-related SOD1 accumulation through an attempt of restoring the UPR response via IRE1 arm. These findings might partially support the modulating effect of resistance training on the oxidative balance through the endoplasmic reticulum stress alleviation in the elderly.

References

- Nojima, Y., et al. (2015). PLoS One, 10(2), e0116007.
- van Dam, L., & Dansen, T. B. (2020). Biochem Soc Trans, 48(2), 379-397.
- Naidoo, N., et al. (2014). Aging Cell, 13(1), 131-141.
- Ogborn, D. I., et al. (2014). Am J Physiol Regul Integr Comp Physiol, 307(6), R664-669.
- Paz Gavilán, et al. (2006). Neurobiol Aging, 27(7), 973-982

**THE USE OF OBJECTIVE ACTIMETRY TO ASSESS THE PHYSICAL ACTIVITY OF END STAGE RENAL DISEASE PATIENTS-PILOT STUDY**

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INTRODUCTION: Patients with end-stage renal disease (ESRD) undergo replacement therapy such as hemodialysis spent about 400-900 hours of passive rest a year. The aim of the study was to assess the level of physical activity in patients with end stage renal disease using an accelerometer - actigraph.

METHODS: The study involved 59 people, divided into two groups. Group I - 25 patients on dialysis and Group II - control 34 healthy people. To assess the level of physical activity, the ActiGraph wGT3X-BT sensor was used, which allows for the objective registration of 24-hour daily physical activity and inactivity and sleep periods, including: total sleep time, intruded wakefulness, and sleep efficiency; automatic sleep detection (detection of awakenings); total energy expenditure expressed in kilocalories (kcal) and as metabolic equivalent (MET); the number of steps completed; the intensity level of physical exercise and the registration of the body position. On the basis of the information gathered by this device, it is possible to determine if the subject has sleep disturbances, additionally it is possible to determine the time spent in a sitting position and the caloric demand useful in choosing the right diet.

RESULTS: The results of the study indicate significant differences in the level of physical activity between patients undergoing dialysis and the control group. There are significant relationships between the age of the subjects and the level of their physical activity. Elderly patients are characterized by a lower average level of physical activity. Both groups also differentiate the time spent sitting, to the detriment of ESRD patients despite significantly younger patients on dialysis.

CONCLUSION: Dialysis patients should be encouraged by the medical staff to increase their physical activity. Monitoring of physical activity using objective devices should be carried out in this group of patients at least twice a year. In future research, we want to compare the result of the actigraph study to the subjective method of the IPAQ questionnaire.

**HIGH INTENSITY INTERVAL TRAINING IN PATIENTS WITH BREAST CANCER UNDERGOING CHEMOTHERAPY: PROTOCOL FOR A PARALLEL GROUP RANDOMISED CONTROLLED TRIAL**

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INTRODUCTION: Neoadjuvant chemotherapy given to women with breast cancer (BC) is associated with cardiotoxicity, reduced cardiorespiratory fitness, fatigue, poor quality of life, fat gain, and muscle loss [1, 2]. In recent years, research on the suitability of high intensity interval training (HIIT) for BC survivors has emerged as well. Systematic reviews and meta-analyses of HIIT for cardiorespiratory fitness in cancer survivors and those undergoing chemotherapy have already shown HIIT to have some degree of effectiveness on improving physical fitness.[3].

This study aims to investigate the effects of individualised adapted aerobic exercise program (IAEP) on physical fitness and quality of life of patients with BC (age 35 to 65 years) during neoadjuvant therapy (NT). In addition, this study will determine association between multicomponent health risk factors and adherence in IAEP in patients with BC. It is hypothesized that IAPE improves physical fitness and quality of life, subsequently contributing outcomes of NT treatment.

METHODS: In the parallel group randomized controlled trial participants will be randomly allocated into IAPE group (n=40) and control group (n=40). All participants will complete EORTC QLQ-C30 and specific breast cancer module EORTC QLQ- 23 to determine the quality of life all six to eight cycles of NT. Daily living activities related physical fitness evaluation will consist of 6 MWT, 30 sec Sit to stand test and 5 reps Sit-to-Stand Test. Peak oxygen consumption (VO2peak) will be measured with Vyntus CPX gas analyser and The University of Northern Colorado Cancer Rehabilitation Institute (UNCCRI) treadmill protocol which has been chosen as most suitable for specific participants group considering wide age range and different previous physical activities experience and preparedness. 4x4 HIIT intervention program will be delivered to IAPE group.

RESULTS: Protocol for a parallel group single-blinded randomised controlled trial for 8-12 week intervention period has been successfully developed. Protocol includes detailed information of Timeline, overview of interventions and conducted tests, participants recruitment eligibility testing flow chart, intervention guidelines, data collection, management and quality control guidelines.

CONCLUSION: The study will address important aspects relative to including physical activity during NT for women with BC. This study is currently underway with funding support from the EEA and Norway Grants 2014-2021 financial Mechanisms project “Exploring the molecular mechanisms behind the effects of physical exercise on breast cancer prevention” (Nr. EEZ/BPP/VIAA/2021/2).

**INFLUENCE OF EXERCISE ON ENDOCRINE ADIPOKINES SECRETION – THE ROLE OF TISSUE CONTENT**

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INTRODUCTION: Regular physical activity and training induce many systematic and organ adaptations, which contribute to the protection against many metabolic disorders, such as metabolic syndrome, obesity or type 2 diabetes. During physical activity, adipocytes release multiple adipokines that affect many organs and body systems. Observed changes are dependent on the type of physical activity and may induce inflammation. Thus, these changes may intensify the inflammatory process. We aimed to assess the changes in secretion activity of adipose tissue in association with intensive aerobic and anaerobic exercises in the context of the exercises induced inflammation process.

METHODS: Population of 48 volunteers (aged 21.78 ± 1.98) were assigned to one of the study groups: LBF low body fat (n=16); NBF, normal body fat (n=19); HBF high body fat (n=13); depending on body fat content (LBF<8%; NBF=8-15%; HBF>14%). Volunteers performed maximal aerobic (Bruce; BTT) and anaerobic (WAnT) tests. Before experimental testing, each individual completed a standardized warm-up on the cycloergometer (five min at 60 rpm, 1 W/kg). Each participant (for the WanT test) was required to pedal with maximum effort for a period of 30s against a fixed resistive load of 75 g/kg of total body mass according to Bar-Or [1]. The Bruce protocol was performed on a treadmill and composed of six stages, beginning at 1.7 mph at an inclination percentage of 10% degree [2]. Blood samples were collected at 4 time-

points: prior, 2-5 minutes after, 60 minutes after and 24h after each type of maximal physical activity. Selected parameters were measured and analyzed: Adiponectin, Follistatin like 1, Interleukin 6, Leptin, Oncostatin, Resistin, Adiponectin/Leptin Ratio. One-way variance recorded significantly higher results of body fat mass and percentage of body fat in HBF compared to LBF and NBF.

RESULTS: The analysis of variance showed a significant effect of 2xWAnT and BTT factor in all tested biochemical markers in addition to interleukin 6. Significant interactions of the body fat content in the case of the HBF group were noted for leptin and resistin (after 2xWAnT) and leptin (after BTT).

CONCLUSION: Our analysis presents different responses depending on the body fat content in different types of exercises. Among populations with high body fat (HBT), the endocrine activity of adipose tissue and the increase in circulating leptin and resistin is associated with leptin/resistin resistance developing in adipose tissue, but it does not affects the systematic inflammation process and does not correlate.

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Bibliography

1. Bar-Or, O., The Wingate anaerobic test. An update on methodology, reliability and validity. Sports Med, 1987. 4(6): p. 381-94.

2. Bruce, R.A., Exercise testing of patients with coronary heart disease. Principles and normal standards for evaluation. Ann Clin Res, 1971. 3(6): p. 323-32.

## MULTICOMPONENT SUPERVISED EXERCISE TRAINING DURING PREGNANCY IMPROVING MATERNAL PHYSICAL ACTIVITY, FITNESS, AND HEALTH: THE ACTIVE PREGNANCY PROJECT

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INTRODUCTION: Physical activity and exercise during pregnancy and postpartum seem to have important benefits, both during pregnancy and in postpartum recovery. The COVID-19 pandemic has accentuated the need for virtual interaction with populations considered to be at greater risk. It is pertinent to implement effective and safe exercise strategies and programs, adapted to the stages of pregnancy and postpartum, and to contribute to evidence-based knowledge about the impact of exercise on physical activity level, fitness, and health parameters.

The objective is to present the outline of the Active Pregnancy Project. The four aims are 1) To implement educational tools for women, exercise and health professionals, based on updated guidelines and evidence on the positive impact of exercise during pregnancy and in postpartum; 2) To build and implement friendly-use and effective virtual tools promoting exercise during pregnancy and in postpartum; 3) To assess the impact of various multicomponent exercise programs delivered in-person and online to improve maternal physical activity, fitness, and health parameters; 4) To assess the impact of exercise and healthy lifestyle on the prevention of common pregnancy and postpartum complaints and diseases.

METHODS: The project was approved by the ethics committee of the higher education institution. The main methods are: updating previous systematic reviews; validating the exercise program as a complex intervention in health; developing educational standards and training for the Pre/Post Natal Exercise Specialist; developing educational tools, such as webinars, workshops, guidelines, and a textbook* for women and professionals; developing the free access Active Pregnancy YouTube channel**; developing and implementing e-health software (app) for guidance and self-management of a healthy lifestyle of women; registering and implementing study protocols for multicenter (in-person and online) multicomponent randomized control trials, based on a customized supervised exercise programs lasting 12 weeks with two intervention groups.

RESULTS: Expected results are related to the publication of papers, various educational tools including a textbook*, a YouTube channel**, and the Active Pregnancy app.

CONCLUSION: The project is focused on the citizen engagement in health, wellbeing, and prevention of diseases, and shall enable women to become co-managers of their health and physical and mental wellbeing, including quality of life, health literacy, and lifestyle factors, with the help of new tools and evidence-based knowledge. The multidisciplinary team and approaches will boost research and knowledge in this field, as well as the role of exercise and health professionals in the health care process.

*Santos-Rocha R (Ed). Exercise and Physical Activity during Pregnancy and Postpartum. Evidence-Based Guidelines. 2 ed. Switzerland: Springer International Publishing; 2022

** https://www.youtube.com/channel/UC0Vyookwc0mcQ5T70imtoNA/playlists

## INFLUENCE OF DIFFERENT TYPES OF EXERCISES AND HABITS ON BLOOD 2-ARACHIDONOYLGLYCEROL LEVEL.

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INTRODUCTION: It is known that endogenous cannabinoids (eCBs), such as 2-arachidonoylglycerol (2-AG) and anandamide, is one of the mediators of euphoria and pain sensitivity. Our previous study identified that a single bout of moderate-intensity exercise increases blood eCB concentration. However, it is unclear whether exercise types and habits affect blood eCB levels. This study investigated whether differences in exercise types and habits affect the changes in blood 2-AG production.

METHODS: Twenty-five female subjects were recruited for this study. Six were national-level college football players (E: 20±1 years), 11 were experienced futsal players (A: 20±1 years) and the other 8 were beginners (B: 19±2 years). The Lactate threshold (LT) was measured using a cycle ergometer. They carried out a futsal match and cycle ergometer exercise for two equal periods of 20 minutes at LT intensity. During futsal playing, they wore heart rate monitors and regulated the exercise intensity. Blood samples were obtained before and after the exercise. Plasma samples were stored at -80℃ until the analysis. Because 2-AG is rapidly isomerized to 1-arachidonoylglycerol (1-AG), the concentrations of 2-AG and 1-AG were measured using LC-MS/MS (1). The sum of these values (2-AG + 1-AG) was used as the index of blood 2-AG level.

RESULTS: There was no difference in age, height, weight, and BMI between the groups. No significant differences in heart rate between the groups in Ergometer (Before 1st period: 68 (64-73) bpm, 81 (73-84) bpm, 82 (76-87) bpm, After 1st period: 130 (115-146) bpm, 127 (121-137) bpm, 133 (129-134) bpm, After 2nd period: 131 (120-149) bpm, 132 (124-141) bpm, 129 (127-133) bpm. (E, A and B, respectively, Data shown as median (quartile)), and in Futsal (Before 1st period: 59 (57-63) bpm, 82 (78-99) bpm, 74 (67-77) bpm, After 1st period: 139

(130-141) bpm, 144 (136-154) bpm, 136 (127-149) bpm, After 2nd period: 141 (126-145) bpm, 146 (140-158) bpm, 133 (126-152) bpm. (E, A and B, respectively)). After the ergometer exercise, 2-AG + 1-AG was significantly increased in all groups (E: 7.6 (7.3-8.8) ng/mL, and 11.0 (10.1-13.6) ng/mL, A: 1.6 (1.3-2.3) ng/mL, and 2.8 (2.1-2.9) ng/mL, B: 3.9 (3.5-4.7) ng/mL, and 5.8 (4.6-6.0) ng/mL). However, there were no significant differences after the futsal match in 2-AG + 1-AG (E: 5.7 (5.0-7.5) ng/mL, and 11.6 (8.9-14.1) ng/mL, A: 1.3 (1.0-2.0) ng/mL, and 1.5 (1.0-2.1) ng/mL, B: 3.8 (2.2-5.8) ng/mL, and 5.4 (3.6-6.6) ng/mL).

CONCLUSION: The result suggested that continuous moderate-intensity exercise increases blood eCB concentration. On the other hands, the exercise habits may not affect changes in eCB concentration.

REFERENCE:

1. F. Fanelli et al., Journal of lipid research, 53(3): 481-493 (2011).

## A STUDY ON THE ENERGY EXPENDITURE OF FITNESS QIGONG EXERCISE PROGRAMS IN THE CHINESE MIDDLE-AGED AND ELDERLY POPULATION

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INTRODUCTION: This study uses the measurement of energy expenditure in the Baduanjin exercise program as a basis to explore the characteristics of energy metabolism in fitness qigong exercise and to further meet the needs of personalised fitness instruction for middle-aged and elderly people.

METHODS: Subjects: 892 healthy middle-aged and elderly people aged 40 and above, excluding those with heart disease, hyperlipidaemia, diabetes, anaemia, etc., including 94 men and 125 women aged 40-59, 266 men and 326 women aged 60-69, and 46 men and 35 women aged 70 and above. Each learnt and became proficient in the Fitness Qigong Baduanjin exercise program.

Experimental method: Experimental tests were carried out in age groups, with the main tests: height, weight, blood pressure and cardiopulmonary function. The subjects wore the CORTEX-3B exercise cardiorespiratory fitness tester and heart rate band, followed the fitness qigong music and completed the fitness qigong exercises. The experimental data were taken as the average values of the smoother phases of the process. Data indicators: METs, HR, RR, RQ, VCO2/VO2, VO2/HR, VO2/kg, etc.

Statistical methods: all data were smoothed (20s) and then statistically analysed using Spss10.0; t-test, Intra-classCorrelation Coeffieient ICC, etc.; significant level was $P<0.05$, very significant level was $P<0.01$. Multiple regressions were used to establish the energy expenditure of fitness qigong exercise programs in the middle-aged and elderly population formula.

RESULTS: 1. As age increases, exercise energy consumption tends to decrease in both men and women; the decreasing trend is greater between the ages of 60 and 69; the level of exercise energy consumption is always higher in men than in women.

2. The relationship between BMI indicators and exercise energy consumption, BMI and exercise energy consumption were significantly lower in men and women at the beginner level and in men ($p<0.01$); only in men at the proficient level was the correlation between BMI and exercise energy consumption significantly lower ($p<0.01$).

3. Age, gender, BMI and energy consumption were weakly correlated with heart rate, oxygen uptake/kg, respiratory exchange rate age, heart rate, oxygen uptake, metabolic equivalent, energy consumption, energy consumption/kg and gender, and oxygen uptake/kg, oxygen uptake, metabolic equivalent, energy consumption, energy consumption/kg were weakly correlated with BMI.

4. The best model of oxygen uptake, with fitness Qigong Baduanjin proficiency, gender and weight as the main predictor equations, is: Y=0.34*EXP(1.12*type)+0.018* weight-0.35 G1-0.41 G0 where: oxygen uptake (Y); type represents fitness Qigong Baduanjin exercise program proficiency, type=1,2,3. Weight represents body weight, in kg. When the gender is male, G1=1 and G0=0; when the gender is female, G1=0 and G0=1.

CONCLUSION: In this study, the relationship between age, gender, BMI and fitness qigong energy expenditure was mastered, and an energy expenditure formula for fitness qigong exercise programs in the middle-aged and elderly population was established.

## METABOLIC DIFFERENCES BETWEEN ADOLESCENT SOCCER PLAYERS WITH ADEQUATE BODY MASS INDEX AND THOSE WITH OVERWEIGHT/OBESITY

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INTRODUCTION: The practice of physical activity in its sports modality is desirable among the child and youth population. The objective of this study was to identify the differences in blood metabolic levels between male adolescents, who were engaged in regular soccer training, with adequate body mass and overweight.

METHODS: 74 male adolescents with normal weight and 72 with overweight according to their Body Mass Index (BMI) participated in the study. All the participants were members of the youth soccer training groups of the Professional Soccer Club Leon (Mexico). They were assigned to two groups: Group I (GI) with a BMI from 20 to 25 kg/m2 and Group II (GII) with a BMI > 25 kg/m2. In all cases, body height (BH), body mass (BM) and hip circumference (HC) were measured, and the following biomarkers in blood were analyzed: glucose (Gluc), total cholesterol (TC), triglycerides (TG) and high (HDL-C), low (LDL-C) and very low density (VLDL-C) lipoproteins.

RESULTS: In average, the participants of GI were 16.0 ± 2.5 years old, with BH of 164.1 ± 8.0 cm and HC of 78.1 ± 9.5 cm, while GII presented 16.0 ± 2.8 years, BH 163.1 ± 7.0 cm and HC of 84.1 ± 11.2 cm. The results of the other variables were as follows. Body mass: GI 58.9 ± 7.8 kg vs GII 75.7 ± 14.1 kg, BMI: GI 21.8 ± 1.8 vs GII 29.1 ± 4.1 kg/m2, Gluc levels: GI 4.70 ± 0.28 vs GII 4.97 ± 0.41 mmol/l, TG: GI 1.09 ± 0.39 vs GII 1.24 ± 0.38 mmol/l, and VLDL-C: GI 0.46 ± 0.10 vs GII 0.52 ± 0.2 mmol/l were higher in the overweight/obese group, evaluated by Student's t test for independent samples with $p < 0.05$. Only TC and HDL-C showed no significant differences with GI 3.9 ± 0.6 vs GII 3.7 ± 0.7 mmol/l and 1.69 ± 0.18 vs 1.65 ± 0.22 mmol/l, respectively.

CONCLUSION: The data are consistent with others reported in the literature and expected as an underlying metabolic condition in athletes from early stages of life in those who are overweighted or obese. It is considered necessary to include studies that assess the metabolic status of participants in different sport activities, particularly in adolescents with high weights (BMI > 25 kg/m2).

### EFFECTS OF SODA BEVERAGE ON ENDURANCE PERFORMANCE DURING EXERCISE

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INTRODUCTION: Despite Coca-Cola being one of the most popular drinks in the world, very few studies in the past have tested the effects of Coca-Cola on athletes. Previous studies have only used Coca-Cola as a source of caffeine, but have not tested out the extensive effects of the beverage. The purpose of this study was to investigate the effects of a soda beverage (Coca-Cola) on heart rate (HR), blood lactate levels, rate of perceived exertion (RPE) as well as time to exhaustion.

METHODS: 10 athletes were recruited for the study (Weight: 62.4 ± 6.8 kg, Age: 21.8 ± 1.1 years). Each participant underwent 3 sessions, in a repeated measure design study. During each participant's first session, they went through a cycling VO2 max test. For the subsequent 2 sessions, they went through 2 different conditions; participants were given one serving of a placebo beverage for one session and one serving of a Coca-Cola beverage for the other session. During both sessions, participants went through a constant cycling activity at 60% VO2 max. HR was measured and blood was collected at 15 minute intervals until time of exhaustion. Participants' RPE was also collected at 5-minute intervals.

RESULTS: Differences in lactate levels between pre cycling to 30 min of cycling for both conditions (Placebo: 1.93 ± 1.98 mmol/L vs Coca-Cola: 1.68 ± 1.36 mmol/L, P = 0.73) and time to exhaustion (Placebo: 2154 ± 667.8 secs vs Coca-Cola: 2310 ± 548.6 secs, P = 0.10) were not significant between the two beverages ($p > 0.05$). Similarly results were non-significant between differences in resting HR and HR at 30 mins of exercise for the two conditions (Placebo: 88.44 ± 18.20 (beats per min (bpm)) vs Coca Cola: 90.7 ± 16.07 bpm, P = 0.402, ($p > 0.05$)). Differences in RPE between the 10th min and exhaustion for the both groups were significant (Placebo: 6 ± 1.7, Coca Cola: 6.7 ± 2.1, P = 0.045) ($p < 0.05$).

CONCLUSION: There were no significant differences in HR, lactate levels and time to exhaustion between the placebo and the Coco-Cola beverage. However, there were significant differences for RPE scores. Coco-Cola beverage may have a psychological effect in performance. Further research is needed to probe the causes.

### EFFECT OF AN ACUTE EXERCISE ON EEG AMONG OBESE WOMEN

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INTRODUCTION: Obesity reduces brain volume and impairs neurocognitive function in the prefrontal region (1). Recent neurocognitive studies using event-related potential (ERP) confirm that the inhibitory control ability in obese women improved after a single bout moderate-intensity interval exercise (2). However, the resting brain wave-$\theta$ wave, which related to inhibitory control, still unknown after a single bout exercise among obese women. The purpose of this study was to explore the brain wave changes in obese women after a single bout of moderate-intensity aerobic combined with resistance exercise.

METHODS: Forty sedentary obese women (age 31.96 ± 7.00 year-old, BMI = 29.89 ± 3.37 kg/m2) were recruited for this study. All participants were randomly assigned to exercise group (EG) or control group (CG). The participant in EG received 30 min of single bout moderate-intensity aerobic combined with resistance exercise, which included 5 minutes warm-up, 30 minutes interval training at 55% of HR reserve (3), and 5 min cool down. Exercise intensity was monitored to ensure participants reaching their target HR zone. Participants in CG sit and rest for equal time to EG. All participants sit comfortable with eyes-closed recorded by electroencephalogram (EEG, eegoTM, Germany) before and after the intervention.

RESULTS: The results showed that the spectral power of Fp1 theta wave in prefrontal area was significantly increase in EG at post-test (10.55 ± 3.84, 12.41 ± 4.44, p= 0.022) while that in CG post-test significantly decrease (10.21 ± 3.62, 8.77 ± 2.90945, p= 0.043).

CONCLUSION: A single bout of moderate-intensity aerobic combined with resistance exercise may improve the inhibitory control ability in the prefrontal region among obese women.

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### DOES DAILY PHYSICAL ACTIVITY AND AEROBIC CAPACITY ASSOCIATE WITH UPPER AND LOWER SKELETAL MUSCLE QUALITY IN YOUNG WOMEN?

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INTRODUCTION: Strength exercise training is favorable for an increase of skeletal muscle mass and produces subsequential force. Absolute skeletal muscle strength and power are popular assessments for physical function. In addition, muscle quality (MQ), defined as exerted muscle strength per unit of skeletal muscle, is also an index of functional impairment.

A previous study reported that moderate aerobic exercise training improves MQ in older adults. A physically active lifestyle may associate with higher MQ independently skeletal muscle mass. Then, this study aimed to clarify the relationship between MQ and daily physical activity, body composition, and aerobic capacity in young women.

METHODS: Twenty-eight young women (21±2 years) were recruited for this study. The body mass, muscle, and fat mass were measured using bioelectrical impedance analysis (InBody720, InBody Japan). Maximal oxygen consumption (VO2max) was measured by the maximum cycle ergometer test. Additionally, to measure physical function and moderate-intensity exercise capacity based on the strenuous activity of daily living, the subjects carried 10kg weight for 300m. During the test, they wore a heart rate monitor to assess the physiological stress (ΔHR: Difference of Heart rate before and after the test).

Isokinetic biceps and knee extensor strength were measured. The thickness of the upper arm and femur was measured using an ultrasound imaging device. MQ was calculated for the upper arm (biceps strength(kg) / muscular thickness (mm) or mean arm skeletal muscle mass (kg)) and leg (knee extensor strength (kg) / muscular thickness (mm) or mean leg skeletal muscle mass (kg)), respectively.

The daily steps, light (1.8-2.9 METs), moderate (3.6-5.2 METs), and vigorous (above 6.1 METs) physical activity levels were measured using a uniaxial accelerometer (LifeCoder GS, Suzuken, Japan).

RESULTS: There were no correlations between daily steps, light, moderate, vigorous physical activity levels, and upper arm and leg MQ. VO2max is also not correlated with upper arm and leg MQ. A negative correlation was found between upper arm MQ (kg/mm) and ΔHR

(r=-0.396, p=0.037). However, their association was not found in absolute biceps, knee extensor strength, and ΔHR. Neither body mass nor skeletal muscle mass correlated with MQ and ΔHR.

CONCLUSION: This study identified that the daily physical activity levels are not strongly associated with MQ in young women. Interestingly, the upper arm MQ was negatively correlated with ΔHR during the moderate-intensity exercise capacity test, but not absolute biceps strength. The results of this study can not explain the phenomena, relative muscle strength may be favorable for physical function based on the strenuous activity of daily living such as carrying a heavy shopping bag.

**THE STABILITY OF ADHERENCE TO 24-H MOVEMENT BEHAVIOURS RECOMMENDATIONS IN MID-TO-LATE ADOLESCENCE: THE CRO- PALS STUDY**

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INTRODUCTION: Physical activity, limited sedentary time and enough sleep are associated with health and contribute to lower risk for the chronic diseases development. Adolescence is an important period during which individual behaviour patterns establish including physical activity, sedentary and sleep behaviour. The aim of the study was to investigate the stability of adherence to 24-h movement behaviours recommendations (RCMD) in mid-to-late adolescence.

METHODS: This longitudinal study involved 618 adolescents (317 girls) in 1st grade of high school and followed them for 3 years. Adherence to 24-h movement guidelines was assessed according to the Canadian 24-Hour Movement Guidelines for Children and Youth (≥60 min per day of moderate-to-vigorous physical activity (PA), <2 h of daily leisure screen time, 8–10 h nightly sleep duration) in 2 time points: 1st grade of high school and again 3 years later. Daily PA was assessed via SHAPES questionnaire while sedentary (SB) and sleep behaviour (SLEEP) was self-reported with additional queries in separated questionnaire. Outcome measures included each of the 24-h movement behaviours measured during 4th grade, while predictor variables included parameters assessed during the 1st grade. A series of simple logistic regression analysis were employed to analyse the odds of adherence to individual and integral 24-h movement behaviours in 4th grade according to individual behaviours in 1st grade of high school. All analyses were done separately for boys and girls.

RESULTS: The prevalence of participants who met PA and SLEEP RCMD decreased during mid-to-late adolescence, while low prevalence (9%) of adolescents who met SB RCMD slightly increased (11%). Significant odds ratios (OR) were find for adherence to all components of 24-h movement behaviours RCMD, except to SLEEP RCMD in boys (PA RCMD: 3.4 [2.0, 5.9] in girls, 3.3 [1.8, 6.1]in boys; SB RCMD 6.1 [2.7, 14.1] in girls, 5.9 [1.9, 13.7] in boys ; SLEEP RCMD 2.1 [1.3, 3.5] in girls, 1.6 [0.9, 2.7] in boys. The odds of adherence to the 24-h movement behaviours RCMD in mid-to-late adolescence was slightly higher in girls than in boys. The highest odds of adherence to the 24-h behaviours RCMD were revealed for the SB RCMD adherence (OR 6.1 [2.7, 14.1] in girls; 5.9 [1.9, 13.7] in boys).

CONCLUSION: The significant stability of 24-h movement behaviours RCMD adherence during mid-to-late adolescence indicates the importance of early promotion of guidelines for physical activity and sleep, and particularly for sedentary behaviour.

**DETERMINATION OF ENERGY EXPENDITURE AND EXERCISE INTENSITY OF SNPE**

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INTRODUCTION: The purpose of this study was to examine energy expenditure (EE) and exercise intensity (EI) of SNPE (Self Natural Posture Exercise), which is relatively effective to release chronic musculoskeletal pain.

METHODS: A total of 39 women (20s-40s) who were certified SNPE instructor level 2 were participated. The volumes of Oxygen ($VO_2$) and heart rates (HR) were measured by K5 (CosMed, Italy) and Polar H10 (Finland) respectively, while performing eight SNPE basic moves (SNPE 1, 2, 3, 4, C, T, L, & SC-move). To determine the exercise intensity of SNPE moves, MET(metabolic equivalents) values of each moves were calculated based on measured $VO_2$. Descriptive and inferential statistical analysis were applied including mean, SD, ANOVA, post hoc Scheffe, and Pearson correlation ($\alpha$<.05).

RESULTS: SNPE #4 move (21.47±5.62 $VO_2$ ml/kg/min) was the highest EE and showed statistically significant difference from other 7 moves (p<.05) such as T-move (15.72±4.23), SNPE #1 (13.70±2.70), L-move (11.62±2.31), SNPE #3 (10.28±2.85), SC-move (8.48±2.51), SNPE #2 (6.52±1.52), & C-move (5.31±1.05). The EI of SNPE moves calculated based on the MET by employing the measured $VO_2$. SNPE #4 (6.14±1.60) was classified into the vigorous intensity, and T-move (4.49±1.21), #1 (3.91±0.77), and L-move (3.32±0.66) were moderate EI. The other moves was determined as low EI, which were SNPE #3 (2.94±0.81), SC-move (2.42±0.71), #2 (1.86±0.43), & C-move (1.51±0.30) in order. HR, nevertheless, showed the different order of intensity such as SNPE #1 (123.54±17.56), #4 (121.83±18.43), T-move (107.69±17.93), #3 (107.22±18.65), L-move (98.93±14.89), SC-move (90.25±12.06), #2 (79.30±13.55), & C-move (75.63±11.42), respectively. It was significantly different among SNPE #1, #4, and other 6 moves (p<.05).

CONCLUSION: SNPE moves showed a wide range of EE, EI, and HR. SNPE #4 was the hardest exercise among SNPE moves, which can be the vigorous physical activity. Therefore, SNPE can be employed to develop a physical activity program as well as releasing a musculoskeletal pain.

## History

**A PERIOD OF RAPID DEVELOPMENT FOR EQUESTRIANISM IN CHINA: FROM 2015 TO 2020**

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A period of rapid development for equestrianism in China: from 2015 to 2020

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INTRODUCTION: Chinas domestic horses established the foundations for commerce, communication, and state infrastructure along the old Silk Road in China [1] As trade patterns changed, the use of horses changed from trade to a sport and recreation. Chinas modern equestrian business has developed significantly over the previous decades, and the expansion between 2015 and 2020 is essential, as

China implements further policies to aid in the development of modern equestrianism. The equestrian sport can propel the horse industry forward, and the horse industry is a unique business in that it integrates primary, secondary and tertiary sectors, with plenty of space for growth. With the “dual circulation” strategy published, the service sector is largely non-tradable. [2] A countrys economic development and national income are positively correlated with its service sector. [3] Sports play a large role within this sector. Equestrian sports also positive changed with the general environment of sports development. This study assesses the development of equestrianism in China from four perspectives: the general sports economic environment; the development of equestrian activities; the economic industries driven by equestrian activities; and relevant equestrian policies. Problems in the current development of equestrian sports are pointed out and recommendations are made.

METHODS: Document analysis will be used to assess policy and documentation that relate to sport, as well as to look for congruence and corroboration. The terms we used to search included a wide range of sectors.

RESULTS: During 5 years, China government publish 6 policies to push the whole equestrian sport development. In equestrian market value has increased 52.1% in four years. The number of equestrian clubs increased 1800. Horse breeding structure was built and more young people join in equestrian.

CONCLUSION: The equestrian industrys rise is due to the sports environment and the increase in consumer demand for equestrian activities. Policy encouragement, combined with the rapid growth of Chinas income in recent years, has fueled Chinas continuous upgrading of its sports consumption, and the demand for middle- and high-end sports such as equestrian which was previously considered a niche sport, now is becoming popular. In the future, the equestrian sport in China will be popular and Localized.

Reference:

[1] Park, K. H. Imperial China : The Art of the Horse in Chinese History. (Art Media Resources Ltd, 2000).

[2] Jiang, H. & Yu, M. Understanding RCEP and CPTPP: from the perspective China’s dual circulation economic strategy. China Econ. J. 14, 144–161 (2021).

[3] Yifu Lin, J. What does China’s ‘dual circulations’ development paradigm mean and how it can be achieved? China Econ. J. 14, 120–127 (2021).

## Mentoring/Coaching

### THE EFFECTS OF THE TWO-YEAR METHODOLOGICAL TRAINING PROGRAM (MIP-NPET) ON THE WORK EFFICIENCY OF BEGINNING PHYSICAL EDUCATION TEACHERS

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INTRODUCTION

In recent decades, there have been several methodological training programs (e.g. ASIP) worldwide to increase the effectiveness of PE teacher work. Effective training programs consist of short units in several elements with different content. Professional aids and samples have a positive effect, these are available in many forms of data during the entire duration of the intervention. In our poster, we present the results of our own methodological training program for beginner PE teachers, which shows the effectiveness of PE teachers work.

METHODS

The sample consisted of 10 physical education teachers (fm: 5; m: 5) participating in the two-year Methodological Intervention Program for Novice PE Teachers (MIP-NPET). At the beginning of the program, they completed their PE teacher training and began their PE teacher work in elementary schools. During the MIP-NPET program, they participated in four training days and ongoing professional consultations. Their feelings about teaching (4 times, at the beginning and end of the program years) as well as their experiences of training in the program (after the 4 training sessions) were reported in reflective diaries. These diaries related to teaching were analysed based on two aspects: organization (organization of student work, discipline) and self-efficacy (motivation, differentiation), training diaries were analysed based on theoretical knowledge and practical knowledge.

RESULTS

Adapting in their own groups of learners what was taught in the trainings reinforced the belief of the beginners that motivation is the key to effective physical education teacher work. By learning a lot of learner-centered exercises and tasks, they have gained tools that can be used not only for motivation, but also for differentiated lesson management. A deeper understanding of the modern theory of motivation, differentiation and evaluation also helped to apply the methods more effectively. Participants highlighted the possibility of joint, practical testing of the tasks and contemporary professional discussions about their individual application experiences as a priority. Thinking together with peers, learning from each other and exchanging experiences were the main strengths of the training program. Applying the learned cooperative games and tasks, they found that they can be adapted well to groups of learners of different ages and compositions, and thus can be good tools for differentiation, motivation and discipline.

DISCUSSION

The opinion of the participants showed that the training program fulfilled the expectations placed on it, helped to solve the problems of starting a teaching job and expanded the professional and methodological repertoire of the career starters as well. The program effectively included specific organizational, procedural, and cognitive elements to increase support for teacher autonomy and to help translate elements of modern methodology learned in teacher education into teacher practice.

## Molecular Biology and Biochemistry

### EFFECTS OF DIFFERENT EXERCISE ON PGC1A/FNDC5/IRISIN PATHWAY EXPRESSION IN SKELETON MUSCLES OF RATS

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INTRODUCTION: The relationship between exercise pattern and PGC1α/FNDC5/Irisin regulatory pathway is a hot topic in energy balance research. The purpose of this study was to investigate the effects of different exercise on the expression of PGC1α/FNDC5 in soleus and extensor digitorum longus muscles and serum Irisin concentration of Sprague-Dawley rats.

METHODS: This experiment has been approved by the ethics committee of the unit. Thirty rats were randomly divided into 3 groups, namely control(Con) group, climbing ladder exercise (Lad) group, and treadmill running exercise (Tre) group. Lad group took an 8-week and once-every-3-day program of resistance exercise using a model of improved climbing ladder with load. Tre group took an 8-week treadmill running of aerobic exercise. Body weight of rats was measured before and after training, and the soleus and extensor digitorum longus muscles were isolated at 48h after exercise. PGC1α/FNDC5 mRNA and protein expression in skeleton muscles were detected by quantitative PCR and Western Blot respectively. And serum Irisin concentration was observed by enzyme-linked immunosorbent assay.

RESULTS: After an 8-week training, body weight of rats from both exercise groups were significantly decreased compared with Con group, indicating that strength or aerobic training had a significant physiological effect on rats. Compared with Con group, there were a differential expression of PGC1α/FNDC5 in soleus and extensor digitorum longus muscle of rats from Lad group; but in Tre group, PGC1α/FNDC5 mRNA and protein expression in soleus muscle of rats were not significantly increased (P>0.05) and PGC1α/FNDC5 protein expression in digitorum longus muscle of rats were not significantly increased (P>0.05). There was no statistical difference in the serum concentration of Irisin among there groups.

CONCLUSION: 1)8-week climbing ladder exercise with load induces differential expression of PGC1α/FNDC5 in soleus and extensor digitorum longus muscles of rats, but don't influence the serum concentration of Irisin. It is suggested that there may be a complex balance effect and antagonist mechanism after a long-term resistance exercise. 2)8-week treadmill running exercise don't significantly influence PGC1α/FNDC5 protein expression in those muscles, which is slightly different from that reported in some literatures. 3)Resisteance or aerobic exercise have effect on PGC1α/FNDC5/Irisin pathway expression in skeleton muscles of rats in different ways, but resistance exercise may be the preferred training mode to induce the expression of PGC1α/FNDC5/Irisin pathway in skeleton muscles of rats.

### RELATIONSHIPS BETWEEN MAXIMAL OXYGEN UPTAKE AND DIVERSITY AND PHYLUM COMPONENTS OF GUT MICROBIOME

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INTRODUCTION: Maximum oxygen uptake (VO2max) is a major indicator of aerobic exercise capacity, and the gut microbiome is a major factor that can affect health and immunity. The purpose of this study is to determine whether aerobic exercise capacity affects the gut microbiome.

METHODS: A total of 32 men participated (28.6 ± 5.1 yrs, 175.5 ± 4.4 cm, 76.3 ± 10.5 kg, 24.7 ± 3.0 kg/m2). And their physical activity level, intestinal health status, disease prevalence, medical history, and eating disorder were assessed before inclusion in the study. The basal level of gut microbiome was examined by stools collected one morning after a 10-hour fasting, and their VO2max was measured. Pearsons correlation analysis was performed to analyze the relationships between VO2max and the diversity and the phylum of gut microbiome. In addition, according to their VO2max, they were divided into Low (LG: mean VO2max of 36.9 ± 4.3 ml/kg/min) and High Aerobic Capacity Groups (HG: 45.6 ± 5.0 ml/kg/min), Independent t-test was performed to determine the differences between groups.

RESULTS: As the results, there was no significant difference in the correlation between VO2max and the diversity index (Abundance, Shannon, OTUs) of the gut microbiome and the phylum (Actinobacteria, Bacteroidetes, Candidatus Saccharibacteria, Cyanobacteria/Chloroplast, Firmicutes, Fusobacteria, Lentisphaerae, Proteobacteria, Verrucomicrobia). Between groups, there were no significant differences in Abundance, Shannon, and OTUs (LG: 50676.7 ± 19013.5, 4.6 ± 0.5, 125.7 ± 26.6 score vs HG: 44208.8 ± 13528.25, 4.5 ± 0.5, 125.0 ± 17.8 score, respectively). In Phylum, Bacteroidetes were higher in HG (55.3 ± 13.8 %) than LG (43.4 ± 14.9 %) (t=-2.349, p=0.026). In contrast, Firmicutes were higher in LG (49.3 ± 13.2%) than HG (39.0 ± 12.6%) (t=2.252, p=0.032). There were no significant differences in Actinobacteria, Candidatus Saccharibacteria, Cyanobacteria/Chloroplast, Fusobacteria, Lentisphaerae, Proteobacteria, and Verrucomicrobia between groups (LG: 0.799 ± 2.212, 0.005 ± 0.008, 0.002 ± 0.003, 0.479 ± 1.099, 0.000 ± 0.002, 5.992 ± 4.799, 0.450 ± .0115 % vs HG: 0.192 ± 0.184, 0.002 ± 0.005, 0.0004 ± 0.001, 0.056 ± 0.106, 0.009 ± 0.036, 5.371 ± 5.387, 0.044 ± 0.165 %, respectively).

CONCLUSION: The results of this study were consistent with previous studies reporting the intestinal distribution of microbiome in healthy people as this study showed a higher aerobic capacity with high Bacteroidetes and low Firmicutes. It is necessary to analyze specific constituent factors later.

### MITOCHONDRIAL TRANSCRIPTION FACTOR A AND MYOGLOBIN GENES VARIATIONS ARE ASSOCIATED WITH ENDURANCE PERFORMANCE IN LITHUANIAN ELITE ATHLETES

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INTRODUCTION: Different genetic elements have a significant impact on the components of sporting characteristics (such as endurance, power, sprint, flexibility etc.). Studies show that proteins in muscle fibers such as myoglobin (encoded by the MB gene) and mitochondrial transcription factor A (encoded by the TFAM gene) are actively involved in aerobic exercise. Myoglobin providing oxygen to the working muscles and TFAM plays an important role in the maintenance of mitochondrial DNA integrity. Therefore, the aim of this case-control association study was to investigate and evaluate MB (rs7293, c.174G>A) and TFAM (rs1937, c.35G>C, p.Ser12Thr) gene variants on the physical performance in Lithuanian elite athletes.

METHODS: A total of 224 elite athletes and 255 non-athlete controls (healthy unrelated Lithuanian citizens) were genotyped for MB rs7293 and TFAM rs1937 variants by restriction fragment length polymorphism method. Statistical analysis was performed using Rv3.2.

RESULTS: Significant TFAM rs1937 polymorphism genotypes distribution were determined between the athletes and controls (GG/GC/CC: 68,3/26,8/4,9% vs 80,0/18,7/1,2%, p = 0.04). Additionally, differences in TFAM CC genotype and C allele frequencies were observed between the group of endurance athletes (CC:4,9%; C alelis 18,3 %) and sprint-power (CC: 0%; C alelis 7,1%; p<0.05). Analysis of the MB rs7293 polymorphism showed that the G allele (58.8%) is more common among male athletes compared to men in the control group (G allele 49.4%; p <0.03) and the MB GG genotype is more common in the endurance group (38.3%) compared to the sprint-power group (27%), team game athletes (12.7%) and control group (27.5%) (p <0.05).

CONCLUSION: Our findings provide support for an association between MB rs7293 and TFAM rs1937 and athletic status in endurance sports. The MB GG genotype and TFAM CC genotype are associated with endurance performance and determines aerobic capacity in Lithuanian elite athletes. It can be argued that the MB rs7293 and TFAM rs1937 genetic markers can be interpreted as overexposing factors for high scores in elite endurance sports. However, these genetic variants should be studied in a larger group of athletes, and the association needs to be confirmed in other populations around the world.

### THE CARDIAC EFFECTS OF NUTRITION AND VOLUNTARY PHYSICAL EXERCISE ON THE RAAS AND OXIDATIVE/INFLAMMATORY PARAMETERS IN SPONTANEOUSLY HYPERTENSIVE STROKE PRONE RATS

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INTRODUCTION: Hypertension is considered as a disease of civilization, because its development and progression are closely linked to unhealthy lifestyle. The aim of our study was to assess the effect of physical exercise in the complex biochemical underlying mechanisms of hypertension.

METHODS: In our study, male Wistar and spontaneously hypertensive stroke prone (SHRSP) rats were used and randomized into groups based on the type of diet (standard chow: CTRL, high-triglyceride diet with 40% lard, fructose-enrich diet with 10% fructose content) and exercise (voluntary wheel-running exercise or lack of the exercise). After 12 weeks of experimental period, myeloperoxidase (MPO) enzyme activity, tumor necrosis factor alpha (TNF-α) concentration; levels of superoxide-dismutase (SOD) and glutathione (GSH); changes in the renin–angiotensine–aldosterone-system (RAAS) as well as expression of endothelial nitric oxide synthase (eNOS) were measured in the cardiac tissue of both Wistar and SHRSP rats.

RESULTS: Compared to the values of the Wistar animals, a significant increase was observed in the inflammatory parameters of SHRSP/CTRL group, which was further elevated as a result of HT and HF diet. A similar tendency was confirmed in the changes of RAAS/angiotensin II, which was accompanied by decreased levels of GSH and SOD as well as down-regulation of eNOS. However, the unfavorable effects of HT and HF diets were compensated with 12 weeks of physical exercise.

CONCLUSION: Our results verify that either HT or HF diet can modulate the RAAS via increasing the inflammatory processes and the oxidative stress. However, 12 weeks of voluntary wheel-running exercise – via the improvement of the oxidant/antioxidant balance – significantly decreased the angiotensin II-mediated endothelial damage.

### ANDROLOGICAL EFFECTS OF SPORT: MODERATE-INTENSITY SWIMMING PROTECTS AGAINST ISOPROTERENOL-INDUCED OXIDATIVE STRESS IN A RAT TESTIS

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INTRODUCTION: Male infertility is closely linked to sedentary lifestyle; however, its underlying mechanisms are not fully elucidated. Our aim was to assess the protective effects of swimming exercise on the male reproductive system in isoproterenol-treated rats.

METHODS: 8-month-old male Wistar rats were divided into five groups as follows: (1) non-interventional controls (CTRL), (2) isoproterenol-treated (ISO), (3) pretreatment swimming training + ISO (PRE+ISO), (4) ISO + posttreatment swimming training (ISO+POST) (5) pretreatment swimming training + ISO + posttreatment swimming training (PRE+ISO+POST) groups. Testicular oxidative stress was induced by ISO injection (1.0 mg/kg). Rats in the pre-or posttraining groups were trained 5 days a week for 3 weeks individually, in a 20 cm × 20 cm pool filled with ~60 cm depth of water of 32–33 °C. At the end of the experimental period serum testosterone levels, sperms' hyaluronan binding and total glutathione (GSH) content, myeloperoxidase activity (MPO), tumor necrosis factor-alpha (TNF-alpha), and interleukin-6 (IL-6) concentrations in the testis and semen were measured.

RESULTS: Serum testosterone levels, sperms' hyaluronan binding, and GSH content were significantly reduced, while MPO, TNF-alpha, and IL-6 concentrations in the testis and semen were elevated after the ISO treatment compared to the CTRL group. Moderate-intensity swimming exercise effectively alleviated the negative effects of high oxidative stress.

CONCLUSION: Our results provide the first evidence that moderate-intensity swimming exercise confers sustained protection from isoproterenol-induced adverse effects on testicular inflammation. These findings give insight into the biochemical background of the beneficial effects of moderate swimming training, which may serve as an effective approach to improve male fertility.

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### OVERREPRESENTATION OF T ALLELE OF MCT1 RS1049434 POLYMORPHISM IN THE GROUP OF POLISH ELITE SPORTSMEN.

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INTRODUCTION: Both the scientific and sporting communities agree that genetic factors contribute to athletic performance. The estimated percentage of the heredity of athletic status is 66%. Currently, around 155 genetic markers are linked to endurance and strength/power traits. Thus, we aimed to investigate whether selected MCT1 rs1049434, NRF-2 rs12594956, MYBPC3 rs1052373, HFE rs1799945 polymorphisms, which have been described as associated with elite sprint/power abilities, are associated with endurance capacity of the high-elite Polish athletes.

METHODS: 53 power and 48 strength high-elite Polish athletes- Olympic Championships medallists were included in a study. Additionally, the control group consisted of 41 healthy Polish individuals. WGS was performed using the following parameters: 150PE, 30x coverage, at least 90GB of data/sample. The following filters were applied per each group: mean GQ > 50, mean DP > 5, HWE p-value > 0.05.

RESULTS: 74 variants in the MCT1 gene, 47 variants in the MYBPC3, 158 variants in the NRF-2 (GABPB1), and 33 variants in the HFE passed all filters and underwent data analysis. We focused on MCT1, MYBPC3, NRF-2 and HFE polymorphisms . Out of all analyzed polymorphisms, only one did not meet HWE criteria - MCT1 rs1049434. This was due to an excess of T allele only in Polish elite athletes. No statistically significant between-group differences were found for any of analyzed polymorphisms.

CONCLUSION: Our study provides evidence of the overrepresentation of the T allele of MCT1 rs1049434 polymorphism in the group of Polish elite sportsmen, leading to a violation of the Hardy-Weinberg assumption. Small group size could lead to such results and therefore future research should include a higher number of participants.

### EFFECT OF LACTIC ACID TREATMENT ON BRAIN FUNCTION-RELATED VARIABLES IN CELL CULTURE AND RATS

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INTRODUCTION: As the association of lactate production (Schiffer et al., 2011) was suggested as an important mediator related to the increase in BDNF during exercise, the increase in lactate produced during exercise could act as an important mediator of brain function activation rather than a cause of fatigue. Does the increase in lactic acid produced during exercise act as an important mediator of brain function activation by hippocampal BDNF expression? In addition, there is a need to clearly identify the molecular biological mechanism involved.

METHODS: Expression of brain function-related factors including MCT2, GPR81, and BDNF after treatment with lactic acid and saline and silence treatment of MCT2 and GPR81 to β-amyloid-treated cells to induce brain function decline by applying the brain astrocyte culture method were analyzed by Western Blotting and RT-PCR. Additionally, by injecting lactic acid into the abdominal cavity of rats, the protein expression patterns of molecular variables related to brain function were analyzed.

RESULTS: Cell viability of C6 glioma cells was significantly slowed after β-amyloid treatment, but recovered after lactate treatment. After β-amyloid treatment, the protein expression levels of MCT2, GPR81, and BDNF were significantly decreased, and after lactate treatment, the protein expression levels of MCT2 and GPR81 were remarkably recovered. After treatment with β-amyloid and lactate, the expression levels of mRNA by item did not show any significant results. When MCT2 and GPR81 were silenced and then lactate was treated, the protein and mRNA expression levels of MCT2, GPR81, and BDNF were significantly recovered. In the hippocampus of rats treated with lactic acid, MCT2 and BDNF protein expression were relatively activated compared to rats treated with saline.

CONCLUSION: Lactate treatment significantly helps in the recovery of cell viability, and it is highly likely to have a positive effect on brain function activation as it helps to activate MCT2, GPR81, and BDNF protein and mRNA expression levels. This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (2020R1F1A1072018)

## Motor Learning and Motor control

### INFLUENCE OF AGEING ON FEED-FORWARD AND FEED-BACK CONTROL IN POSTURE STABILITY

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INTRODUCTION: Few studies have examined the influence of aging on dynamically characteristic of posture sway. The purpose of this study was to investigate the influences of aging on feed-forward and feed-back control in posture stability.

METHODS: Twenty-one older subjects (69.2±5.6 years) and Six healthy young subjects (21.5±0.5 years) participated in this study. Stabilographic examinations were performed. The time-series data for the COP were acquired at 100 Hz with a 30-s sampling time. We calculated the directional change of COP trajectory by using Nagano method (Nagano et al. 2010). This method can analyze the dynamic characteristics of postural control.

RESULTS: The directional change of COP sway in the feed-forward phase of older subjects were significantly smaller than that of young subjects. This implies that the COP sway of young subjects displayed a random-like nature as one would expect from predictive postural control in the feed-forward phase. Meanwhile, the directional change of COP sway in the feed-back phase of older subjects were significantly larger than that of young subjects. This maybe because older subjects compensate the degradation of postural sway of feed-forward phase in feed-back phase.

CONCLUSION: It has become clear that dynamically characteristics of posture sway of older subjects were maintained movement at feed-forward phase and enlarged movement in the opposite direction at feed-back phase.

### ANTICIPATION AND SPLIT STEP EFFICIENCY IN EXPERT TENNIS PLAYERS (FEDERER VS DJOKOVIC, 2019 WIMBLEDON FINALS)

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INTRODUCTION: The efficiency of the split step is usually observed and taught from the aspect of force production. But without the acknowledgment of the hitter's stroke intention, split step is performed as a neutral preparatory vertical jump with the body weight equally distributed and without lateral preference. Due to the high spatiotemporal demands of the tennis game, expert tennis players tend to decide of the movement direction and intensity while still being above the ground (Uzu et al., 2009). The decision of how the body weight will be distributed at the time of the landing presents the crucial decision for the split step efficiency at the landing sequence (Melvill-Jones & Watt 1971; Lees 1981; McNitt-Gray 1993)

METHODS: We observed the split step performance of two expert players, Federer and Djokovic, at the Wimbledon finals match. The speed of play should be highest on grass (ODonoghue & Ingram, 2001) demanding the most efficient movement responses. Expert performance observed in situ should provide the most relevant information of the essential behavior needed for the performance to be successful (Ford et al., 2009). Guided by the Mecheri et al. (2019), we observed receiver's split step from the two phases, dependable on the hitters stroke movement: 1. Split-step take-off (air phase) when receiver's foot in contact with the court left the ground initiating the split-step; 2. Split step landing phase when the receiver's foot touched the ground and lateral step as the directional movement is initiated.

To create intensified lateral step (pivot), experts tend to supinate ankle joints (inwards) during the air phase enabling more explosive pronation (outwards) during the landing. By pivoting the leading foot towards the ball direction, players initiate rotations of the whole unit of the body (toe-knee-hip-shoulder) towards the impact zone (Vaverka et al., 2003). Obviously, if the receiver has intention of intensifying the lateral movement when landing, the decision of supination made at the pre-contact phase of the stroke should be based on the perception of the hitter's movement at the stroke set-up phase, or even before. Therefore, the SUP movement should be considered as crucial aspect of the anticipatory movement competency of the expert tennis players with decision of its execution made based on the observation and prediction

RESULTS: Our expectation was that the supination to pronation (SUP) sequence is the most frequent pattern in the anticipatory split step response. The sequence timely relates to the receiver's air phase (decision about the response) and hitter's pre-contact movement. Our data show that efficiency of the responsive decisions made at the air phase (accuracy of the SUP split step pattern) could be of highest importance for the outcome of expert's performance

CONCLUSION: Training split step from the decision-making perspective should improve movement competency of tennis players, speeding up the reaction time by observing the game context and its dynamics

## EFFECTS OF TONGUE POSITION ON POSTURE STABILITY: A PILOT STUDY

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INTRODUCTION: Body posture has been shown to be affected by various factors, including vision, trigeminal afferents, head-neck position and proprioception. Jaw and neck regions share anatomical, biomechanical and neurological links; in addition, dental occlusion status contributes to the maintenance of postural balance. Here we investigated the effects of the tongue-mediated activation of trigeminal nerve endings, located at the Palatine Spot (PS), on postural parameters of healthy active adults.

METHODS: Seven active men (age 26.6 ± 3.6 yrs; height 176.9 ± 4.7 cm; weight 79.4 ± 9.0 kg; BMI 25.4 ± 2.9 kg/m2) and seven active women (age 26.0 ± 3.4 yrs; height 165.4 ± 9.7 cm; weight 58.3 ± 7.5 kg; BMI 21.3 ± 1.8 kg/m2) were recruited. Specific postural parameters were recorded using the DIERS Pedoscan platform: the sways of the Center of Pressure at the left and right foot (CPL and CPR) and the sways of the Center of Mass (CoM); sways were monitored on the antero-posterior (AP) and on the medial-lateral (ML) planes. Static and dynamic balance were evaluated with/without tongue positioned at the PS.

RESULTS: During the static balance test, when tongue was located at the palatine spot, men significantly reduced CoM sways at the ML plane ($p<0.05$); a similar behavior was observed when male and female data were grouped ($p<0.05$). Considering the dynamic balance, we observed a significant reduction of AP sways in the CoM of grouped men and women ($p<0.05$). Interestingly, within all considered groups (men, women, all), the AP sways of CPL and CPR were always significantly higher compared to ML ones, both during the static and the dynamic balance tests ($p<0.05$); nevertheless, when the tongue position was evaluated, no statistical significance was observed.

CONCLUSION: This pilot study confirms how the correct tongue position within the mouth is instrumental to get a better posture. In particular, the activation of the trigeminal nerve endings allows to reduce the ML sways of CoM in the static balance, whereas it reduces the AP sways of CoM in the dynamic evaluation.

## RELIABILITY OF THE COUNTERMOVEMENT VERTICAL JUMP PERFORMANCE AFTER VERBAL INSTRUCTIONS RELATED TO DOWNWARD MOVEMENT PHASE EXECUTION.

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INTRODUCTION: The vertical countermovement jump (CMJ) performance is influenced by the execution of the downward movement phase (1). The instructions given to the athletes prior CMJ execution could influence the CMJ performance and the biomechanical variables obtained (2). However, the cues given could affect the consistency of the biomechanical variables of the CMJ. The present study evaluated the reliability of the biomechanical variables of the CMJ after different cues.

METHODS: Fifteen healthy adult participants habituated to performing CMJs (age: 21.4±2.95 years) performed 3 CMJ after the instruction "jump as high as possible" (CMJP), 3 CMJ after the instruction "jump as high as possible after descending slower" (CMJS) and 3 following the instruction "jump as high as possible after descending as fast as possible" (CMJF). The jumps were performed on a force platform (1000 Hz). Force data of each jump were used to calculate: time of downward movement phase (ECC_t), maximum velocity achieved in the downward movement phase (ECC_v), rate of force development in downward movement phase (ECC_RFD), estimated minimal center of gravity height (min_h), and take off velocity (TO_v). After checking normality and heterocedascity assumptions, reliability of the CMJs following each verbal instruction was assessed. Systematic error (ANOVA for repeated measurements), relative reliability (coefficient of variation, CV, and intra-class correlation, ICC), and absolute reliability (standard error of measurement, SEM, and minimum detectable change, MDC) were evaluated.

RESULTS: Only ECC_t in the CMJS showed differences between attempts (systematic error) where the descent time of the first attempt was longer than the second. The relative reliability of the downward movement phase variables (ECC_t, ECC, ECC_RFD) following the different instructions was low. CV between 6.51% and 28.58% and the ICC presented very dispersed values (ICC 95% CI lower and higher values were separated by up to 40%). The CMJF presented the lowest variability in these three variables. Also, the downward movement phase variables showed higher variability when looking at relative reliability, where the ECC_RFD had the highest SEM and MDC values in the CMJS and CMJP. On the other hand, the variables min_h and TO_v showed lower variability and greater consistency between attempts being CMJF the condition with the less reliability.

CONCLUSION: The CMJ following verbal instructions to modify the downward movement phase does not affect the repetitiveness of the test, which in general is usually moderate (3). CMJ following the instruction to descend as fast as possible seems to have the advantage of greater reliability in the downward movement phase execution but, in turn, it loses repeatability in the jump performance.

REFERENCES:

1. Gheller G, et al. Hum Mov Sci. 2015;42:71-80.
2. Sánchez-Sixto A, et al. Sport Biomech. 2021;6:1-11.
3. Roe G, et al. Int J Sports Phy. Perform. 2016;11(5):581-6.

**EARLY DEVELOPMENT OF CHILDREN'S DROP-LANDING MOVEMENTS COORDINATION**

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INTRODUCTION: Drop-landing develops as a motor skill during childhood [1]. Knowing more about how children coordinate movements during landing will give us the opportunity to better equip individuals with proper technique and prevent potential injuries. Principal component analysis (PCA) can be used as a holistic approach to quantitatively describe movement coordination [2]. Our aim was to assess drop-landing movement coordination of young children related to predictable or unpredictable actions after landing.

METHODS: Forty-two children in four age-groups (G1=3-4.5 yrs, G2=4.5-6 yrs, G3= 6-7.5 yrs, and G4=7.5-9 yrs) were equipped with body landmark markers. They were asked to perform20 drop-landings on two force plates in four conditions. One where participants were aware of what to do after landing (participants had to remain stable and stationary); and three where participants did not know what do until they contacted the force plates and a light cue switched on (landing and remain stable and stationary, landing and run to the left, and landing and run to the right). PCAs were calculated for the pre-impact phase (300 ms before impact) and the absorption phase (650 ms after impact) on normalized and weighted markers coordinates and yielded the principal movement components (PPs). Waveform PCA analysis [3] was conducted for each PP. First and second Waveform-scores and their variability were submitted to repeated measures MANOVA (Age-group x Condition).

RESULTS: Only differences by age-group were found. During the beginning of the pre-impact phase, G1 abducted the legs with slight hip flexion while separating the arms and moved more the trunk-head-arms in the saggital plane than the other groups. In the middle of the phase, G1 decreased the amount of movements of the trunk-head-arms in the saggital plane and presented smaller use of knees extension while moving slightly up their arms. Also, G1 always presented higher variability than the other groups in this phase. During the absorption phase, G1 moved more the arms at the beginning of the phase while in the middle of the phase they increased the use of the hip-knee-ankle flexion-extension and the arm abduction-adduction. Also, G1 showed a trend to decrease the use of ankle flexion and CoM movement at the end of the phase. On the other hand, G2 mainly did not show differences with the other groups in the absorption phase.

CONCLUSION: The results suggest that (1) drop-landing movement coordination development could be related with age and it is not affected by the predictability of the action after landing at this young ages; (2) the youngest children have not acquired pre-impact movement coordination and they explored how to perform this part of the task showing larger variability; and (3) a transition to more consolidated and experienced coordination occurs between the ages of 4.5 to 6 years.

[1] Swartz. J Athl Train. 2005; 40(1):9-14

[2] Federolf. J. Biomech. 2016; 49:364-370

[3] Mohr et al. Front. Bioeng. Biotechnol. 2021; 9:657357

**SUCCESSFUL REHABILITATION THROUGH NEUROMUSCULAR STIMULATION-BASED TRAINING OF ASTASIA-ABASIA GAIT IN A LADY MIMICKING LEFT HEMISPHERIC SYNDROME STROKE**

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INTRODUCTION: Psychogenic somatoform disorders may manifest as stroke mimics in the form of bizarre gait abnormalities. Here we describe the inpatient rehabilitation course of a patient who was admitted with initial concerns of recurrent falls, but whose stroke workup was entirely negative. She was severely disabled on admission, unable to walk independently, with examination revealing an astasia-abasia gait pattern mimicking unilateral monoparesis of the right lower limb. The patient underwent a period of successful neuromuscular conditioning incorporating manual, myofascial, and transcutaneous electrical stimulation which resulted in a dramatic increase of her gait speed from 0.01m/s to 0.5m/s, along with subsequent near-normalization of her gait pattern and return to independent living.

METHODS: During the course of a 4-week inpatient rehabilitation regime, a baseline measurement of gait speed, Berg Balance Score, Trunk Impairment Scale, and Timed Up and Go test was performed. Strength was quantified using the modified Research Council grading criteria before and after the rehabilitation programme. A combination of manual therapy, body weight-assisted gait training, and neuromuscular electrical stimulation using submaximal near-tetany amplitudes of 35-40mA was used on the patients iliopsoas, quadriceps, and tibialis anterior, in order to achieve a near-normal gait pattern. Gait speed was measured pre- and post-intervention.

RESULTS: A video recording of the patients gait pre- and post-intervention showed a clear improvement in the gait pattern, foot placement, and gait speed. Objective measures of balance and gait parameters including TUG (60secs to 25secs), BBS (18 to 30 points), TIS (5 to 15 points), and gait speed (0.01m/s to 0.5m/s) were obtained, indicating improved performance. Functional Independence Measure scores improved from 50 to 75.

CONCLUSION: The rehabilitation of patients with conversion disorder has been reported, but the utility of neuromuscular stimulation in cases of severe gait abnormalities has hitherto never been reported. Here we report a case of the successful use of NMES therapy in combination with physical therapy and gait retraining for a middle-aged woman with psychogenic functional gait disorder, and present a potential programme to be applied for patients with a similar condition.

## Neuromuscular Physiology

**HAMSTRING ACTIVITY DURING NORDIC HAMSTRING EXERCISES AND RAZOR CURLS ON FLAT AND SLOPED PLATFORM**

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INTRODUCTION: Hamstring strain injury (HSI) frequently occurs in the biceps femoris long head (BFlh) during high-speed running. Since the injury situation of HSI occurred in the late swing phase during high-speed running, hamstring exercise with high activity in the elongated position of the BFlh is recommended to HSI prevention. Although the conventional Nordic hamstring exercise (NHE) predominantly activates the semitendinosus muscle (ST), it has been reported that utilizing a sloped platform reduces the activity of the ST. Razor curl (RC) may also change their hamstring activity patterns due to different angles of the platform. Therefore, the purpose of this study was to investigate whether different angles of the platform would change the activity of the hamstring and the the BFlh length at peak BFlh

electromyography (EMG) activity during the RC. The purpose of this study was also to compare RC and NHE for those changes caused by different angles of the lower leg slope.

METHODS: This study adopted a crossover design. Twelve male volunteers (age 23.3 ± 2.5 y, height 169.9 ± 4.8 cm, weight 66.4 ± 7.3 kg, mean ± SD) participated in this study. Participants randomly performed following tasks: NHE with the platform angle set at 0° (NH), NHE with the platform set at 40° (N40), RC with the platform angle set at 0° (RC), and RC with the platform angle set at 40° (R40). The peak EMG activity of BFlh and ST during tasks was normalized by the value of peak EMG activity during maximum voluntary isometric contraction of prone leg curl with knee flexion angle set at 45°. To calculate the BFlh length at peak BFlh EMG, the EMG and kinematic analysis were synchronized using a trigger mechanism. The BFlh length was calculated by the flexion angles of hip and knee. Statistical analysis was performed using two-way ANOVA (within-factor: NH, N40, RC, and R40; between-factor: BFlh and ST). In addition, statistical analysis was also performed using one-way ANOVA (within-factor: NH, N40, RC, and R40). The significance level was set at $p < .05$.

RESULTS: The BFlh %MVIC was significantly higher for NH than RC ($p < .05$). In addition, the BFlh %MVIC was significantly higher for N40 than R40 ($p < .05$). The ST %MVIC was significantly higher for NH than N40 ($p < .05$), RC ($p < .05$), and R40 ($p < .05$). A significant difference between BFlh %MVIC and ST %MVIC was observed in NH ($p < .05$), and RC ($p < .05$).

The BFlh length at peak BFlh EMG of NH was significantly lower than those of N40 ($p < .05$), RC ($p < .05$), and R40 ($p < .05$). In addition, the BFlh length at peak BFlh EMG was significantly lower for N40 than RC ($p < .05$).

CONCLUSION: Although the RC is often prescribed a hamstring exercise which is specific to the late swing phase of high-speed running, it is recommended to utilize other exercises to compensate for the lower activity of hamstring for HSI prevention.

## EFFECT OF 10 DAYS OF UNILATERAL LOWER LIMB SUSPENSION ON NEUROMUSCULAR CONTROL

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INTRODUCTION: Segmental limb reduction in mechanical loading may occur as a consequence of surgery, injury or illness, but also result from a reduced daily physical activity or a decreased gravitational input. An extensive literature shows that neuromuscular function is rapidly impaired by disuse in the first days of unloading (1), with muscle function-dependent specificities (2). Anti-gravity muscles, for instance, and knee extensors (KE) in particular, appear to be the most susceptible to unloading-related atrophy and contractility impairments (3). Regarding neural adaptations, despite an impaired muscle activity, the literature generally reports a preservation of the central neural drive and an enhancement of spinal excitability following the muscle inactivity period (1). However, because it is simpler and less binding for the subject to assess lower limb spinal excitability on the soleus, no data are available for KE. Thus, this investigation sought to identify the neural and muscular mechanisms involved in the loss of KE strength after 10 days of muscle unloading.

METHODS: Ten healthy volunteers (age: 22.9 ± 4.0 years old; body mass index: 22.9 ± 2.1 kg/m2) participated in this investigation. A testing session was conducted before (BLS1) and after (LS10) 10 days of unilateral lower limb suspension (ULLS). In each session, the KE function was assessed through the measure of cross-sectional area (CSA), maximal voluntary contraction (MVC), specific force (MVC/CSA) and maximal voluntary activation level (VAL). In addition, electrical stimulations were delivered over the femoral nerve to elicit maximal H-reflex (HMAX) and M-wave (MMAX) of the vastus medialis (VM) muscle at rest. We calculated the HMAX/MMAX ratio which is an index of spinal excitability. To assess nerve conduction velocity, the latencies of both HMAX and MMAX were also measured.

RESULTS: The MVC (-27.1 %, $p < 0.0001$), CSA (-4.4 %, $p = 0.007$), MVC/CSA (-23.7 %, $p = 0.0001$) and VAL (-5.5 %, $p = 0.013$) significantly decreased after the ULLS. Compared to BLS1, VM MMAX was unchanged at LS10 while HMAX/MMAX ratio increased by 33.1 %. The ULLS increased the VM MMAX latency whereas it did not modify the HMAX latency.

CONCLUSION: The protocol consisting of 10 days of ULLS resulted in a reduction in KE strength. The impairment in muscle performance is attributable to adaptations in both muscle structure and neural function. The decrease in voluntary activation is accompanied by an increase in spinal excitability. These observations suggest that presynaptic inhibition and/or post-activation depression of Ia afferents are reduced by disuse in KE, as already observed in PF. In addition, these findings imply that, contrary to most previous studies (1), unloading interferes with motor unit activation.

REFERENCES:

1. Campbell et al., Sports Med, 2019

2. Clark et al., Eur J Appl Physiol, 2007

3. Clark, Med Sci Sports Exerc, 2009

## DO STIFFNESS CHARACTERISTICS INFLUENCE CHANGE OF DIRECTION ABILITY IN BADMINTON PLAYERS?

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INTRODUCTION: Change of direction (COD) ability is a key predictor of athletic performance in badminton players [1], and stiffness may be one of the important factors affecting COD ability in badminton players [2-3]. The objective of this study was to investigate whether stiffness characteristics could influence the COD performance.

METHODS: A total of 15 badminton masters and first-class athletes (9 males: 19.8 ± 2.5 yr, 180.0 ± 7.0 cm, 71.0 ± 9.9 kg; 6 females: 20.2 ± 1.2 yr, 169.0 ± 7.0 cm, 60.0 ± 7.5 kg) were recruited in the study. A dynamic weight-bearing vest warm-up ((10% of body weight)) has been proved to improve COD ability. Prior to the warm-up (T0) , stiffness of soleus, gastrocnemius medialis (GM), and Achilles tendon (AT) for both sides were evaluated by MyotonPRO (MyotonPRO, Myoton AS, Tallinn, Estonia); vertical stiffness (Kvert) was measured by a force plate (Kistler Instruments, Winterthur, Switzerland) for both legs; COD ability was assessed by the badminton half-court agility test [6]. These variables were repeated measured at T0, 0-6 min following the warm-up (T1), 7-12 min following the warm-up (T2) and 13-18 min following the warm-up (T3). One-way repeated measures ANOVA and covariance analysis were used for data analysis.

RESULTS: There was a significant interaction effect in time for athletes COD ability at T1, T2 and T3 compared to T0 ($F=13.948$, $P<0.001$, $\eta 2p =0.499$). Bonferroni post hoc test showed that COD ability at T1 ($P =0.018$), T2 ($P=0.010$) and T3 ($P =0.004$) were significantly improved compared to it at T0. Right AT stiffness measured at T3 was significantly increased compared to those at T0 ($P=0.024$) and T1 ($P=0.039$). Compared to left soles stiffness at T1, it was significantly increased at T 2 ($P=0.047$). Right GM stiffness at T3 was significantly increased compared to it at T2 ($P=0.049$). The analysis of covariance discovered that right AT stiffness ($P=0.081$), left soleus stiffness ($P=0.531$) had an effect on COD ability improvement.

CONCLUSION: The increased stiffness of the right AT and left soleus muscle following a dynamic weight-bearing vest warm-up may be one of the mechanisms leading to the improved COD ability in badminton players.

REFERENCES:
1) Jeyaraman & Kalidasan, Int J Adv Innov Res, 2012
2) Maloney et al., J Strength Cond Res, 2019
3) Kalkhoven & Watsford, J Sports Sci, 2018
4) Maloney et al., J Appl Biomech, 2014
5) NAVA, University of Texas Rio Grande Valley, 2015
6) Hughes & Cosgrove, Assessment of elite badminton athletes, 2007

## Nutrition

### EFFECTS OF DIFFERENT DOSES OF ANTIOXIDANTS(VITAMIN E) INTAKE ON EXERCISE INDUCED OXIDATIVE STRESS, ANTIOXIDATIVE CAPACITY AND CHRONIC INFLAMMATION

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INTRODUCTION: Antioxidant enzymes are produced in a living body to defend against exercise induced oxidative stress. However excessive oxidative stress causes chronic inflammation. Therefore, it has been considered beneficial to supplement antioxidants from outside of the body to enhance protective function to the oxidative stress. On the other hand, since appropriate oxidative stress by exercise may generate improved carbohydrate metabolism and antioxidant enzymes production, excessive exogenous antioxidants may rather suppress beneficial effects of exercise. Indeed, several studies have shown disadvantageous effects of exogenous antioxidants during exercise intervention, while the others have not. The inconsistent findings may be due to the fact that each of the previous studies examined effects of a single dose of exogenous antioxidants on a single load of exercise. Therefore, it would be expected to conclude the debate by examining effects of several exogenous antioxidant doses on different loads of exercise intervention. The purpose of this study was to investigate effects of two levels of exercise stress and exogenous antioxidant doses on the exercise induced oxidative stress, antioxidant capacity and chronic inflammation.

METHODS: Wistar male rats were divided into two groups; sedentary (SED) and exercise (TR). The exercise was gradually increased from 4 weeks of low-intensity (90min/week) to 4 weeks of high-intensity (300min/week). The total duration was 8 weeks. TR was subdivided into low (70 mg/kg: TR+N), medium (350 mg/kg: TR+VE-M), and high (700 mg/kg: TR+VE-H) according to the amount of vitamin E (VE) intake. Oxidative stress (d-ROMs), antioxidative capacity (BAP) and chronic inflammation (hsCRP) were measured with blood sample before and after each of exercise loads using FREE Carrio DUO (WISMERLL) and ELISA. Antioxidant enzymes (SOD) were measured with leg muscles by Western blotting only after the whole exercise intervention.

RESULTS: d-ROMs increased as exercise intensity was augmented in all TR, and was higher in TR+N and TR＋VE-M than in SED after high-intensity exercise ($p<0.05$), while it was not different between SED and TR+VE-H. BAP increased in TR+VE-M and TR+VE-H after high-intensity exercise as compared with before ($p<0.05$). hsCRP increased in TR+N ($p<0.05$) and TR+VE-H ($p=0.055$) after high-intensity exercise as compared with before, but it did not increase in TR+VE-M. SOD was higher in the TR+N group in the soleus muscle.

CONCLUSION: The present results suggested that oxidative stress increased in an exercise loads dependent manner regardless of VE intake dose, and that a medium dose of VE with high-load exercise mostly reduced chronic inflammation, while a high dose of VE might exacerbate the inflammatory response. Taken together, these findings suggest the presence of the appropriate dose of exogenous antioxidants dependent on exercise loads.

### NEW ZEALAND BLACKCURRANT EXTRACT ENHANCES INTERMITTENT, HIGH-INTENSITY RUNNING CAPACITY, INDEPENDENT OF PREDICTED MUSCLE FIBRE TYPE

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INTRODUCTION: New Zealand blackcurrant (NZBC) extract has been shown to enhance exercise performance, although inter-individual variations are common (1, 2). Many factors may contribute towards the inter-individual variation (3). Previous work suggested that NZBC extract may have muscle fibre type (FT) specific responses (4). The aim of this study was to examine the influence of predicted muscle (FT) distribution on the inter-individual response to NZBC extract on intermittent, high-intensity running capacity (IHIRC).

METHODS: Familiarised active males (n = 16, age: 23±3 yrs, height: 179±5 cm, mass: 79±11 kg, $\dot{V}O_2max$: 55.3±5 mL/kg/min, M ± SD) completed a fatiguing isometric protocol (FIP) to predict muscle FT distribution (5). Participants completed the Intermittent High-Intensity Treadmill based Running Capability test (Int. HIT-RC) (2) on four occasions; twice after 7 days NZBC extract (210 mg anthocyanin) & twice after placebo (PL) (double blind, randomised, cross-over design, wash-out ≥14 days). IHIRC was measured via total running distance (TRD) & high-intensity running distance (HIRD). Data from the two PL & two NZBC trials were pooled & paired-samples t-tests were used to compare differences between mean PL & mean NZBC IHIRC, with significance accepted at $p<.05$. Pearsons correlation coefficient was used to examine the relationship between change in IHIRC & FIP force decline. Participants were categorised into predominant type I (n=4) & type II (n=2) muscle fibre subgroups for individual analysis (5).

RESULTS: TRD was significantly greater following NZBC (4107±780m) compared to PL (3779±862m) ($p<.01$). HIRD increased by 8.4% after NZBC (2630±517m) compared to PL (2415±552m) ($p<.01$). There was no significant correlation between FIP force decline & IHIRC following NZBC ($p>.05$). In participants with predominant type I muscle fibres (n=4), HIRD increased by 10.9% following NZBC (2749±702m) compared to PL (2478±743m). Type II subgroup (n=2) showed a 4.6% decrement in TRD following NZBC (2761±237m) compared to PL (2878±13m).

CONCLUSION: Predicted muscle FT may have an influence on inter-individual responses to NZBC extract, with the type I subgroup showing greater improvements in IHIRIC, compared to type II subgroup. Previous work also suggested increased fatigue resistance in predominant type I muscle fibre subgroups (4).

No association was observed between FIP force decline & IHIRIC when analysing the full data set, suggesting other inter-individual differences, such as absorption, distribution, metabolism, & excretion (3) of blackcurrant anthocyanins may influence response to NZBC extract when muscle FT distribution is not clearly categorised in subgroups (Type I or Type II).

References

(1) Cook et al., (2015), doi:10.1007/s00421-015-3215-8.

(2) Perkins et al., (2015), doi:10.1123/ijsnem.2015-0020.

(3) Tian et al., (2018), doi:10.1080/10408398.2018.1533517.

(4) Willems et al., (2020), doi:10.3390/sports8100135.

(5) Hamada et al., (2003), doi:10.1046/j.1365-201X.2003.01121.x.

## REACTIVE DIVING AND SPRINTING PERFORMANCES IN SOCCER GOALKEEPERS IMPROVED BY CAFFEINE CONSUMPTION AND POST- ACTIVATION PERFORMANCE ENHANCEMENT

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INTRODUCTION: Goalkeepers are typically the last line of defence and perform a very specialised role in team sports such as hockey and soccer. The most decisive moments for goalkeepers in match-play are often dictated by the ability to make a save, which involves explosive actions such as dives and jumps.

METHODS: The purpose of this study was to assess the effect of caffeine and post-activation performance
enhancement (PAPE) on reactive sprinting and diving times in goalkeepers.

A total of twenty-five goalkeepers (soccer; n= 25) participated in the study (age: 21.68 * 2.21 years; height: 1.74 ‡0.05 m; weight: 74.30 € 11.71 kg; playing experience; 8.48 +: 4.05 years).Numerous tests which assessed simple and complex reaction/movement times for various treatments were completed.

RESULTS: Within-group differences were present for the treatments, showing that
reactive sprinting and diving times were
enhanced by 5.17 and 14.34%, respectively,
under caffeine consumption, and by 4.25
and 13.60%, respectively, under plyometric
conditions. Caffeine and plyometric trials
were not significantly different for sprinting
(MaN = 0.013s, p= 0,817) and diving
(MaN = 0,000 s, p= 0,999), respectively.

CONCLUSION: Firstly, neuromuscular perturbations in the form of caffeine consumption or plyometric drill implementation are effective in improving goalkeeper performance, and may likely be related to increased information processing speed and/or enhanced lower extremity force production capacities.

## EATING HABITS AND FOOD ATTITUDES OF CLIMBERS IN HIGH MOUNTAIN CONDITIONS

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INTRODUCTION: Due to the negative effects of weather and environmental conditions, mountain climbers are exposed to the risk of health deterioration and even loss of life. Proper preparation for the expedition, in particular taking care of factors influenced by climbers, including nutrition, may contribute to the prevention of nutritional deficiencies that affect the deterioration of the health and efficiency of the body. The aim of the study was to analyze the eating habits and food attitudes of Polish climbers in high mountain conditions.

METHODS: The study group consisted of 23 men and 4 women aged 23 to 49 years (average 34.1 ± 6.9 years), participating in summer alpine expeditions at an altitude of more than 5 thousand above sea level, lasting at least 3 weeks. The analysis of eating habits and attitudes was based on the authors questionnaire.

RESULTS: The majority of climbers (85.7%) declare that their habitual diet significantly differs from that in the high mountains. The most common choices in terms of consumed products in the mountains among the respondents include: bars (100%), freeze-dried dishes (86.75%), chocolate (71%), energy gels (39.3%), jelly beans (35.7%), salty snacks (32.1%) and dried meat (28.6%). Due to the high frequency and amount of carbohydrate snacks consumed, 75% of climbers declare that they are satiated with sweet taste, while 78.6% of respondents most often prefer sweet snacks in the mountains. The deficit groups of food products during the trip include: vegetables (92.9% of choices), fruit (82.1%), eggs (60.7%), milk and dairy products (57.1%), butter and cream (46.1%), fish (34.3%) and meat (35.7%). On the other hand, the following products are most often eaten by climbers: sugar and sweets (85.7%), nuts and seeds (67.9%), whole grain products (64.3%) and refined cereals (57.1%). As many as 50% of climbers report digestive discomfort (flatulence, abdominal pain, diarrhea) after consuming freeze-dried products. The most frequently consumed freeze-dried products during a trip by climbers include: lunch dishes, soups, porridges, porridge, desserts and fruit. Climbers usually take for an expedition: isotonic drinks (78.6%), tea (60.7%), water (53.6%), coffee (14.3%) or juices (10.7%). Majority of respondents (57.1%) believe that the amount of consumed fluids is not sufficient. The dietary supplements used by climbers include: protein and protein-carbohydrate supplements, caffeine, probiotics, omega-3 fatty acids, as well as some vitamins and minerals. After returning from the expedition, 73.3% of respondents noticed a decrease in body weight. Almost all climbers (92.9%) declare that the amount of food has an impact on the well-being in the mountains, and 96.4% emphasize that the quality of food is also very important.

CONCLUSION: There is a need to develop dietary and supplementation recommendations that serve as guidelines for climbers to improve their well-being and exercise capacity in severe alpine conditions.

**EFFECTS OF NEW ZEALAND BLACKCURRANT EXTRACT ON CLIMBING PERFORMANCE, MUSCLE OXYGENATION AND RECOVERY IN RECREATIONAL ROCK CLIMBERS.**

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INTRODUCTION: Anthocyanin-rich New Zealand blackcurrant (NZBC) extract enhanced climbing endurance with multiple efforts (1). Blackcurrant increased femoral arterial diameter during contraction (2) and improved forearm blood flow (3), thus could enhance O2 delivery. Off-loading of O2 in the flexor digitorum profundus (FDP) accounted for 24% of variance in climbing ability [4]. Enhancement of the O2 cascade at microvascular level may improve climbing performance and recovery. We examined the effect of NZBC extract on single climbing performance, physiological indices and O2 delivery at microvascular (FDP) level.

METHODS: 10 male recreational rock climbers (M±SD: age 22±3yrs, height 180 ± 5cm, mass 77±16kg: IRCRA grade; 12.8 ± 1.9) volunteered. Participants consumed capsulated NZBC extract (600 mg·day-1 CurraNZ™; containing 210 mg anthocyanins) or placebo (PL) for 7 days (double blind, randomised, cross-over design, wash-out ≥14 days). A continuous wave near infrared spectroscopy device (cw-NIRS) was placed over the FDP, sampling at 25 Hz to determine the Tissue Saturation Index % (TSI%). Following warm-up, participants climbed to exhaustion at a self-selected pace on a Treadwall (Brewer Ledge M6) at 90° with recording of physiological and performance parameters, followed by 10-minutes passive rest and 10-minutes active recovery. In the first 3-minutes, cw-NIRS recorded time to half recovery (TTHR) of TSI%. Other recovery measures included blood lactate (ear), heart rate and handgrip strength. Paired-samples t-tests were used with $P<0.05$ for significance.

RESULTS: No differences between trials were observed for climbing speed, distance, climb duration, peak VO2, change in heart rate, RPE at failure and TSI% minimum. During recovery, no differences were observed for heart rate (5min), handgrip strength and TSI%. Although not statistically significantly different, (high level of variability) TTHR of TSI% was 33% faster during recovery following NZBC (33.16 ± 26.40s), than PL (49.32 ± 26.40s) supported by a small effect size and low power ($t(9) = 1.582$, $p = .148$, $\eta 2p = .217$ Power = .293). A PPM correlation showed a negative relationship approaching significance between Peak VO2 and TTHR; the greater the oxygen consumption the quicker the time to half recovery, following NZBC extract ($r = -.554$, $p = .097$).

CONCLUSION: Seven days of NZBC extract did not improve muscle oxygenation during and following a single indoor climb to exhaustion. Faster TTHR of TSI% was observed with NZBC intake but the small effect size and power observed suggest further testing is needed. Faster TTHR of TSI% has been observed following NZBC extract in fatiguing isolated forearm task in slightly higher-grade climbers [5].

REFERENCES: (1) Potter et al, Eur J Appl Phys 2019, (2) Cook et al, Nutrients 2017, (3) Matsumoto et al, Eur J Appl Phys 2005, (4) Fryer et al Eur J Appl Physiol 2016, (5) Fryer et al, Int J Sports Nutr Exerc Metab 2020

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**EFFECTS OF A HIGH-CARBOHYDRATE DIET COMBINED WITH A HIGH-FAT DIET ON ENDURANCE PERFORMANCE.**

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INTRODUCTION: It is well known that a high carbohydrate diet improves endurance performance. Thus, the athletes increase carbohydrate ingestion for a few days before a competition, however, it also temporally increases blood glucose level and glycolysis. Whereas, a high-fat diet increases serum free fatty acid levels, and fat oxidation, and decreases glucose utilization for energy resources. On the day of competition, combining high-carbohydrate and fat meal may contribute preservation of glycogen, and enhances physical performance.

METHODS: Six subjects ( 3 males (30±9 years) and 3 females (26±5 years) were recruited for this study. The lactate threshold (LT) was measured using a cycle ergometer. Before 3 days of the test, a high carbohydrate meal (more than 7.5g/kg/day) was provided. A high-carbohydrate meal (C) was prepared with 360 kcal of 100% carbohydrate, and a high-fat meal (F) was prepared with 369 kcal of 63% fat. They carried out the Wingate test twice (First phase), and a cycle ergometer exercise for 60 minutes at LT intensity to consume muscle glycogen. After that, anaerobic performance was evaluated using the Wingate test (Second phase). Before 3 hours of the test, subjects ate C and C (C+C) or F and C (F+C) meal. Blood samples were obtained at rest, before and every 15-minutes during the LT intensity pedaling to measure blood glucose, serum triacylglycerol (TG), and lactate. At the same time, expired gas was collected to calculate energy expenditure.

RESULTS: There were no significant differences in peak and average power per body weight on the first and second phase Wingate test. Serum TG at rest was significantly higher in F+C (F+C: 155±37 mg/dL, C+C: 106±30 mg/dL, $p=0.037$, Data shown as mean ± standard deviation). During LT intensity exercise, energy expenditure and blood glucose levels were not significantly different, blood lactate at 45 minutes was lower in F+C than that of C+C (F+C: 3.5±1.6 mM, C+C: 4.6±1.5 mM, $p=0.045$）

CONCLUSION: Differences in pre-exercise diet did not affect anaerobic performance after vigorous and moderate intensity exercise. However, the higher resting serum TG in F+C and lower lactate at 45 minutes of LT exercise suggest that muscle glycogen utilization during exercise may have been more suppressed than in C+C. Consuming a high-fat diet before consuming a high-carbohydrate diet may allow the athlete to compete with some increased fat utilization.

REFERENCE:

D.L.Costill et al., J Appl Physiol. 43: 695-699(1997)

**INFLAMMATION, RESISTANCE EXERCISE AND PROTEIN: DO THEY WORK TOWARDS A HEALTHIER LIFE?**

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INTRODUCTION: Inflammation is a natural part of aging process, which has been referred as inflammaging. Inflammaging has been associated with several health problems and limiting conditions (1). Knowing that resistance exercise plays an important role in improving quality of life in the elderly, through the capacity of preserving muscle mass, and that protein supplementation is also determinant to maintain lean body mass, we hypothesize that resistance exercise and/or protein supplementation, could provide benefits to the chronic inflammatory status of elderly people.

METHODS: To test our hypothesis, three main electronic databases were searched (PubMed, Scopus and Web of Science) until March 2022. Articles that included resistance exercise intervention, enteric protein

supplementation, or both, and inflammatory parameters (c-reactive protein, IL-6, IL-8 and TNF-Alpha) in adults older than 64 years, were included.

RESULTS: In the carried-out research, 6074 articles were obtained, then scrutinized. After evaluations three separated analyses were performed: one for resistance exercise (N=21), other for the elderly sample that only took protein supplementation (N=5), and the last analysis focused on articles that used both resistance exercise with protein supplementation (N=4). Using Comprehensive Meta-Analysis Software®, no significant value ($p \leq 0.,05$) between intervention and the decrease of inflammatory parameters was found for each analysis.

CONCLUSION: Contrary to what we hypothesized, it does not seem that resistance exercise, protein supplementation or both, can decrease the rising of inflammatory parameters in the elderly.

1- Franceschi C, Campisi J. Chronic inflammation (inflammaging) and its potential contribution to age-associated diseases. J Gerontol A Biol Sci Med Sci. 2014 Jun;69 Suppl 1:S4-9

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## HIGH CARBOHYDRATE DIET PARTIALLY PREVENTS DISUSE-INDUCED ATROPHY IN RAT SKELETAL MUSCLE

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INTRODUCTION: Muscle disuse promotes myopathy, leading to decreased daily physical activity and exercise capacity. Increasing protein intake is essential for maintaining or gaining muscle mass. However, it remains unclear whether carbohydrate intake contributes to muscle mass gain, although glucose itself was reported to stimulate muscle protein synthesis and reduce protein degradation (Hedden and Buse. Am J Physiol 1982, Saha et al. Diabetes 2010). Herein, we examined the potential of a high carbohydrate diet to prevent disuse-induced muscle atrophy.

METHODS: Twenty-four 10-week-old male Wistar rats were divided into two groups (n = 12 in each group); a low-carbohydrate diet (Low-CHO) group and a high-carbohydrate diet (High-CHO) group. In all the rats, the right leg sciatic nerve was severed on the first day of the experiment. The contralateral left leg was used as the control leg and subjected to the same surgery except for nerve transection. Following the denervation surgery, the Low-CHO and High-CHO groups were fed with a low and a high carbohydrate diet, respectively, for 7 days. The Low-CHO contained 20% carbohydrate, 60% fat, and 20% protein, while the High-CHO comprised 70% carbohydrate, 10% fat, and 20% protein. The energy intake in both groups was matched by pair-feeding. After 7 days of the dietary intervention, soleus, plantaris, and gastrocnemius muscles were harvested and weighed. All muscles were homogenized with ice-cold RIPA buffer containing protease and phosphatase inhibitors. The protein concentration of the muscle homogenates was quantified and the absolute muscle protein volume was calculated.

RESULTS: In both the Low-CHO and High-CHO diet groups, the muscle weights of the soleus, plantaris, and gastrocnemius muscles from the denervated lower limb were significantly lower than those from the contralateral lower limb. The relative change in soleus weights (denervated leg/contralateral leg) was not significantly different between the Low-CHO and the High-CHO groups. On the other hand, the relative change in plantaris and gastrocnemius weights were both significantly 6% higher in the High-CHO group than in the Low-CHO group. The absolute muscle protein volume in the denervated muscles was significantly lower than that in contralateral muscles. However, no difference in the relative change of the absolute muscle protein volume between the Low-CHO and the High-CHO was observed.

CONCLUSION: The high carbohydrate diet may partially prevent disuse-induced muscle atrophy in type II dominant muscles.

## EFFECT OF PYRUVATE SUPPLEMENTATION ON FOUR COAGULATION ITEMS AFTER ONE-TIME ACUTE EXHAUSTION EXERCISE IN RATS

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INTRODUCTION: Pyruvate has proven anti-inflammatory and antioxidative properties, but recently anticoagulant properties have been suggested. Additionally, acute strenuous exercise (100% individual anaerobic threshold) caused activated partial thromboplastin time decreased and induced platelet activation. Consequently, this study focused on the influence of pyruvate supplementation on four coagulation items after one-time acute exhaustion exercise in rats.

METHODS: 24 male Sprague-Dawley rats were used for this research. The rats were randomly divided into four groups: control group (C group, no exercise, n=6), pyruvate group (P group, no exercise, n=6), exercise group (E group, n=6), pyruvate and exercise group (PE group, n=6). The rats with P and PE group were gavaged with 616mg pyruvate per kilogram of body weight. the rats with C and E group were gavaged with 616mg maltodextrin per kilogram of body weight. All rats were gavaged with maltodextrin or pyruvate one hour prior to the familiarization run and exhaustive exercise The experiment design divided into two stages: familiarization stage and exercise stage. During the familiarization period, all rats of E and PE group were accustomed with treadmill running for 6 d. The protocol of familiarization stage was 10 min with a speed of 5m/min, and gradually increased treadmill speed with 5m/min per 3 min, until treadmill speed reached to 30m/min, subsequently, rats performed 3-5 sets high intensity interval exercise (HIIT). Each set of HIIT included 45m/min(110%VO2max) running and 10 m/min interval After the familiarization period, all rats of E and PE group were performed exhaustive exercise:13 sets HIIT. In the familiarization stage and exercise stage, treadmill was at 10° inclination all the time, in addition, treadmill was equipped with an electric stimulation grid at the rear. All rats were immediately euthanized by intraperitoneal injection of 10% pentobarbital sodium, Blood samples were collected from the abdominal aorta, blood samples were used to detected blood concretion four item. The values are expressed as the mean ± standard error of the mean (SEM). Data were analyzed by two-way analysis of variance (ANOVA) and least significant difference (LSD) in different groups

RESULTS: Blood concretion four item: PT(prothrombin time), Compared to C group, E group PT was significantly increased($p<0.01$), compared to E group, PE group PT was apparently decreased($p<0.001$); APTT(activated partial thromboplastin time), Compared to C group, E group APTT was notably increased($p<0.001$); compared to E group, PE group APTT was apparently decreased($p<0.001$); TT(thrombin time), Compared to C group, E group TT was significantly increased($p<0.001$), Compared to P group, PE group TT was significantly increased($p<0.001$), compared to E group, PE group TT was apparently increased($p<0.05$); FIB(fibrinogen), Compared to C group, E group FIB was significantly decreased($p<0.05$), Compared to P group, PE group FIB was significantly decreased($p<0.05$),compared to A group, P group FIB was apparently increased($p<0.05$)

CONCLUSION: Acute exhaustive exercise induced a significantly increase in TT, APTT, PT and lead to a notably decreased in FIB. Pyruvate supplementation restored TT, APTT, PT and FIB to normal range

### ACUTE SHORT-TERM INCREMENTAL EXERCISE DID NOT ALTER DETECTION THRESHOLD LEVELS OF SWEET TASTE IN FEMALE STUDENTS

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INTRODUCTION: Oral taste perception is strongly influenced by buffer capacity of saliva during and after physical stress and the latter's modality. The aim of this study was to determine whether a short exercise bout influences sweet taste perception and detection in female students.

METHODS: 40 non-smoking recreationally physically trained and sensorily untrained female college students (age: 21.5±3.3, BMI: 21.4±2.2 kg/m2) were tested pre (T0) and post (T1) a maximal incremental cycle exercise test. After 3 minutes warm up at 20 Watts, workload was increased every minute by 15 Watt till exhaustion. Two identical threshold tests, using 9 solutions with saccharose concentrations ranging from 0 (=water) to 8 g/l in ascending order and one neutralizing rinsing solution administered between tastings were performed directly before (T0) and 3 min after the exercise bout (T1). Subjects were asked to document their subjective sensations in a taste-perception protocol. Protocols were compared in terms of distribution frequency and examined for significant differences ($p<0.05$).

RESULTS: 29 participants (72.5 %) identified the sweet taste at T0 and T1, 3 (7.5 %) of them did not identify at T1, another 3 didn't identify at T0, and 8 (20 %) never identified the sweet taste. The median detection threshold (DT) was at 2 g/l prior to and at 1.5 g/l after testing (n.s.). The perception threshold (PT) was the same before and after testing (3 g/l, n.s.). Furthermore, a positive correlation between DT T0 and T1 (0.413, $p<0.01$) and PT between T0 and T1 (0.701, $p<0.001$) was examined. No correlation was found between BMI or IPAQ Score and taste perception. However, a weak but non-significant correlation between BMI and IPAQ was detected ($r=0.307$, $p=0.054$). The subjects who identified the solutions correctly as sweet had a significant higher BMI (21.5 [3.9] kg/m², $p<0.0$) compared to those who were not able to identify (19.6 [1.5] kg/m², $p=0.038$).

CONCLUSION: This is the first study showing that a short incremental exercise bout does not influence the taste perception of young recreationally trained female students, as only 20 % of participants were unable to identify the sweet taste correctly. Future studies should focus on physical stress levels and include body composition as a higher IPAQ score positively correlated with the sweet taste identification.

## Philosophy and Ethics

## Physical Activity Promotion

### THE MODERATING EFFECT OF CARDIOVASCULAR FITNESS ON THE DETRIMENTAL INFLUENCE OF EXHAUSTIVE EXERCISE ON PROCESSING CAPACITY UNDERLYING COGNITIVE CONTROL

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Introduction

Although cardiovascular fitness has been demonstrated to moderate the negative impact of exhaustive exercise on cognitive control, available evidence from research using traditional mean behavioral measures (e.g., accuracy, mean reaction time, etc.) remain somewhat controversial. Accordingly, the purpose of this study was to further address this issue by using a theory-driven diagnostic tool, the Systems Factorial Technology (SFT), which has the capacity to reveal the decisional mechanisms underlying cognitive processes.

Methods

Young adults aged 18 to 30 years with higher (n = 30; VO2max = 47.8 ± 5.6 ml/kg/min) and lower (n = 30; VO2max = 36.7 ± 3.9 ml/kg/min) levels of cardiovascular fitness were asked to execute a laboratory cognitive control task (i.e., the go/nogo version of redundant-target task) prior to and after a graded exercise until exhaustion (GXT). SFT was conducted to estimate the resilience capacity, which reflects the processing capacity underlying cognitive control.

Results

Following the GXT, both higher-fit and lower-fit groups showed quicker responses but decreased accuracy overall relative to the performance at the pretest. However, the analysis of SFT revealed that the resilience capacity decreased selectively for the lower-fit group, while such an effect was not found for the higher-fit group.

Discussion

The current findings suggest a maintenance of processing capacity associated with cognitive control in higher-fit individuals following the GXT, while a decrease in processing capacity in individuals with lower level of fitness. This study offers an alternative mechanistic explanation regarding the protective effect of cardiovascular fitness on cognitive control in response to a maximum physical stress.

### COUNTERMEASURES FOR THE DEVELOPMENT OF SPORTS FOR THE ELDERLY IN CHINA IN AN AGING SOCIETY

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Introduction

The aging process of Chinas population is getting worse and intensifying. At the end of 2020, Chinas elderly population aged 60 and above reached 264 million, accounting for 18.7% of the total population, and the elderly population aged 65 and above reached 191 million, accounting for 13.5% of the total population. China is already in a mild aging society and is heading towards a middle aging society development. Through the analysis of the current situation of physical exercise for the elderly in China in an aging society, we explore the problems arising in the physical exercise of the elderly in China, and put forward targeted countermeasures.

Methodology

This study mainly uses literature review, logical analysis and mathematical statistics.

Results and discussions

(1) Through multi-categorized logistic regression analysis, it is found that the main factors affecting the participation of the elderly in physical exercise include place of residence, age, education level, occupation, and health condition. (2) The proportion of the elderly in urban areas participating in physical exercise is 30% higher than that of the rural elderly. (3) With the increase of education, the proportion of the elderly participating in physical exercise has also gradually increased. (4) As the elderly (60 years old and above) get older, their participation rate in physical exercise gradually decreases. The proportion of elderly people aged 60-69 and 70-79 participating in physical exercise is 70.6% and 40.6% higher than that of elderly people aged 80 and above, respectively. (5) The proportion of healthy elderly people exercising is 14.2% higher than that of sick elderly people. (6) The elderly who work in government departments have the highest proportion of physical exercise.

Countermeasure: (1) Rationalize the allocation of public sports service resources, increase policy support for rural sports, strengthen the construction of sports infrastructure in rural areas, publicize rural sports culture, and expand the popularity of rural sports. (2) Improve sports security for the elderly. Do a good job in the prevention of sports injuries for the elderly and implement the policy guarantee system for sports insurance for the elderly. (3) Improve the training system of social sports instructors. Colleges and universities include social sports instructors in compulsory courses, cooperate with communities, hospitals, etc. to train practitioners with all-round development of practical theory; establish a regular assessment incentive system for employed social sports instructors, and standardize the team. (4) Enrich the content of sports activities for the elderly. The introduction of some novel sports with good effects for the elderly to choose from, that can also increase the innovation and promotion of traditional sports and enrich the lives of the elderly.

### ANALYSIS AND PREVENTION OF MUSCULOSKELETAL DISORDERS AMONG VOLUNTEER AND PROFESSIONAL FIREFIGHTERS IN THE TARN DEPARTMENT (FRANCE)

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Introduction

Musculoskeletal disorders (MSDs) have been defined as the "disease of the century" for several years. This major health and safety issue leaves no one unexposed and affects firefighters in their daily emergency relief to people (ERMP) which accounts for approximately 44.5% of accidents (CNRACL, 2020), and also in their sports training, accounting for approximately 51% (CNRACL, 2020). ERMP represents more than 80% of the interventions against 12% for fires. Exposure to risk factors is therefore more important.

Method

This study aims to measure the exposure of firefighters to MSDs through a questionnaire in order to identify the various prevalence factors. The questionnaire was constructed according to two hypotheses: MSDs occur firstly in response to exposure to biomechanical risk factors and secondly in response to exposure to psychosocial risk factors. The questionnaire was therefore constructed on the basis of and adapted from the "Nordic" type questionnaire by Kuorinka et al. (1987) and the "Job Strain model" questionnaire by Karasek et al. (1979) to the world of firefighters. The study population (35 ± 4 yr) is composed of 41 professional firefighters (PFS) and 64 volunteer firefighters (VFS). The PFS have a compulsory daily physical activity (PA) (functional training, etc.) unlike the VFS who are not subject to this obligation and practice during their leisure time.

Results

89.5% of the firefighters say that they are aware of the risk whereas 10.5% are not. The study shows a vulnerability for the following areas: 71% of injuries are to the lower back against 28% for the neck, shoulder, knee and ankle-foot regions. 48% of the firefighters say they are affected by these injuries in their leisure activities. 49.5% reported an increased heart rate during intervention and 80% when the beep sounded during sleep and 38% felt anxious about the uncertainty of the intervention.

The results show there is no difference in risk awareness between the PFS and the VFS. The discomfort following an injury during usual activities is higher for professional firefighters than for volunteers ($p \leq 0.05$) whereas there is no significant difference between PFS and VFS in discomfort during leisure activities.

Discussion/Conclusion

The high frequency of ERMP has an impact on the occurrence of MSDs in firefighters. PA to prepare PFS for operational missions seem to have positive effects on MSDs on a daily basis because it prepares the body to biomechanical constraints and improves cardiorespiratory fitness.

All French firefighters are exposed daily to biomechanical and psychosocial factors which have a strong impact on their physical and mental health.

Karasek R. et al., Am J Public Health. 1981;71(7):694-705.

Kuorinka I et al. Appl Ergon. 1987;18(3):233-237.

## Physical Education and Pedagogics

### PHILOSOPHICAL DISCUSSION ON TOPICS ABOUT SPORTS: PRACTICE IN A UNIVERSITY GENERAL EDUCATION CURRICULUM

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INTRODUCTION: In Japan, the public education system was introduced by the Meiji government as part of a policy of increasing wealth and military power. As such, the Japanese public education was started under the strong influence of nationalistic purposes. To this day, quite a few education reforms have been made. However, in comparison with other countries, the Japanese education system still has the following three key problems: 1) rigid teaching style without flexibility, 2) a passive lecture style, and 3) too much weight put on rote learning. The Central Council for Education has pointed out two factors that the Japanese style of school education should materialize in the 2020s, which are (1) optimal individualized learning (individualized instruction and individualized learning) and (2) cooperative learning.

Method:

In universities, the problem-solving style of learning and active learning are currently being introduced. This study examines the practice of philosophical discussions on sports-oriented topics and the learning outcomes of learners in the case of seminar-style classes in a university general education curriculum.

Result and Discussion:

The subject of this study is the classes with the topic of fair play. We examined the relationship between fair play and pursuit for winning using a real example. In the first class, learners watched the video example (incident of the five consecutive intentional walks at the National High School Baseball Championship: NHSBC) and discussion on whether the play was justified or not. The result of the first vote (the walks are); Justified 20, Not justified 9. In the next class, after listening to the explanations of the points from the lecturer, the result of the second vote: Justified 17, Not justified 12. Five students changed their views. As for the reason for the change, among those who changed from justified to not justified (four students), two answered that it was because the educational benefit was more important than winning, while the others answered that the process was more important than the result and having good experiences was more important than winning. The reason chosen by the student who changed from not justified to justified was that it should be understood that sports are competition. The NHSBC has a huge impact on the future of the players because it affects the choice of who will be drafted by professional baseball teams.

CONCLUSION: Because the students were highly interested in sports and chose this course focusing on sports of their own free will, the discussions in the classes were active and lively. Nonetheless, there still were students who did not participate in the discussions. In addition, from the lecturer's perspective, too many students did not seem to be assertive enough. Students should discuss issues more frankly while respecting others. I hope that the cooperative style of learning will develop further in Japan from the level of compulsory education.

## EXAMINING THE PEDAGOGICAL IMPACT OF HEALTH EDUCATION IN HUNGARIAN SCHOOLS IN THE LIGHT OF THE SCHOOL HEALTH INDEX (SHI)

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INTRODUCTION: In Hungary, a model of institutional evaluation is emerging as a gap area in school health education, which evaluates school health education from the perspective of student needs and demands. Based on international literature, it is important to recognise and identify school-specific strengths and areas for improvement [1,2]. The aim of our research was to develop an institutional evaluation framework that could assess the pedagogical impact of health education through objective indicators.

METHODS: The framework's main benchmark is the School Health Index (SHI), what measures 5 domain, namely (1) the physical and (2) personal environment of the school, (3) health behaviour and (4) health literacy characteristics of the pupils, and (5) their subjective health status.

The SHI student questionnaire contains 128 closed questions. All domains were assessed with likert-scale based questionnaires, and all domain were categorised based on their scores. The indicators are defined in categories of excellent, adequate, needs improvement and needs increased improvement.

The sample consisted of 5 high schools in Northern Hungary, from which students (N=747) were selected by expert sampling.

RESULTS: The Physical and Personal Environment Indicators got the lowest average scores (59.4%; 50.1%-70.2%). The Personal Environment Indicator averages were (57.77%; 50.6-66.3%). The Health Behaviour Indicator were 70.6% on average (68.1%-72.2%). The Health Literacy Indicator got the highest average score (74.5%; 66.0%-82.5%). The Subjective Health Indicator got the lowest average score of 46.1% (40.8%-51.9%). The average score of iEGI were 61.9% (55.6%-66.9%).

CONCLUSION: The physical environment in 3 schools are categorised as „need improvement", also the personal environment in 4 schools, the health behaviour and health literacy indicators are categorised as „adequate" in all schools, and the subjective health indicator is categorised as „need improvement" in all schools. Four schools have an SHI in the adequate category.

For each of these schools, the area for „need improvement" is the personal and physical environment, which reflects the role of teachers, non-teaching staff, parents and external organisations and associations, as well as the condition and facilities of the infrastructure surrounding the pupils, from a health perspective.

Our framework can be used for evaluate and monitor of health education in the school sector.

REFERENCES

1. Brener, N.D., Pejavara, A., McManus, T. (2011): Applying the School Health Index to a nationally representative sample of schools: update for 2006. J Sch Health. 81(2):81-90.

2. Langford, R., Bonell, C. P., Jones, H. E., Pouliou, T., Murphy, S. M., Waters, E., Komro, K. A., Gibbs, L. F., Magnus, D. és Campbell, R. (2014): The WHO Health Promoting School framework for improving the health and well-being of students and their academic achievement. Cochrane Database of Systematic Reviews. 4.

## RESEARCH ON THE APPLICATION OF METAVERSE IN COLLEGE PHYSICAL EDUCATION

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INTRODUCTION: With features of immersing virtual world, ubiquitous access and decentralization, Metaverse will revolutionize college Physical Education which underpins sports' long term vitality. Due to limited resources, many sport activities cannot be developed in college. This paper aims to explore the practicability and scenarios of applying Metaverse in college Physical Education, and raise measures to tackle foreseeable difficulties.

METHODS: Literature review and logical analysis

RESULTS: There's broad space for Metaverse to benefit college Physical Education. With technologies of 5G, block chain, virtual reality, etc, "Physical Education-Metaverse" community could be established among college union members. First, college students could have free access to the community with digital headsets regardless of locations. They can create and decorate own avatars to socialize remotely with avatars of other users, exchanging ideas and working out together. Second, different scenarios can be created to suit various sports, like imitating mountain climbing or skiing background. In 3-D animated virtual world, students could enjoy outdoor recreations without environment limits, enhancing their enthusiasm of working out. Third, with intelligent monitoring sensors, targeted improvement on

fitness and physique can be achieved. College users could wear digital sensors to monitor not only motions but also physical change of bodies, so that reports with scientific advice could be formulated for targeted improvement.

CONCLUSION: To facilitate college Physical Education with Metaverse, measures are raised from two aspects, hardware and software. Hardware of Metaverse should be enhanced by deepening research in Virtual Reality, Augmented Reality, Block Chain, Digital Twin, etc. Colleges shall optimize Metaverse infrastructures with advanced wearable devices and 5G network. For software, first, "Physical Education-Metaverse" community should be promoted step by step. Metaverse-Sports Experience Areas can be first set up at campus, allowing students to feel the potential of Metaverse in person. Pilot colleges with rich resources will be selected for trail practice, and then successful experience could be spread to other places. Second, regulations on Metaverse in college Physical Education shall be strengthened to alleviate digital risks. As big data will be processed extensively while current provisions are almost blank, introducing strict regulations and supervision are vital to safeguard the data safety. Colleges should also protect students' privacy and prevent information form leaking out. Third, guidance ought to be provided to help students enhance self-discipline and balance virtual and real life. "Physical Education-Metaverse" community should have the fatigue systems that set reasonable time limit to avoid addiction. With measures above, Metaverse could upgrade college Physical Education with easier access to sports scenarios without physical limitations.

## MODIFYING PHYSICAL ACTIVITIES FOR MAXIMIZING LEARNING OPPORTUNITIES: PERSPECTIVES OF FINNISH PHYSICAL EDUCATORS AND SPECIAL EDUCATORS ON INCLUSIVE TEACHING STRATEGIES

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Introduction

Recent curricular reforms have aimed to make the Finnish education system more inclusive which requires the implementation of differentiated and individualised teaching practices within schools (Mihajlovic & Meier, 2022). In Finland, as it is internationally, efforts have been made to increase adaptive teaching strategies and collaborative practices between different professionals in the physical education (PE) context. So far, current research has revealed significant findings on how pupils with special educational needs (SEN) can be successfully included in integrated PE settings, focusing mainly on the perspectives of PE teachers (Hutzler et al., 2019). In comparison, little attention has been paid to the instructional strategies of different pedagogues involved in the PE classroom.

Methods

Drawing on the data from a multiple case study in a Finnish context, we explore how four PE teachers and four special education teachers attempted to work inclusively within PE. Document analysis of the current Finnish national curriculum and semi-structured interviews with special educators and PE teachers were used to extend the current understanding of pedagogical practices for dealing with diversity in PE. The interviews were content-analysed adopting a deductive-inductive approach utilizing the TREE/STEP model and the Inclusion Spectrum.

Results

Interested in the interplay between curriculum approaches and its reflections in inclusive teaching, the results of the present study illuminate how PE and special educators often showed willingness to modify the physical activities to meet the individual needs of all learners in PE which included the rules, equipment, and environmental modifications. Both teacher professions take individual responsibility for the teaching activities, but their traditional role as independent and autonomous professionals may also be an obstacle for collaboration.

Discussion

Overall, this paper contributes to a growing body of pedagogical research portraying the perspectives of different practitioners involved in the PE classroom. Future research should further examine the perspectives of different professionals as it may contribute to a more comprehensive perspective on diversity and inclusive teaching strategies. Paying greater attention to these issues holds strong potential to enrich the existing knowledge regarding a shared vision of inclusive teaching and could help other teachers justify their educational choices.

References

Hutzler, Y., S. Meier, S. Reuker, and M. Zitomer (2019). Attitudes and self-efficacy of physical education teachers toward inclusion of children with disabilities: a narrative review of international literature. Physical Education and Sport Pedagogy, 24(3), 249–266

Mihajlovic, C., & Meier, S. (2022). Including students with special educational needs in physical education: An analysis of the current Finnish national core curriculum. The Curriculum Journal, 00, 1–18. https://doi.org/10.1

## DO VERBAL DISCUSSIONS IN PHYSICAL EDUCATION CLASSES INTERFERE WITH PHYSICAL ACTIVITY?

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Introduction

In recent years, verbal communication in physical education classes has become increasingly important. It is noted that through discussion activities, children can deepen the learning in physical education by sharing problems and solving issues (1). However, it has been pointed out that active discussion may prevent children from exercising (2). The purpose of this study was to examine the relationship between verbal communication and the amount of physical activity in elementary school physical education classes.

Methods

In this study, the survey was conducted in volleyball classes. The amount of physical activity and verbal communication were measured in physical education class of sixth-grade students (17 boys and 18 girls). Physical activity was measured in METs using an activity meter. The amount of verbal communication was analyzed and calculated using the Business Microscope (Hitachi, Ltd.) based on body vibration data from 3-axis accelerometers. Pearsons correlation coefficient was calculated for physical activity and verbal communication to verify the relationship.

Results

In volleyball classes, when children worked on individual tasks in their groups through discussions, there was no significant correlation between the amount of physical activity and verbal communication. However, when the children worked on the task as a group while

devising their game strategies, a significant correlation (r=.481, p=.007) was found between the amount of physical activity and the amount of verbal communication.

Discussion

Initially, discussions in physical education classes were regarded as a factor that decreased the amount of physical activity, but the results of this study verified that there was no such relationship. Rather, when the task was shared in a group, the amount of physical activity was higher for children who had more verbal communication. These findings suggest that the awareness of tasks is positively linked to physical activity in physical education classes. In situations where learning is conducted in physical education classes through group discussion and sharing of tasks, it is assumed that children who are unable to recognize the task and participate in the discussion are also unable to engage in physical activity. Therefore, it is necessary for teachers to understand the state of childrens discussion and engagement in physical activities, and to provide appropriate support for them.

Reference

1) Japan Ministry of Education, Culture, Sports, Science and Technology (2017) The courses of study for elementary school in Japan.

2) Yuji, M. (2012) Concern to "Enhancement of Language Activity" in Physical Education. Aichi University of Education Bulletin, 37. Pp.7-13.

### EFFECTIVENESS OF ADVENTURE EDUCATION ON HEALTH OUTCOMES RELATED TO PHYSICAL, PSYCHOLOGICAL, AND SOCIAL DEVELOPMENT IN CHILDREN: A SYSTEMATIC REVIEW

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Effectiveness of adventure education on health outcomes related to physical, psychological, and social development in children: A systematic review

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INTRODUCTION: Physical, psychological, and social development are essential throughout the developmental period of children. The positive effects of adventure education (AE) on physical, psychological, and social development are well-documented and previous systematic reviews have paid more attention to adults. However, due to age-related developmental limits, children encounter obstacles that are distinct from those faced by adults. whether adventure education can be beneficial to physical, psychological, and social developments in children remains to be addressed. Therefore, the objective of this systematic review was to investigate the impact of adventure education on children's (0-18 years old) physical, psychological, and social development.

METHODS: The review was reported based on Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA 2015). Articles were retrieved in seven databases (EMBASE, PubMed, MEDLINE, Web of Science, SPORTDiscus, PsycInfo, Psychological database) from 2000 to 2021. Methodological quality was examined in accordance with Version 2 of the Cochrane risk-of-tool for randomized trials (RoB2).

RESULTS: Eighteen studies were screened. First of all, AE contributed to physical development in healthy and unhealthy children aged 9 to 16, moreover, positive changes in physical activity were sustainable for up to 18 months. Secondly, the investigation of psychological development (9-18-year-old health and unhealth children) showed that the changes in self-esteem, self-efficacy, and quality of life yielded inconsistent results. Finally, AE was conducive to the social development in 11-17-year-old healthy and unhealthy children and 3-7-year-old unhealthy children.

CONCLUSION: AE intervention is found effective to produce physical, psychological, and social benefits in children. The majority of studies focused on 9-18-year-old unhealthy and healthy children only one study involved 3-7-year-old unhealthy children. However, most of the studies in this field have weak methodological quality and thus, the present evidence should be considered with caution.

## Physiology

### MUSCLE OXIGENATION DURING DIFFERENT INTENSITY AND DURATION OF TIME TRAINING SESSIONS IN WORLD-CLASS KAYAK ROWERS

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INTRODUCTION: Aerobic metabolism processes in muscles play essential role in 1000 m. distance for kayak rowers' work. Interval training method is used as one of the means of training methods, applied for kayak rowers training. Therefore, the aim of the study was to explore an effect of different intensity and duration of time training workouts for world-class kayak rowers' (500 and 1000 m.) muscle oxygenation.

METHODS: Case study was carried out during preparatory cycle in 1919-2020. Two world-class kayak rowers participated in this study (K2). Muscle oxygenation was measured using MOXY Oxygen Monitor device while athletes worked on kayak ergometer DANSPRINT. Sensors were fixed on athletes' Quadriceps and Pectoralis Major Muscles.

After 30 warming up, there were two different interval-training sessions. The first – athletes repeated 6 min duration work 6 times, which was followed by 6 min sitting at rest. During 6 min workout athletes worked 60 s - 220 W (at anaerobic threshold limit) and 60 s – 60 W. The second session – athletes also repeated 6 min duration work 6 times, which was followed by 6 min sitting at rest. However, during 6 min workout athletes worked 10 s - 320 W (at critical intensity limit) and 30 s – 60 W.

RESULTS: Muscles deoxygenation processes were better visible in Quadriceps muscles than in Pectoralis Major Muscles. Oxygen consumption during 6 min session (60 s - 220 W and 60 s – 60 W) changed by more than during 6 min session (60 s - 320 W and 30 s – 60 W). However, amount of oxygen equally returned to baseline level during 6 min rest after different 6 min sessions. Heart rate during 6 min different intensity and duration of time training workout reached ventilation anaerobic threshold. During 60 s rest after 60 s - 220 W work HR decreased until 120-130 b/min, while during 30 s rest after 60 s - 320 W workout decrease significant more. Lactate concentration show little activity of glycolytic reactions and was without differences in both different training sessions (3.5-4.5 mml/l).

CONCLUSION: This study revealed that during different intensity and duration of time training workouts did not provoke different scale of muscle oxygenation in world-class kayak rowers'. Though during second training session athletes reached capacity that achieves through

competitions, glycolytic reactions was active without significant differences comparing to the first training session. We can assume that for enhancing aerobic metabolism is suitable to use workout at anaerobic threshold limit.

### RELATIONSHIP BETWEEN CHANGES IN RECTAL TEMPERATURE AND MICROBIOTA DURING TRANSIENT EXERCISE ON CHANGES IN THE EXTERNAL ENVIRONMENT

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INTRODUCTION: Recently, it is important problem that global warming is progressing in the outdoor sports activity. From such a current situation, it is urgent to take appropriate measures for athletes in summer training or competitive race. In a heat condition, the necessity of taking physical condition management for athletes is emphasized by understanding the adaptation state of internal organs due to changes in the seasonal changes. There are considered that the gut microbiota is associated with physical condition, and it is also suggested that relevant to seasonal changes. The purpose of this study was to investigate, the relationship between changes in rectal temperature during exercise seasonal changes, and changes in gut microbiota and to obtain useful materials for the field.

METHODS: Nine healthy male adults (mean age, height, weight, % of Body fat, VO2max: 23.4 ± 3.0 years, 172.0 ± 6.5 cm, 73.6 ± 12.2 kg, 19.9 ± 6.9 %, 41.7 ± 5.9 ml/kg/min) participated 2 trials of aerobic exercise (Spring-Summer and Autumn-Winter). In Spring-Summer and Autumn-Winter sessions, participants performed 30-min aerobic exercise on a cycle-ergometer at intensity corresponding to 50% of VO2max. We examined whether the gut microbiota would change and whether the defecation status would improve in Spring-Summer and Autumn-Winter sessions. Gut microbiota on two times of stool samples in spring and autumn were classified by next-generation sequencing. In addition, we investigated the Bristol stool scale questionnaire was used to evaluate the form of fecal into seven types with the aim of obtaining basic material useful for the field.

RESULTS: Changes in rectal temperature increased immediately after-exercise compared to baseline, in addition, it was suggested higher than Autumn-Winter compared to Spring-Summer. Interestingly, it was shown that the subjects with high rectal temperatures immediately after-exercise may have low levels of Bacteroidetes phylum. In addition, it was shown that subjects on highly % of body fat that significantly higher rectal temperature immediately after-exercise ($p < 0.05$). On the Bristol scale, there were 3 out of 9 subjects in good condition in "Type 4" in "Autumn-Winter".

CONCLUSION: These results suggested that it was possible there may be gut microbiota associated with physical adaptability such as temperature sensitivity. Revealing the association between exercise and the gut environment can substantially contribute to health promotions. In the future, the gut microbiome data may be available for individual exercise prescriptions. This work was supported by JSPS KAKENHI (17H02147) and Grant for Wesco Scientific Promotion Foundation.

### DIFFERENCE BETWEEN FIT VS. UNFIT IN CEREBRAL AUTOREGULATION TO SEVERE ORTHOSTATIC STRESS

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INTRODUCTION: It has been known that gravitational stress acutely increases arterial cardiac baroreflex sensitivity (Iwasaki, 1998). Our previous study reported that severe orthostatic stress with lower body negative pressure (LBNP) acutely enhanced the arterial-cardiac baroreflex sensitivity in sedentary individuals, while the severe orthostatic stress suppressed it in fit individuals (Suzuki, 2021). However, it is still unclear whether the severe orthostatic stress would affect cerebral dynamic cerebral autoregulation especially with regard to different physical fitness level. The purpose of the present study was to test our hypothesis that the severe orthostatic stress would acutely enhance the dynamic cerebral autoregulation in sedentary individuals, but not in fit individuals.

METHODS: Eight male endurance athletes (Fit; 24±10 years old, VO2max 61±3ml/kg/min) and 9 male non-athletes (UnFit; 24±4 years old, VO2max 36±7 ml/kg/min) were recruited. They underwent severe orthostatic stress test using graded maximal LBNP. The graded maximal LBNP consisted of -15 mmHg, -30 mmHg and -40 mmHg LBNP for 5 minutes each, then incremented by -10 mmHg every 3 minutes until pre-syncope. Beat-to-beta mean arterial blood pressure (MAP; Finometer), middle cerebral artery blood flow mean velocity (MCAvmean; transcranial Doppler), and end-tidal CO2 (EtCO2; Capnometer) were measured for 5 minutes before and after the graded LBNP test in the supine position with spontaneous respiration. In offline analysis, 5 minutes data of beat-to-beat changes in MAP and MCAvmean were used for transfer function analysis (TFA) to estimate dynamic cerebral autoregulation (dCA).

RESULTS: EtCO2 decreased in both groups after the maximal LBNP($P=0.001$). In Fit, MAP and MCAvmean increased after the maximal LBNP. The low-frequency (0.07-0.2 Hz, LF) gain of TFA was lower after the maximal LBNP as compared with before ($P=0.014$). However, the change in LF gain did not differ between Fit and UnFit ($P=0.483$).

CONCLUSION: The present findings suggest that dCA was improved after the acute severe orthostatic stress by the maximal LBNP, which was not different in fitness levels.

### EFFECT OF SAUNA BATHING ON SENSORY FUNCTION AND PERFORMANCE OF TASKS

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INTRODUCTION: It is necessary to use a simple parameter about the health of the spectator in order that early detection of heat stroke during watching sports. Exercise under hot environment lower neural activity about cognitive process and salty taste sensitivity. These reports suggest that the sensory response may change with body temperature. The sauna is an environment where can elevation of body temperature and profuse sweat in a short time. Therefore, this study aims to clarify the influence of sauna bathing on sensory function and performance of task.

METHODS: Ten healthy young men (age: 22 ± 1 years, weight: 57.4 ± 6.2 kg, height: 173.5 ± 3.6cm, BMI: 19.1 ± 2.1) volunteered as subjects for this study. Subjects sit and rest for 20 minutes in a sauna (atomospheric temperatures: 47.5 ± 3.1 ° C, relative humidity: 62.2 ± 19.8%, WBGT (Wet-Bulb Glove Temperature): 43.4 ± 0.8 ° C). The measurements were body weight, pulse rate, thermal sensation, thirsty sensation, fatigue, sensory function and performance of tasks. Sensory function was measured using perceptual function test at the finger-tip, back of the hand, forearm and neck. This test was to measure the number of times subjects perceived, when they got pressure

stimulation 5 times on each point. The performance of tasks test was to measure the number of characters that subjects typed as much the specified English word as possible in 30 seconds using a smartphone.

RESULTS: The body weight after the sauna were significantly lower than the one before the sauna ($P < 0.05$), and the amount of body weight reduction was 0.32±0.09kg. Furthermore, pulse rate, thermal sensation, thirsty sensation and fatigue was significantly higher than that before the sauna. These results shows that sauna used in this study influenced physiological response like a heat stroke.

Regarding sensory function, no significant differences were observed in the finger-tip between before and after sauna bathing. On the other hand, the number of times perceived in back of the hand, forearm and neck point were significantly lower than before sauna bathing. However, no significant differences were found on performance of typing character task.

CONCLUSION: It was clarified that there are areas where the sensory function of the skin is reduced by heat stress. Among them, it was suggested that the part with low density of tactile points easily affected by heat stress. On the other hand, it was clarified that the performance of task had little influence at the hot environment and the measurement method of this study.

Therefore, we concluded that the use of cutaneous sensory stimulation may lead to early detection of heat stroke at sports spectators. We hope that results of this research will lead to the basic data of "a simple screening test for heat stroke using sensory reactions".

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## EFFECTS OF BLOOD FLOW RESTRICTION AND RESISTANCE EXERCISE ON CARDIOVASCULAR RESPONSE AND MUSCLE MECHANICAL PROPERTIES DURING THERMAL STRESS

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INTRODUCTION: The purpose of this study was to evaluate the effect of blood flow restriction and resistance exercise on cardiovascular response and muscle mechanical properties under heat and cold stimulation.

METHODS: Seven healthy male subjects (26.4 ± 1.7 yrs, 174.5 ± 2.0 cm, 72.7 ± 6.8 kg, 23.8 ± 1.7 kg/m2, 16.5 ± 3.1 %body fat) participated in 6 testings in combination of 3 environmental conditions at low (LT; 10.7 ± 0.7 ℃, 23.6 ± 3.2 % relative humidity (RH)), room (RT; 25.4 ± 0.6 ℃, 36.0 ± 10.8 % RH) and high temperature (HT; 39.5 ± 1.5 ℃, 50.6 ± 2.8% RH) during either blood flow restriction (BFR) or not (NBFR). For exercise, Preacher Curl-Dumbbell was performed 3 sets, 30 repetitions in a set for 1 min followed by 1 min resting. After the exercise 15 minutes of recovery time was given. The exercise intensity in NBFR was 50% of 1 repetition maximum (RM), and that in BFR was 30% of 1RM while arm blood flow was restricted at a pressure of 200 mmHg. During the testings, blood flow (BF), blood pressure (BP), oxygen saturation (SpO2), and muscle mechanic properties (stiffness; SF, and frequency; FQ) were measured. For statistical analysis, two-way repeated-measures ANOVA was performed, when an interaction effect was found, a one-way analysis of variance was used to perform post-hoc verification.

RESULTS: When the 1-minute interval recovery period of BF was analyzed, there was an increase in HT. SpO2 was higher in LT at 5 and 15 minutes of recovery. SF was high in LT from immediately after 2 sets of an exercise to 15 minutes after recovery. FQ was high at RT from immediately after 3 sets of an exercise to 15 minutes after recovery. During blood flow restriction, systolic blood pressure immediately after exercise showed high in NBFR. The interaction effect was found in FQ after exercise ($F=7.909$, $P=.006$) and after 5 minutes of recovery ($F=22.729$, $P=.003$). After exercise, RT+NBFR (14.4 ± 1.0 Hz) showed statistical significance compared to RT+BFR (12.5 ± 1.2 Hz, $P<.008$), HT+BFR (12.1 ± 0.9 Hz, $P<.001$) and HT+NBFR (12.7 ± 1.5 Hz, $P<.020$). HT+BFR showed a statistical difference from LT+NBFR (1.36 ± 1.5 Hz, $P<.025$). Five minutes after recovery, HT+BFR (11.2 ± 0.6 Hz) showed statistical differences compared to RT+BFR (12.9 ± 0.9 Hz, $P<.018$) and RT+NBFR (13.1 ± 1.3 Hz, $P<.010$).

CONCLUSION: There was no difference in BF, BP, SpO2, and SF when blood flow restriction and resistance exercise was performed under environmental stress. An interaction was found in FQ, which was positively correlated with the level of muscle contraction. This means that when performing resistance exercise while restricting blood flow, the contractility of muscles can be affected depending on environmental conditions.

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## EFFECTS OF INTERMITTENT, CONTINUOUS AND MIXED RUNNING EXERCISE ON FEMORAL BONE QUALITY PARAMETERS IN RATS

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INTRODUCTION: It is now well established that physical exercise is an effective preventive means to reduce and treat certain chronic diseases, particularly musculoskeletal disorders. At the bone level, running exercise is well known for its positive effect on the different parameters of bone quality. However, there is no consensus regarding the effects of different running exercise modalities studied in the literature.

Thus, the objective of this study was to compare, for the first time, the effects of three treadmill exercise modalities: intermittent, continuous, and mixed exercise on bone quality parameters in rats.

METHODS: Thirty-nine male Wistar rats (5 weeks old) were randomly divided in 4 groups: sedentary control (SED; n=10), intermittent exercise group (IE; n=10), continuous exercise group (CE; n=10) and mixed exercise group (ME; n=9). Exercise groups rats were exercised 5 days/week, for 8 consecutive weeks. Femoral micro-architectural parameters were assessed by micro-CT, femoral bone remodeling parameters (osteocyte apoptosis and osteoclast resorption) and bone histomorphometry were assessed by histological analysis.

RESULTS: Femoral trabecular thickness was increased in the mixed exercise group compared to the other exercise groups ($p<0.0001$). the cortical thickness, the osteocyte lacunae occupancy rate, the number of apoptotic osteocyte lacunae and the osteoclastic resorption surface were not significantly different between the groups. Statistical differences are occasionally noted depending on the anatomical region treated of the femur.

CONCLUSION: These results suggest that, the adaptive bone responses differ according to the exercise modality performed and that mixed exercise seems to have more effect on bone trabecular microarchitecture.

### CHANGES IN SKIN ADVANCED GLYCATION END-PRODUCTS VALUES OF UNIVERSITY STUDENTS IN FITNESS & SPORTS CLASSES

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INTRODUCTION: Advanced glycation end-products (AGEs) are harmful compounds formed through an excess of protein and sugar in the human body. Excessive accumulation of AGEs has been reported to accelerate the aging process and contribute to diseases such as arteriosclerosis and diabetes. In addition, the accumulated amount of skin advanced glycation end-products (AGEs) is likely to be affected by lifestyle-related habits, including diet and exercise. Therefore, we measured AGEs in the Fitness & Sports class, which is a part of general education subjects at the university. Lectures on exercise and sports activity practices and meals were given during the first and second half of the period. Changes in the AGEs value were recorded. Accordingly, we decided to examine whether AGEs measurement can be employed as an indicator to measure health.

METHODS: Participants included 51 healthy female students who were enrolled in Tokyo universities. Classes of 100 minutes per week lasting 14 weeks from April to July 2021 were conducted. The survey, which was conducted during the second and 14th week, targeted the practical content of two classes: Walking & Fitness (Class A) and Badminton, Soft Volleyball (Class B). In addition, regular body composition measurements, including body weight and fat percentage, were conducted along with lectures on diet when needed. The participants learned the effects of exercise and diet on the body during the classes. A diagnostic tool called the TruAge scanner was used to measure AGE levels by measuring the amount of AGEs accumulated on the skin.

RESULTS: The value of the April AGEs for female college students in the Fitness & Sports class decreased by −5.82% compared with that of the July AGEs. While the decrease in Class A was −5.64%, the decrease in Class B was −4.80%. Although there was no significant difference between the two classes, the AGE value of Class A, which comprised mainly of aerobics, decreased further in the second measurement.

CONCLUSION: Even if the students had attended only Fitness & Exercise once a week, it had a positive effect on reducing the skin AGEs level for students who did not exercise daily. Furthermore, their awareness of exercise and dietary intake had a positive effect on the students.

### IMPACT OF 14 DAYS OF A MICROGRAVITY ANALOG AND AN EXERCISE COUNTERMEASURE ON LOWER LIMB STRENGTH AND ELECTROMYOGRAPHIC ACTIVITY

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INTRODUCTION: The microgravity context that astronauts experience leads to a significant decrease in the load applied to the body and results in muscular underuse. During prolonged exposure to microgravity, a considerable loss of muscular strength is observed, especially in the lower limbs. This loss is a major threat to the autonomy of astronauts and could be a survival matter in an emergency context. While muscular atrophy is the most evoked mechanism, the loss of strength precedes and exceeds the rate of atrophy which suggests the contribution of other mechanisms. Among them, the deterioration of the neuromuscular junction could explain the latency between atrophy and loss of strength, but the literature is scarce on the potential mechanisms involved in strength and muscle loss during microgravity. Objectives: The first objective was to verify how two weeks of head-down bed rest (HDBR) – the most widely used microgravity analog – influences lower limbs' strength and neuromuscular activity. As these deteriorations are usually secondary to muscle underuse, the second objective was to verify if an exercise program can prevent the deterioration of strength and neuromuscular activity.

METHODS: Maximal voluntary contraction strength (MVC) of the quadriceps will be measured in 24 participants (aged 55-65; 50% women) with isometric knee extension on a dynamometer (Biodex, System 3). Participants will then perform a contraction at 25% of MVC during which surface and intramuscular EMG signals will be recorded. In addition, the amplitude and area of the compound muscle action potential will be determined by stimulating the femoral nerve. These tests will allow the estimation of motor units number, their size, and the stability of the neuromotor junction. Participants will then be exposed to 14 days of HDBR after which all tests will be repeated. During HDBR, half of participants will be engaged in one hour of training per day comprising muscular and cardiovascular exercises, while the other half will be subjected to passive mobilization by a physical therapist. Following a 7-day recovery period, participants will return to their daily activities and follow-ups will be conducted 4 weeks and 4 months after leaving the facility to verify if any changes persist.

RESULTS: Data collection is ongoing but preliminary results suggest that one hour of daily exercise is not sufficient to mediate the loss of muscle strength induced by 14 days of HDBR. An ambulatory period of 4 weeks following HDBR does not appear to be sufficient to restore strength and neuromotor junction, whereas 4 months do. Neuromotor activity is under analysis and the complete results will be presented at ECSS 2022.

CONCLUSION: The benefits of this project are very relevant for the space sector and the medical field, especially in the context of older adults who are bedridden for long periods.

### EFFECTS OF ELECTRICAL STIMULATIONS AT DIFFERENT FREQUENCIES ON THE STRUCTURE OF TIBIAL ARTICULAR CARTILAGE IN HINDLIMB-SUSPENDED RATS

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INTRODUCTION: [Background] Osteoarthritis (OA) is a disease in which articular cartilage is reduced due to aging, loss of muscle volume, obesity, etc. and causes pain. OA progresses over time and is divided into three stages (early, middle, and late).It is thought that it is important for OA to early treat of OA is important for the reason why a repair of the degenerative knee joint is difficult.Currently, exercise and electrical stimulation are also used as therapies for the early treatment of OA.However, it has also been reported that exercise therapy increases pain levels due to the excessive load on the joints of the elderly.Therefore, Recently, a treatment method using a vector potential (VP) has been developed and is drawing attention.We have already found and reported that the articular cartilage thickness is maintained in rats in which the articular cartilage degeneration is caused by hindlimb suspension, by a new electrical stimulation method using vector potential. However, the effect is due to the electrical stimulation at a specific frequency, and it has not been clarified how the difference in frequency has an effect on the maintenance of articular cartilage.[Purpose]

This study aimed to morphologically investigate the effect of electrical stimulations of different frequency on the structural changes of tibial articular cartilage that was caused by mechanical unloading in rats.

METHODS: Twenty male rats (wistar strain, 7-week-old) were used as materials and they were divided into HS, VP and CO. Moreover, VP was subdivided, by frequency, into VP2（2KHz）、VP20（20KHz）and VP200（200KHz).CO was normally bred in the cage for 3 weeks. Tails of HS, VP2, VP20 and VP200 were suspended in cages for 3 weeks.The electrical stimulation was accomplished under anesthesia using a VP generator (Sumida Denki Co., Ltd.). The conditions of electrical stimulation of VP were AC, 67mV, 0.13mA, 2㎑, 20㎑, and 200㎑, and were set to 30 minutes /day, 5 days /week.

After the experimental period, the tibia in each group was excised and was analyzed histologically.

RESULTS: Thick trabecular bones were densely present in CO, but they were thin in HS, as observing those bones of the epiphyseal cancellous bone.

The trabecula bones gradually increased from VP2KHz to VP200, and the trabecular bone in VP20 and VP200 was thick and dense, and they were near that in CO.

As regards the articular cartilage, tidemark in HS elevated significantly than CO. On the other hand, the same change wasn't recognized in VP and the thickness of an uncalcified layer was maintained.

CONCLUSION: [Discussion] The tidemark elevated and the thickness of the calcified layer of the articular cartilage increased.However, in the VP the thickness of the unmineralized layer of the articular cartilage was maintained. It seems that the maintenance of the thickness of the uncalcified layer in VP is related to the suppression of the elevation of tidemark. [Conclusions]It was suggested that the decrease in articular cartilage thickness caused by redu

**VOLUNTARY EXERCISE ENHANCES OVA-SPECIFIC IGE ANTIBODY PRODUCTION BY OVA EPICUTANEOUS EXPOSURE IN MICE.**

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INTRODUCTION: The number of patients with food allergies continues to rise, especially among infants. Recently, it has been reported that allergen hypersensitivity, the cause of food allergy, may be induced by dermal exposure to allergens. Although it is well known that exercise affects immune function, the effect of exercise on dermal exposure to allergens remains unclear. Therefore, the present study examined the effect of voluntary exercise on the acquisition of allergen hypersensitivity induced by allergen transdermal exposure.

METHODS: Six-week-old male BALB/c mice were divided into sedentary and exercise groups and reared individually for the experiment. Mice in the exercise group were placed on a running wheel in the rearing cage and exercised until the end of the experimental period, and the number of counts of wheel running and body weight during this period were measured. Two weeks after the start of exercise, mice including those in the sedentary group were exposed to OVA percutaneously. Briefly, the backs of mice shaved with clippers were coated with 4% SDS solution and 300μg OVA was added. Three weeks after final epicutaneous exposure with OVA, blood samples were taken and the concentration of OVA-specific IgE in serum was measured by ELISA. All experiments were performed with the approval of the Animal Experimentation Committee of the Kurashiki University of Science and the Arts.

RESULTS: In this study, body weight was significantly lower in the exercise group than in the sedentary group until epicutaneous exposure with OVA ($p<0.05$), but this difference disappeared during the second week of transdermal OVA administration, and no significant difference was observed between the two groups thereafter. In contrast, the OVA-specific IgE concentration in blood was significantly higher in the exercise group than in the sedentary group ($p<0.01$).

CONCLUSION: Our study suggests that voluntary exercise during the OVA epicutaneous exposure may enhance the response to OVA and increase the production of OVA-specific IgE antibodies. These findings might suggest that exercise may increase allergen hypersensitivity due to dermal exposure under certain conditions.

**EXERCISE-INDUCED CARDIAC ADAPTIONS IN RHEUMATOID ARTHRITIS DURING INTERLEUKIN-6 VS. TUMOR NECROSIS FACTOR ANTIBODY THERAPY: PROTOCOL FOR A RANDOMISED CONTROLLED TRIAL**

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INTRODUCTION: Rheumatoid arthritis (RA) is a chronic autoimmune disease characterized by a systemic inflammation which is believed to mediate a 2-3 fold increased cardiovascular risk in patients with RA independent of conventional risk factors. The worldwide prevalence is estimated to 1%. The pro-inflammatory cascade is largely driven by the cytokine tumor necrosis factor (TNF) and interleukin-6 (IL-6) by a variety of cells. The inflammatory state is thought to play a key role for the increased cardiovascular risk. Consequently, disease-modifying therapy targeting TNF or its downstream cytokine IL-6, may attenuate the risk of cardiovascular disease.

IL-6 is a pleiotropic cytokine that is released from exercising skeletal muscle, acting as a myokine. In contrast to the TNF-mediated overexpression of IL-6 in the pro-inflammatory response, the exercise-induced release of IL-6 is stimulated by TNF-independent mechanisms, suppresses the production of TNF, and regulates both cardiac and metabolic adaptations to exercise training. As the effects of exercise may mitigate the overall cardiovascular risks in RA patients, knowledge of IL-6 and its role in exercise-induced adaptions is called for. Here, we introduce a novel RCT study that compare the two most frequent type of biological treatments, TNF inhibition and IL-6 blockade, and their effect on exercise adaptions in RA patients.

METHODS: RA patients treated with IL-6 blockade or TNF inhibitors are included in a 12-week randomized investigator-blinded high intensity interval training study (n=80). Patients are stratified for medical treatment and sex and allocated 1:1 to the exercise or control (no exercise) group. Patients will be encouraged not to change eating or physical activity habits during the study. Baseline and followup analysis are identical and include: cardiac MRI, abdominal MRI, transthoracic echochardiography, oral glucose tolerance test, questionnaries, and VO2max test.

RESULTS: The primary outcome is the difference in changes of the left ventricular mass (g) assessed by state-of-the-art methodology; cardiac magnetic resonance scan. Secondy outcomes include difference in changes of visceral mass (g), cardiac structural and functional changes and RA disease specific outcomes.

CONCLUSION: We hypothesize that IL-6 signaling regulates exercise-induced cardiac and metabolic adaptions and therefore pharmacological blockage of IL-6, but not pharmalogical inhibition of TNF, impairs exercise-induced adaptions, namely structural changes in cardiac ventricular mass and changes in viseral fat mass.

As biological treatments in RA patients are ever evolving, novel RCT studies that explore their potential limitating effects on exercise is called for.

### EFFECT OF FATIGUE GENERATED BY EFFORT ON REACTION TIME.

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INTRODUCTION: The simple reaction time (SRT), the minimal time needed to respond to stimuli is a physiological response toward a neutral sense stimulus. The aim of the presented study was to estimate the changes in simple reaction time (RT) in fatigue conditions induced by two efforts of a different nature.

METHODS: Twenty participants performed an incremental test (INC) to volitional exhaust for fitness level and VO2max estimation. The 40-min effort (LE) with the intensity of 80% VO2max was performed for fatigue elicitation. Respiratory parameters were measured breath-by-breath (K4b2, Cosmed, Italy). Participants performed a simple RT task before (pre-test) and follows the 5 min of recovery (post-test) for incremental and 40-min effort. Visual: red, orange, green light, and auditory: one sound, stimuli were given in random order. The mean value of reaction time was calculated excluding the first and last values and separately for each type of stimuli (3 colors and a sound). Blood was collected for estimation of lactate concentration (Dr Lange Küvettentest, LKM 140, Germany) and venous blood was collected to determine the concentration of selected neurotransmitters (ELISA Test Demeditec Diagnostics GmbH Germany).

RESULTS: VO2max in the incremental test was 53.79 ± 4.52 ml/kg/min. Lactate concentrations in the blood reach 9.25 ± 2.77 and 4.25 ± 1,2 [mmol] for INC and LE respectively. The concentration of neurotransmitters: Adrenaline, Noradrenaline and Dopamine in plasma, and Serotonin in serum increased significantly as a result of both efforts ($p<0.05$). Independently on effort performed, the direction of alteration in reaction time was the same and showed a decrease. There were no differences in RT in pre-test measurement while the significant effect of conducted efforts on simple RT was noted (INC, P=0.04; LE, P=0.003 respectively). Significant decrease in RT for red and orange light after INC (P=0.05 and P=0.003) and LE (P=0.02, P=0.04), and sound stimuli after LE (P=0.03) effort were noted.

CONCLUSION: We expected a return to the rest or longer reaction time after the efforts made. Five minutes after the tests, reaction times were still shorter than at rest. Interestingly, the most noticeable reduction in reaction time was noted for red and orange stimuli, but not for green. The increase of neurotransmitters in plasma and serum indicates the development of fatigue, although not translated into a decline of SRT directly after the efforts. It may be that 5 min after the effort the excitation of the nervous system enables a faster reaction and biochemical changes caused by exercise precede fatigue, which is manifested in the function of the nervous system.

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### DO THE EFFECTS OF DEVELOPMENTAL TRAINING IN SKELETAL MUSCLE PERSIST INTO OLD AGE?

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INTRODUCTION: It is known that exercise is effective in preventing muscle weakness that occurs during aging. On the other hand, it is not clear how training during the developmental period affects muscle function decline in the subsequent old age. We reported that the training conducted during the developmental period suppressed the regression change of the neuromuscular junction in the subsequent old age and maintained the fatigue tolerance of the muscle. Therefore, we examined the sustainability of the effect of developmental training on skeletal muscle endurance in old age from the viewpoint of oxidative metabolic capacity in the muscle.

METHODS: Fischer344 strain female rats were experimental animals. The Experimental muscles were PLA and EDL. Rats were divided: the group developmental training(T), the group subjected to normal rearing until 66 weeks of age(AC), after developmental training (DT), and the group retraining from 54 weeks of age after developmental training (RT). Developmental training consisted of intermittent running on a treadmill for animals. Training from old age consisted of running using forced exercise wheels (co. MELQUEST). ATPase and SDH staining were used to examine changes in muscle fiber type composition ratio and oxidative metabolism. Tissue images were observed with a light microscope and analyzed with ImageJ software. SDH activity is indicated by optical density (OD / min).＜RESULT＞ In AC group, Type I occupancy rate, the area occupancy rate (%area) by muscle fiber type increased significantly in PLA, and the number ratio (%no) by muscle fiber type increased significantly in EDL. Significantly higher values were shown in the DT and RT group. There was no difference in OD showing SDH activity.

RESULTS: The SDH activity, which is an index of muscle endurance, did not show any effect. In the muscle fiber type composition ratio, %area of EDL and the %no of PLA showed high values for Type I in the AC group. Aging-related slowing was observed. At a young age, type transfer is unlikely to occur between Type I and Type II. However, it has been reported that in old age, regressive changes in the neuromuscular junction and denervation cause transition between Type I and Type II. De-training and Re-training were not different from those in the young group. It is suggested that the age-related changes due to training were suppressed. Muscle fibers that are identified as IIb-FOG or Type IId are fast type but have high oxidative ability. Therefore, the increase in IIb-FOG may be that increased the muscle endurance of the training group.

CONCLUSION: From the results of this study, it can be expected that developmental training suppresses changes in histological characteristics associated with aging. In particular, it inhibits the transition to slow muscle fiber type. It is suggested that the training effect during the development period can be maintained for a long period of time.

### EFFECT OF GLUCOSE DELIVERY ON ADIPOGENESIS OF HUMAN MSCS EXPOSED TO A COMBINED MECHANICAL AND HYPOXIC STIMULUS

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INTRODUCTION: Effect of hypoxia on substrate use could be relevant to know the nutritional requirements for exposed hypoxia population. Since the oxygen requirement of ATP synthesis is greater during fatty acid oxidation than glucose oxidation, a switch in substrate preference away from fatty acids represents a possible mechanism of adaptation to hypoxia (Braun 2008). There is strong evidence that in hypoxia the transcription of genes related to membrane transport of glucose (GLUT-4) and glycolysis (Semenza 2003), density of lactate transporters and lactate dehydrogenase (McClelland and Brooks 2002) are up-regulated. HIF pathway also increases the expression of pyruvate dehydrogenase kinase 1 (PDK1) contributing to the suppression of oxidative metabolism (Murray et al. 2018).

However, when the hypoxic stimulus is combined with elevated basal metabolism (mechanical stimulus, as consequences of exercise), the energy deficit can obscure the effects of ‘‘true’’ hypoxia suggests that it is a more potent metabolic stimulus (Braun 2008). On the other

hand, the caloric restriction at altitude dampens the rise in blood glucose availability normally experienced at increased elevations (Barnholt et al. 2006). Lower blood glucose concentrations contribute to a shift in substrate selection from carbohydrate to alternate fuel sources such as fat or ketones to support energy needs. However, a reduction in lipid dependence at altitude has been noted when the subjects develop controlled diet in altitude (Roberts et al. 1996).

Taken together, these data could provide key insights that inform practical recommendations for nutrition at altitude (Braun 2008). There is a lack of knowledge in the scientific literature about predominant metabolic pathways when combining a mechanical and hypoxic stimulus with increased or decreased energy intake. Moreover, the physiological mechanisms are not described. Thus, the aim of this study is to know how the combination of agitation and intermittent hypoxia during adipogenesis, with a greater or lesser supply of nutrients, could influence on the capacity of these cells to generate fat vesicles.

METHODS: Cultures of human mesenchymal stem-cells of bone marrow were induced to adipocytes and exposed 4 days per week to agitation and hypoxia (1 or 2 hours per days). The culture medium was changed twice a week for part of the cultures and three times a week for the other part. Expression of adipogenic genes as well as fat vesicle formation were studied

RESULTS: In adipocyte where the culture medium was changed 2 days a week, subjected to hypoxia and agitation (both 1d/4w and 2h-4d/w), lower levels of fat vesicles were observed compared to the control group. However, the amount of fat was higher when the culture medium was changed 3 days per week.

CONCLUSION: Hypoxia training combined with a controlled diet may improve body composition through loss of fat mass.

**EFFECT OF TRAINING PHASE ON 8OHDG WITH MENSTRUAL CYCLE IN FEMALE ATHLETES**

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INTRODUCTION: The Menstrual cycle influences change physical and psychological condition and performance in female athletes.

Previous studies have reported that increased stress and anxiety during the luteal and menstrual phases, as well as decreased agility performance, endurance performance, intermittent endurance performance.

8-hydroxy-2-deoxy-guanosine (8OHdG) excreted into the urine is a marker of oxidative stress, and it has been reported to be associated with fatigue, psychological stress, and exercise. It has also been reported that 8OHdG changes with the menstrual cycle. However, it is unclear how the training phase (competitive phase, preparation phase, transition phase) influences 8OHdG with the menstrual cycle in female athletes.

Thus, the purpose of this study was to investigate the effect of training phase on the 8OHdG with menstrual cycle in female athletes.

METHODS: 17 female competitive collegiate athletes participated in this study. We conducted the measurements during competitive phase and preparation phase of menstrual phase, follicular phase and luteal phase. Subjects were taken their urine on the day of measurement. First morning urine sample was collected. The 8OHdG concentration was measured using enzyme-linked immunosorbent assay.

RESULTS: The urinary 8OHdG concentration was significantly higher during competitive phase than during preparation phase ($P<0.05$). However, the urinary 8OHdG concentration did not show significant change with menstrual cycle. 2-way ANOVA was used to determine the effect of training phase on the urinary 8OHdG changes with menstrual cycle, and no interaction was found, but there was a main effect of training phase ($p<0.05$).

CONCLUSION: The results of this study showed that the urinary 8OHdG level with training phase but not with menstrual cycle. There was also no effect of training phase on the 8OHdG with menstrual cycle in female athletes.

**HEAT STRESS AMPLIFIES METABOLOMIC PERTURBATIONS INDUCED BY EXERCISE**

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INTRODUCTION: During endurance exercise, environmental heat stress induces greater carbohydrate (CHO) oxidation and is characterised by increased respiratory exchange ratio, relative hyperglycaemia and accelerated muscle glycogenolytic rate (Febbraio, 2001). Using untargeted metabolomics, we aimed to characterise the effect of environmental heat stress during exercise on the human serum metabolome.

METHODS: Twenty-three trained male triathletes ($VO_2peak$ = 64.8 ± 9.2 mL·kg·min-1, 332 ± 45 W) completed fixed duration (30 min) maximal exercise tests in Hot (35°C) and Temperate (Temp) (21°C) conditions. Power output (PO), heart rate (HR), core body temperature (Trec) and Rating of perceived exertion (RPE) were recorded throughout. Venous blood samples collected immediately pre- and post-exercise were assessed by untargeted 1H-NMR metabolomics in accordance with best practice set out by the metabolomics standards initiative (Sumner et al. 2007). Data were analysed via uni- (P values corrected for multiple tests by FDR) and multi-variate analyses to identify differences between conditions.

RESULTS: Mean PO was higher in Temp (231 ± 36 W) vs. Hot (223 ± 31 W) ($P < 0.001$). Mean HR (Temp = 162 ± 10 beats·min-1, Hot = 167 ± 9 beats·min-1, $P < 0.001$), peak Trec, ΔTrec ($P < 0.001$) and peak RPE ($P = 0.005$) were higher in Hot vs. Temp. Metabolite abundance (Δabundance) was analysed from pre- to post-exercise with Principal Component Analysis revealing distinct clustering per condition and partial least squares discriminant analysis accentuating variance between conditions. Ten metabolites critically important for distinction between conditions were identified. Six metabolites saw greater increase (2-Hydroxyvaleric Acid, Acetate, Alanine, Glucarate, Glucose, Lactate) in Hot than Temp ($P < 0.05$). Leucine and Lysine decreased in both conditions but to a greater extent in Temp ($P < 0.05$). Citrate ($P = 0.04$) was greater in Temp whilst Creatinine decreased in Hot only ($P > 0.05$).

CONCLUSION: Environmental heat stress poses a serious threat to endurance exercise capacity reducing workload and increasing physiological strain. Consistent with current literature, we have shown increased lactate accumulation and relative hyperglycaemia in response to exercise in hot conditions. Increased glycolytic metabolites in Hot with a concomitant increase in citrate in Temp indicates greater contribution of glycolytic CHO metabolism under heat stress. Furthermore, we have highlighted additional important metabolites including essential amino acids which increased during exercise in temperate conditions, highlighting environmental variation in protein metabolism.

### CHANGES IN CENTRAL ARTERIAL STIFFNESS AFTER THE FIRST VERSUS SECOND BOUT OF ECCENTRIC EXERCISE OF THE ELBOW FLEXORS

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INTRODUCTION: Resistance exercise training increases muscle volume and function. Eccentric resistance exercise (ECC) is effective for muscle hypertrophy and strength gain and improves metabolic function, but unaccustomed ECC induces muscle damage. Muscle damage is a factor for the delayed increase in central arterial stiffness, which is an independent risk factor for cardiovascular disease (1). However, the relationship between the magnitude of muscle damage and the change in arterial stiffness is not clear. The magnitude of ECC-induced muscle damage is significantly reduced after the second bout of the same exercise, which is termed as the "repeated bout effect" (RBE) (2). Therefore, the present study compared between the first and second bouts of ECC for changes in arterial stiffness to test the hypothesis that arterial stiffness would increase greater after the first than the second ECC bout.

METHODS: Eleven healthy, untrained young men (22.6±1.8 y) who were normotensive (< 140/90 mmHg) and non-obese were recruited. They performed two bouts of ECC of the elbow flexors consisting of 6 sets of 10 eccentric contractions for each arm using a dumbbell set at 80% of one-repetition maximum strength separated by 2 weeks. Carotid-femoral pulse wave velocity (cfPWV), an index of central arterial stiffness, and some indirect markers of muscle damage such as maximal voluntary isometric contraction torque (MVC), muscle soreness, serum creatine kinase (CK) activity and high sensitivity C-reactive protein concentration (hsCRP) were measured before and 1, 24, 48, 72 hours after the exercise. Changes in these variables were compared between bouts by two-way repeated measures ANOVA (MVC, cfPWV), and Kruskal-Wallis and Mann–Whitney U test (muscle soreness, CK and hsCRP).

RESULTS: Decreases in MVC were greater ($P<0.05$) after the first (e.g., 24 h post-exercise: -59.0±12.0%) than the second bout (-20.0±10.6%). Muscle soreness developed greater after the first (peak: 25.9±32.9 mm in a 100-mm scale) than the second bout (6.8±8.8 mm). CK activity increased larger ($P<0.05$) after the first (peak: 26,341±24,809 IU/L) than the second bout (206±87 IU/L), but hsCRP concentration did not change significantly after both bouts. A significant ($P<0.05$) increase in cfPWV from the baseline (789.8±105.6 cm/s) was observed at 48 h after the first bout (824.1±103.9 cm/s), but no significant changes were evident after the second bout. The magnitude of increase in cfPWV was not correlated with the magnitude of changes in any of the muscle damage markers (r=-0.01–0.71).

CONCLUSION: The smaller changes in the muscle damage markers after the second than the first bout indicate typical RBF. The RBE was also evident for cfPWV, which increased 4.5±4.4% at 48 h after the first bout but unchanged after the second bout. These suggest that central arterial stiffness increases when muscle damage is induced by ECC.

(1) Barnes et al. J Appl Physiol. 2010.

(2) Hyldahl et al. Exerc Sport Sci Rev. 2017.

## Physiotherapy

### RUMBA DANCE COMBINED WITH BREATHING TRAINING AS AN EXERCISE INTERVENTION ON IMPROVING STRESS URINARY INCONTINENCE IN POSTMENOPAUSAL WOMEN

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INTRODUCTION: Stress Urinary Incontinence (SUI) refers to involuntary leakage from the urethra, synchronous with exertion/effort, sneezing or coughing, which is common among postmenopausal women and has a negative effect on quality of life. Due to the limitations of existing clinical treatments for SUI, Clinicians and Physiotherapists are interested in complementary strategies for managing the symptoms. Studies have shown that mild-to-moderate physical activities reduce the risk of SUI by multiple mechanisms, such as reducing obesity and slow the reduction of estrogen levels. Therefore the objective of this study is to determine whether the Rumba dance combined with breathing training (RDBT) can reduce the severity of incontinence and improve the quality of life of patients with SUI.

METHODS: Randomized clinical trial involving sedentary postmenopausal women who reported mild to moderate SUI on 1-hour pad test, the volunteers were not already engaged in Rumba dance and not received estrogen replacement therapy. The patients were randomly assigned to RDBT group(N=14) and control group(N=11), The intervention included 90 minutes of RDBT three times a week for 16 weeks, the vaginal resting pressure(VRS), pelvic floor muscle(PFM) strength and endurance, 1-hour pad test, International Consultation on Incontinence Questionnaire-urinary incontinence short form (ICIQ-UI-SF) , quality-of-life questionnaire(QOL) were measured at baseline and 16 weeks. None of the participants reported adverse events.

RESULTS: The mean (+/-SD) age of the participants was 54.75±6.40 years. After 16 weeks, in the RDBT group, the VRS increased from 76.00±16.23cmH2O to 95.09±18.90cmH2O ($P<0.01$). The grade of PFM strength of class Ⅰ (2.77±2.01 VS 4.23±0.83, $P<0.01$)and class Ⅱ (2.62±2.26 VS 4.38±0.77, $P<0.01$) were both enhanced, and the PFM endurance of class Ⅰ (-3.15±1.99% VS -0.46%±0.97, $P<0.01$) and class Ⅱ (-0.69±0.95% VS -0.23±0.44%, $P<0.01$)were increased respectively. The urine leakage on 1-hour pad test were significantly decreased from 3.91±3.61g to 1.88±1.78g ($P<0.01$). Finally, the severity of self-reported (ICIQ-UI-SF) significantly reduced from the score of 6.12±2.15 to 3.81±1.68 ($P<0.01$), and the quality of life (QOL) improved from scores of 75.73±11.93 to 83.48±7.88($P<0.01$).

CONCLUSION: A 16-week RDBT program can increase the PFM strength and endurance to reduce the severity of incontinence symptoms and improve the quality of life in patients with SUI, demonstrating the feasibility of recruiting and retaining postmenopausal women with SUI into a RDBT therapeutic program.

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## Psychology

### COACH INTERPERSONAL STYLE, COMPETENCE AND MOTIVATION IN HIGH PERFORMANCE ATHLETES

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The self-determination theory (SDT; Deci and Ryan, 1985; Ryan and Deci, 2000) postulates that the motivational climate created by the coach is related to the motivation of athletes via the satisfaction of their psychological needs (Reinboth, Duda and Ntoumanis, 2004). The purpose of this study was to analyze the association between the interpersonal styles that athletes perceive the coach to generate (ie autonomy support, and controlling style), the competence need (satisfaction and frustration), and motivational regulations in high performance sport. A set of questionnaires was administered to 239 high performance athletes (117 woman, 122 man) with a mean age of 23.37 years (SD = 5.7) who participated in a variety of sports. The bivariate correlation results showed that the autonomy support style was positively associated with the competence perception ($r = .24$, $p < .01$, but not with frustration of competence). While the controlling style was negatively associated with the perception of competence ($r = -.13$, $p < .05$) and positively associated with the frustration of competence ($r = .27$, $p < .01$). The satisfaction of competence was associated positively with autonomous motivation ($r = .24$, $p < .01$) and negatively with controlled motivation ($r = -.21$, $p < .01$). The frustration of competence was related positively with controlled motivation ($r = .21$, $p < .01$) and amotivation ($r = . 20$, $p < .01$). In conclusion, this work partially supports the postulates of SDT within high-performance sports.

### IMPACT OF THE COVID-19 PANDEMIC ON ATHLETES BELONGING TO THE JAPAN PROFESSIONAL FOOTBALL LEAGUE

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Introduction

The coronavirus disease of 2019 (COVID-19) pandemic has led to dramatic changes in the sports environment (Grix, Brannagan, Grimes, & Neville, 2021). The changes in the sports environment have impacted psychologically on athletes.

Methods

To clarify these psychological changes, a survey was conducted of 29 athletes belonging to a single Japanese Professional Football League (J-League) team. This measured the participants' motivation using the Sport Motivation Scale Questionnaire (SMS), and self-efficacy using the Psychological Performance SE Scale (SE) for a football season before and after the onset of the pandemic.

Results

A comparison of the participants' SMS (2019 = 73 points; 2020 = 69 points) and SE (2019 = 88 points; 2020 = 83 points) scores before and after the start of the pandemic, using the t-test, indicated a declining trend in both the motivation and self-efficacy of athletes for the 2020 season. No significant difference was found (SE: $t(28)=1.29$, $p=0.21$, SMS: $t(28)=1.50$, $p=0.15$). However, changes in individual players were evident. Seven athletes indicated a drop of more than 5% in their SMS scores for the 2020 season, with a further three athletes showing an increase of more than 5%. Regarding SE scores, five players displayed a drop of more than 5% for the 2020 season, with three athletes showing an increase of more than 5%.

Discussion

These results indicate that the pandemic may have had a negative psychological impact on the motivation and self-efficacy of these athletes. However, individual differences were found in athletes' responses to the crisis. Therefore, it is necessary to further examine the underlying factors behind the psychological changes observed in athletes during this period.

This work was supported by Individual Special Research Subsidy (Kwansei Gakuin University, 2020).

### INTERNATIONAL PILOT STUDY PARTICIPATION MOTIVATION IN IRANIAN STUDENTS

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International pilot study participation motivation in Iranian students

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Introduction

Motivation is the force that causes movement in humans. In fact, any agent that causes (internal or external) activity in a living being is considered as a kind of motivation. According to the Motivation is the driver of guidance, control, and persistence in human behavior. Therefore, it is important to know the motivation for students participation in physical activities.

Methods

The sample consists of 50 Iranian female students aged 13 and 14 years old who filled out participation motivation questionnaires online in a pilot test. The Participation Motivation Questionnaire (PMQ) was designed by Gill, Gross, and Huddleston in 1983. This questionnaire consists of thirty questions and originally included eight possible factors that describe the possible reasons for participation in sport on a 5-point Likert scale (not at all important= 1 to extremely important= 5). The factor structure of the PMQ has been variable in prior research studies and so exploratory factor analysis was performed on the data.

Results

According to the varimax rotation, there were 7 factors. They consist of belonging to friends, team orientation, competition/ excitement, important people, fame/status, skill development, energy release. Intrinsic motivation factors included skill development, energy release, team orientation, and belonging to friends and extrinsic motivation factors included prestige/status, important people, and competition/excitement. Descriptive statistics indicated that the students most important motives for participating in physical activity were skill development, team orientation, and energy release.

Discussion

Findings of this pilot test showed that there are 7 factors for this questionnaire among Iranian students. Our finding is supported by Shafizadehs (2007) result. The results also showed that intrinsic motivation factors were the most important reason for students

participation in physical activity, which is in line with Yildirims (2021), Ignatova et al.s (2017), Zahariadis & Biddles (2000). In conclusion, a different approach should be considered in order to motivate adolescents, as intrinsic motivation (e.g. I want to participate) is more adoptable in this age group, rather than extrinsic motivation (e.g. I must participate).

Keywords: Motivation, Participation Motivation Questionnaire (PMQ), Iranian students

References

Yildirim, M. (2021). Investigation of Sports Participation Motivations of Physical Education
and Sports School Students. International Education Studies; Vol. 14, No. 8; 2021. ISSN 1913-9020 E-ISSN 1913-9039

Ignatova et al. (2017). Motives of students for participation in sport activities. Research in Kinesiology. 2017, Vol. 45, No. 1, pp. 82-84

Zahariadis, P. N. and Biddle S. J. H. (2000). Goal orientations and participation motives in physical education and sport: their relationships in English school children. Athletic Insight: The Online Journal of Sport Psychology.

## THE MEDIATING ROLE OF EMOTIONAL SYMPTOMS IN THE ASSOCIATION BETWEEN FITNESS AND ACADEMIC PERFORMANCE: DADOS STUDY

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The positive association between fitness and academic performance has been previously documented in adolescent population. Nevertheless, the mechanisms that may be behind this association need further exploration. Emotional symptoms could play an interesting role, since their presence has been negatively related with fitness and academic performance. Thus, the main aim of this study was to analyze the mediating role of the emotional symptoms in the association between physical fitness components and academic performance in a sample of adolescents. A total of 264 adolescents (126 girls) aged 13.9±0.3 years old and participants of the DADOS (Deporte, ADOlescencia y Salud) study were included in the analyses. Physical fitness components were assessed through the handgrip test for upper-limb muscular strength, standing long jump for lower-limb muscular strength, 4x10-m shuttle run test for speed-agility, and 20-m shuttle run test for cardiorespiratory fitness. The emotional symptoms index was evaluated through the Behavior Assessment System for Children and Adolescents. Academic performance was assessed by the final academic grades of math, language, and overall grade point average. Boot-strapped mediation procedures were performed and indirect effects with confidence intervals not including zero were considered statistically significant. The findings of this study showed that the positive association between lower-limb muscular strength, speed-agility, and cardiorespiratory fitness with academic performance indicators were mediated by the emotional symptoms index (percentage of mediation ranging from 27% to 77%). Enhanced physical fitness, particularly in lower-limb muscular strength, speed-agility, and cardiorespiratory fitness might decrease the presence of emotional symptoms, with potential benefits on adolescents' school grades.

## CAUSES OF FATIGUE IN ELITE FOOTBALL: A SURVEY OF ELITE FOOTBALL STAKEHOLDERS

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Introduction

In sport, burnout contributes to decreased performance, increased risk of injury, sports dropout and decreased mental and physical health. Mental fatigue (MF) and physical fatigue (PF) are precursors to burnout. Most research focuses on the physical load experienced during training and competition. In the modern game, elite football stakeholders are exposed to on and off-field stressors which may cause fatigue. The purpose of this study was to subjectively identify factors that contribute to fatigue and identify the type of fatigue that manifests because of exposure to these causes.

METHODS: An online questionnaire investigated whether a) football specific, b) associated professional factors, and c) psychosocial factors: i) caused fatigue, ii) the extent to which it caused fatigue and iii) the type of fatigue induced in elite football stakeholders (N=103).

Results

Both on and off-field factors contributed to fatigue. Only four factors were applicable to less than 80% of respondents (sponsor commitments (74%), safety at matches (77%), media scrutiny of football-related performance (76%) and non-footballing matters (73%)). Training and match stimuli including physical (always:51%- training; always 70%- matches) and mental (always:42%- training; always 32%- matches) loading, number of sessions (always:54%- training; always 64%- matches), recovery time between matches (always:75%) and travel time, particularly in relation to training (always:54%) domestic away matches (always:47%) and international travel (always:72%), were high contributors to fatigue. For these variables between 25% and 70% indicated they caused fatigue to a large extent. Off-field stresses related directly and indirectly to the job include feeling isolated (always:29%), safety concerns (always:26% in public; always 34% at matches) and lack of job security (always:41%) as well as interactions with other stakeholders. MF was just as pertinent as physical fatigue with most stimuli causing a combination of mental and physical fatigue. Stimuli that included mental loading only (such as fear, feeling isolated, identity, and football and non-football-related scrutiny from other stakeholders) resulted mainly in MF. Feeling isolated (80%), the attitude of family and friends towards their profession (79%) and fan scrutiny and judgement related to non-football matters (77%) were the dominant causes of MF. It must be highlighted that not all these were regular causes of fatigue.

Discussion

On and off-field occupational stressors cause fatigue in elite football stakeholders. The prevalence of both MF and PF requires more integrated fatigue management strategies which should be further studied to minimize the impact fatigue has on football performance and stakeholder wellbeing. These findings highlight the importance of approaching fatigue management from a holistic perspective and extending attention beyond just the current narrow scope of focus.

## STUDY ON THE EFFECT OF CONTINUED DANCE ACTIVITY ON THE PREVENTION OF FRAILTY - FROM INTERVIEWS WITH THREE ELDERLY WOMEN

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Introduction

In the research of dance practice for the elderly, the effects of dance on frailty prevention have not been adequately discussed. It is not clear in what aspects of frailty, i.e. physical, psychological or social, does dance have effect on and what kind of dance programs are appropriate for frailty prevention. Prior research has suggested that dance programs in senior care facilities may have an impact on reducing psychological symptoms, such as BPSD, and maintaining or improving quality of life by reactivating the mind-body connection.

The purpose of this study is to determine what kind of frailty prevention could be achieved when the elderly continues dance activities and what kind of program structure would be suitable for them.

Methods

We conducted questionnaire on and semi-structured interviews to three elderly women, Age 71.67±1.25 (n=3), The subjects do not have any disease, and they had been dancing at least twice a month for at least 2 years. The SF-12 ver.2 was used for the QOL survey. Questions for the interview included subjective changes subjective changes before and after the dance activity, motivation to continue the activity, and program content sought in the future.

Results

The three subscale summary scores of the SF-12 were calculated using the national standard value of 50. The average summary scores for the three study subjects were 43.37 for the physical component summary, 53.53 for the mental component summary, and 57.63 for the role/social component summary.

The interviewees felt a particular sense of comfort and openness in moving in accordance with the rhythm in dance compared to non-dance activities. As for the changes compared to before the activity, the respondents felt more psychological changes than physical changes. In terms of motivation for the activities, it was found that they were more interested in having a change of mood, a sense of liberation, and communications with other participants than in physical exercise. Although the activities were mainly focused on learning fixed movements and dancing in unison, two of the three participants expressed a desire for improvisational expressive activities in the future, while one participant was less motivated.

Discussion

The results suggest that the psychological and social effects of dance may be greater than the physical effects when older adults continue to dance. It also showed that elderly people participate in activities with the expectation of liberating themselves and communicating with others. From this we consider that creating programs to achieve such goals may enhance the effect of dance in frailty prevention. The two participants showing a willingness to participate in improvisational expressive activities, suggests that an improvisational dance program in which the elderly can participate with ease may be an appropriate program to be implemented further. We expect the effects of such activities to be verified in the future.

## HOW SPANISH ROWERS HAVE COPED WITH COVID CONFINEMENT PERIOD: A PSYCHOLOGICAL AND BEHAVIORAL STUDY.

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Spanish Sports situation during COVID-19 pandemic described as very hard: uncertainty, incredulity, and distress were reported, and included worry about the Olympics cancellation, future in general, future economic support and return to sports participation. The aim of this research is to present how Spanish rowers have been personally, and emotionally affected by the situation created; as well as to describe how they have coped with this negative situation. Participants: 193 rowers participated in the survey. (Mean age = 19.4 ± 3,9) Female: 40,9% Mean age = 19,4 ±3,8 53%; Men: 59,1% Mean age = 19.3 ± 3,9), 80,8% compete at Spanish National level and 19,2% at International level. Procedure: an online questionnaire named RECOVID-19, was designed to assess how athletes were living their lives during periods of home confinement. The main purpose of the questionnaire was to assess the impact of prolonged confinement on athlete's psychological, emotional, and behavioral performance, and included a validated Spanish version of Profile of Mood State, socio-demographic questions, training conditions at home, rule acceptance, motivation, stress, and other behavioral problems. Results showed that during confinement, (24,4%), of participating rowers practiced training routines at home between 8-10 hours per week and (29%). between 11-13 hours a week. Gender differences, tested by multi-group analysis, revealed that engaging in coping activities was more often associated with negative emotional states among female rowers, who scored higher in negative thoughts, anger, and fatigue. Lack of motivation and behavioral problems was associated in both men and women with negative emotional states. Rule acceptance was positively related to positive emotional states, whereas the ongoing availability of training information and future conditions were equally protective factors for both genders, increasing the vigor sensation, and decreasing fatigue, tension, and depression. Better training conditions in both also increased vigor sensation. During confinement, coping activities were important to reduce distress, and were used extensively. Video calls, online and other networking activities (96,4), reading (57,77), watching TV (84,5%), listening to music (80,8%), learning something new (52,3%) like cooking (19,2), practicing relaxation techniques (48,2%) or mindfulness (11,4%) were the most popular coping activities reported by rowers. Conclusions: Among this sample of Spanish rowers coping with confinement, women and men have presented different characteristics, and have experienced the situation differently. Coach information, and psychological information have been beneficial and have facilitated coping with this very new and difficult situation between Spanish rowers. Programs to protect athletes facing critical situations , should consider the different reactions between men and women in planning interventions.

## ASSOCIATIONS OF SPECIFIC SCREEN-BASED SEDENTARY BEHAVIORS WITH ANXIETY AND STRESS AMONG CHINESE COLLEGE STUDENTS

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Background: Mental health issues, including anxiety and stress, are associated with an increased risk of morbidity and mortality. Some epidemiological studies found that prolonged sedentary time or screen-based sedentary time were negatively associated with anxiety and stress. However, the associations between screen-based sedentary behaviors and mental health may vary by type of screen time. Evidence showed that college students engage in a larger amount of sedentary time due to their time in class and time studying. The associations of specific screen-based sedentary behaviors with anxiety and stress remain to be clarified. Therefore, the objective of the study was to examine the associations between different types of screen-based sedentary behaviors with anxiety and stress among Chinese college students.

Methods: A total of 518 Chinese college students participated in this cross-sectional study. Screen-based sedentary behaviors on weekdays and weekends were self-reported using a questionnaire. The participants were required to report their content-specific screen-based recreational behaviors, including time on video viewing, social media, leisure reading, and video gaming. Anxiety symptoms were evaluated using the Self-Rating Anxiety Scale (SAS) and stress symptoms were evaluated using the Perceived Stress Scale (PSS). Physical activity and sleep were objectively measured using the Axivity AX3 (Newcastle, UK) wrist-worn triaxial Accelerometer. We categorized the participants into three groups ("0–60 min," "1–2 h," and ">2 h") based on the time spent engaging in each screen behavior. Independent associations between various types of screen behavior and prevalence of anxiety and stress were examined by one-way analysis of variance (ANOVA).

Results: The ANOVA revealed that the main effects of video viewing, social media, and leisure reading on anxiety were significant. College students who spent more than 2 h/day on video viewing (both weekday and weekend), social media (both weekday and weekend), and leisure reading (only weekend) had a higher score of anxiety than 0-60 min/day. The ANOVA revealed that the main effects of video viewing and social media on stress were significant. College students who spent more than 2 h/day on video viewing and social media had a higher score of stress than 0-60 min/day (both weekday and weekend). The ANOVA revealed that the main effects of leisure reading and video gaming on sleep were significant. College students who spent more than 2 h/day on leisure reading and video gaming had a worse score of sleep than 1-2 h/day. There was no association between objectively measured physical activity and anxiety and stress.

Conclusions: The present study revealed that the associations between screen-based sedentary behavior and anxiety and stress varied by the types of screen behaviors. Interventions targeting prolonged screen-based sedentary behaviors should consider the types of screen content.

## EFFECT OF EXAM PERIOD ON PHYSICAL ACTIVITY, COGNITIVE FUNCTIONING AND SLEEP VARIABLES AMONG STUDENTS DURING COVID-19

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PURPOSE

The main objective of the study was to explore the effect of the exam period on sleep, physical activity and cognitive functioning among physical education students during COVID-19 lockdown.

METHODS

Twenty-one senior male students from the physical education department voluntary participated in the study. ActiGraph GT9X Link was used for sleep scoring (Sleep Efficiency %, Total Sleep Time [TST], and, Wake time after sleep onset [WASO]). Sleep measurements included also sleep log, daily self-rating scale of the sleep quality, and sleep quality Assessment (PSQI). The Cambridge Neuropsychological Test Automated Battery (CANTAB) was used to measure accurately the cognitive functioning. The cognitive test batteries included Rapid Visual Information Processing (RVP), Paired Associates Learning (PAL) and Spatial Working Memory (SWM). RVP measured the Sustained Attention. PAL assessed the Visual Memory. SWM is a notable executive function demands and it measured the strategy as well as working memory errors. Physical activity was measured using step counter walking 3D pedometers. Data were collected two weeks before and during the mid-term exam period. Students had 5 mid-term exams with a senior project report.

A 1-way analysis of variance (ANOVA) for repeated measures was used to examine the difference before and after exam periods in physical activity, cognitive measurements and sleep variables. When significant F values were observed ($p<0.05$), paired comparisons were used in conjunction with the Holm's Bonferroni method for controlling type I error to determine significant differences.

RESULTS

No significant differences were found in cognitive measurements and sleep variables between periods ($p>0.05$). Repeated-measure ANOVA results revealed significant effects with the number of steps using pedometers ($F=4.71$, $p=0.006$, $ES=0.21$, $P=0.87$). Pairwise comparison showed that significant higher number of steps was observed during week 3 and 4 (exam period) comparing to week 2 (before the exam period).

CONCLUSION

Hence, the exam period increases the physical activity of the senior male students during COVID-19 lockdown but does not affect the cognitive function and sleep variables.

Keywords: mid-term exams, number of steps, Rapid Visual Information Processing, Paired Associates Learning, Spatial Working Memory, undergraduate students, pandemic.

## A PSYCHOLOGICAL STRESS ASSESSMENT MODEL BASED ON PHYSIOLOGICAL SIGNALS IN A VIRTUAL REALITY ENVIRONMENT

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A psychological stress assessment model based on physiological signals in a virtual reality environment

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INTRODUCTION: With the development of virtual reality (VR) technology, virtual reality exposure therapy (VRET) offers a great opportunity to explore stress disorder recognition and treatment [1],[2]. With integrated sensors, VRET could acquire users' physiological data under specified stress. Physiological signals exhibit unique characteristics during stress, hence the extraction of features and classification of stress levels from signals are gaining enormous popularity and importance currently. Therefore, the aim of this study was to create a psychological stress assessment model based on physiological signals using the machine learning algorithm, which is adaptable to different stress conditions provided by VR.

METHODS: 57 adults (20.9±1.9 yrs) volunteered to participate in this study after signing informed consent forms. Participants were asked to first take the Short State Anxiety Inventory（SSAI）to assess benchmark stress states before putting on a heart rate belt, EDA (electrodermal activity) wrist band and a VR head-mounted display. Then they logged into the self-developed VR stress training system, which comprises of three stressful scenes with two stress modes and sit peacefully in a chair for 3 min, during which benchmark values of EDA, heart rate and eye-blink rate were recorded. Participants then entered the three VR scenes in a random order and complete the SSAI immediately after the experience of each mode.

The physiological dataset was divided into training and validation sets (sample size ratio 8:2) respectively, and stress levels were labeled as “no stress”（1-2）, “low stress”（2-3） and “high stress”（>3） based on the score intervals from SSAI. Moreover, the statistics of EDA, heart rate, and eye-blink rate per participant were calculated as the feature vector to feed into the machine learning models.

RESULTS: Rest-state values were significantly lower than those in stress modes. Average heart rate and EDA were higher in the high-stress mode than the low-stress mode. As for the self-reported stress ratings, results showed that all three VR scenes produced a higher stress level. In addition, mean, median, standard deviation, maxima and minima of EDA, heart rate and maxima of eye-blink rate were used as an eleven-element feature vector to feed into the SVM, LR, RF, kNN, XGBoost and bagging supervised learning algorithms. The performance metrics of bagging algorithm achieved the highest scores on accuracy (0.742), F1-score (0.709) and recall (0.774).

CONCLUSION: This study revealed the relationship between physiological data and self-reported stress ratings and the psychological stress assessment model adopted the bagging ensemble learning algorithm for the best classification results, which motivates the further investigations of stress disorder recognition and treatment.

1. Salkevicius et al. (2019) 2. Taneja et al. (2017)

## Sociology

### THE DEVELOPMENT OF WOMEN SPORT IN THE TIME OF COVID-19: THE ANALYSIS OF THE POLICY-PRACTICE IN TAIWAN AND UK

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[INTRO/AIMS] Since the spread of COVID-19 has caused an unprecedented global pandemic, the lockdown policy not only severely impacted the economy of the sports industry, but also limited the development of sports. This situation seems to gradually magnify the plight of the development of womens sports under the epidemic. This study seeks to analyze the impact, policy and countermeasures of the development of womens sports under the epidemic in two countries with different political, social, and economical backgrounds, namely, Taiwan and the UK. [METHODS] Two complementary theoretical approaches are adopted, those of governance theory and a strategic-relational approach, which allows us to identify how such outcomes were mediated and shaped, and in particular how different sets of interests were implicated, how power was exercised, and whose interests were met. The empirical analysis draws on a qualitative case-study approach, which was based on documentary materials and semi-structured interviews. [FINDINGS] The gender play gap seems to be a long-term problem in womens sports development. During the epidemic, even though women have the same work-from-home, telecommuting issues, or training programs as men, they have to deal with most of the family matters in addition. Due to prolonged isolation and closure of sports facilities, participation in sports has been seriously affected, the UK government and relevant units, such as Sport England have actively proposed various coping strategies, including the campaign of Joint the Movement, and This Girl Can. Although it has not been confirmed what benefits these programs can have on womens participation in sports, it seems that the government are paying more attention to womens sports. In Taiwan, there was no large-scale city lockdown, and a higher proportion of the population exercising regularly was created in 2021. Even though various gender inequalities hinder the development of womens sports, Taiwan reached a new high sports participation rate during the epidemic. However, while observing the policy side in Taiwan, it is less active than in the UK. Taiwan government and relevant units did not seem to have launched a sports development strategy under the epidemic. The weakness of womens participation in sports seems to have been forgotten in the policy context during the epidemic. The growth of the sports population, especially the female sports population, seems to be based on the Taiwanese peoples awareness of linking sport with health. [CONCLUSION] This study found that the development of the womens movement under the epidemic has different appearances due to the governments role and cultural background. The severity of the epidemic should not be completely linked to the development of womens sports. Sports promoters might use the epidemic to become a booster for the development of womens sports.

## Sport Management and law

### A COMPARATIVE STUDY OF CONVENIENCE AND SATISFACTION BETWEEN COMPREHENSIVE COMMUNITY SPORTS CLUBS AND ORDINARY PUBLIC SPORTS CLUBS

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INTRODUCTION: Comprehensive community sports clubs (CCSCs) are one of the sports promotion policies that the Japanese Ministry of Education, Culture, Sports, Science and Technology has implemented since 1995 in order to realize a society of lifelong sports in Japan and are region-based sports clubs. However, the promotion has not necessarily been successful. To further spread and develop CCSCs, it is important to know what contributors are required. As ways to seek the factors not to pervade, it is thought that it is necessary to make clear what differentiates those who want to go to CCSCs and those who do not, though they all want to exercise or play sports. Thus, this study aimed to examine the differences in convenience and satisfaction between those who belong to CCSCs and those who belong to sports clubs other than CCSCs (OTHER).

METHODS: A questionnaire survey was conducted on 334 people (CCSC = 140, OTHER = 194) who regularly play sports in sports clubs. Questionnaire items were nine: 1) Satisfaction with the equipment; 2) Convenience of the means of transportation; 3) Convenience of parking; 4) Comfort of use; 5) What is required of the facility; 6) Satisfaction with the sports environment; 7) Contribution to the improvement of physical fitness; 8) Satisfaction with the costs; and 9) Contribution to containing medical costs. Then, QTTT (Quantification Theory Type Two, which is discriminant analysis using dummy variables as independent variables) was conducted using the nine items as independent variables and whether to belong to CCSC as a dependent variable.

RESULTS: The results of the QTTT showed that the multiple correlation coefficient obtained was 0.780 and the correct discriminate ratio was 88.2%, indicating a good distinction. When considering partial correlations and ranges of category weights, a relatively large impact by independent variables were found in 1) Satisfaction with the equipment (partial correlation = 0.732 and range = 2.034); 4) Comfort of use (0.270, 1.186); 5) What is required of the facility (0.195, 0.638); 2) Convenience of the means of transportation (0.183, 0.491); and 6)

Satisfaction with the sport environment (0.150, 0.359). When examining the direction of the signs of the items with a large impact, a good evaluation of CCSC was found in 4) Comfort of use, but not in 6) Satisfaction with sports environment. Both extremely good and bad opinions for CCSC without any slightly good/bad opinions were found in 1) Satisfaction with the equipment and 2) Convenience of the means of transportation. This was also found in item 5) What is required of the facility, whereas OTHER showed expectations for professional instruction, and for CCSCs, there was a desire for hobbies/pastimes other than sports/exercise and the provision of useful information.

CONCLUSION: Bipolarization of good and bad evaluations was found in CCSC, which had expectations for another added value other than sports rather than professional instruction.

## Sport Technology

### EYE-TRACKING ANALYSIS DURING FENCING FIGHTING

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INTRODUCTION: Fencing is an interpersonal sport and has three disciplines: epee, foil and sabre, with different rules and using different swords. The aim of this study was to clarify the different characteristics of the three fencing disciplines of epee, foil and sabre from the viewpoint of the eye gaze.

METHODS: Eighteen members of the University Fencing Team (3 disciplines x 6 members) have participated in national level competitions such as the National University Student Championships and the National Sports Festival. Some of them have competed in international competitions. Each fencer wore a pair of Tobii Pro glasses 3 (Tobii Technology), an eye-analysis device, wearing a fencing mask with a polyethylene made transparent face, and competed against each other. Fights were played as the first person to reach five points wins. Two fights were played with the same fencer (once with and once without the glasses). The time of seconds it took each fencer to score (total time) was measured. The eye gaze sites were classified into following four: 1) mask to neck, 2) chest and shoulders, 3) arms and hands, and 4) other. For the analysis of the gaze time (dwell time), the first three fights were analysed, and the area with the longest dwell time before each point was scored was selected. All data are expressed as mean ± SD, and significance difference tests between disciplines and between retention sites were analysed using one-way ANOVA in SPSS, and Tukeys HSD was used for multiple comparisons.

RESULTS: The total time and dwell time for epee, sabre and foil were 16.7±10.4 and 15.7±10.5 sec., 9.6±6.4 and 8.9±6.3 sec., 4.1±2.7 and 3.6±2.5 sec., respectively. Epee had a statistically significantly longer eye dwell time than sabre (p=0.02), but no significant difference were found between epee and foil, and also foil and sabre. There were no significant differences in eye dwell time by site for epee and foil, but for sabre the musk to neck (6.0±2.1 vs. 1.5±1.0 and 2.3±1.5 sec) were significantly longer than the chest and shoulders, and others (p=0.005, p=0.028).

CONCLUSION: Because the effective surface of the epee is the whole body including the foot, the part of the body that is at more intensively focused when fighting might be lower than in other disciplines (arms and hands, 55.6%). In the sabre and the foil, the gaze was concentrated on the upper body (mask to neck 50.0%, chest and shoulders 28.6% and arms and hands 0% for sabre, chest and shoulders 46.7%, mask to neck 20.0% and arms and hands 13.3% for foil) because the effective surface was the upper body. In summerly, there is a difference among the disciplines in the duration of the eye dwell time and the eye dwell area tends to be slightly lower in epee than in foil and sabre. Sabre seems to have different eye dwell time characteristics by site compared to epee and foil.

### INVESTIGATING SENSOR LOCATION ON THE USE OF CONTINUOUS GLUCOSE MONITORING DURING EXERCISE IN HEALTHY ADULTS

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INTRODUCTION: Continuous glucose monitors (CGM) have recently emerged as a biological monitoring tool for non-diabetic athletes, with the primary purpose of monitoring glucose levels during endurance exercise. These minimally-invasive sensors measure minute-by-minute glucose concentrations through interstitial fluid (ISF) sampling, and are typically worn on the back of the arm. As most endurance sports depend primarily on repetitive contractions of the leg muscles, there may be differences in site-specific glucose uptake if the sensors are worn on the leg rather than the arm. The primary aim of this investigation was to determine whether CGM placement on the inner quadriceps would result in discrepant recordings compared to placement on the triceps brachii during incremental cycling exercise following glucose intake in healthy adults. Secondary aims were to determine if heating or muscle contractions via involuntary stimulation could explain any variation between sensor-readings.

METHODS: Complete data from 9 healthy participants (M:6, F:3) was recorded for 30min following 100g glucose ingestion during four conditions: resting control, incremental cycling exercise, quadriceps electrical muscle stimulation, and skin heating via electric heating blankets. Each condition was randomized for order separated by ≥48h, and occurred in the morning following an overnight fast. As a comparator, finger-stick capillary glucose samples were taken during control and cycling conditions.

RESULTS: Under control conditions, the arm sensor better reflected capillary glucose samples with a mean absolute relative difference (MARD) of 12.4±9.3% vs 18.3±11.4% in the leg, and there was a main effect of sensor location (P=0.01) whereby the leg sensor was consistently lower than the arm over the 30min period. During incremental cycling exercise, there was a time-by-sensor location interaction (P=0.02) such that the glucose sampled at the leg was reduced directly after the maximal portion of the exercise test, but MARD between capillary and ISF samples were similar across sensor locations (arm:15.5±12.0% vs leg: 16.7±10.8%). Muscle contractions via electrical stimulation negated the resting differences between sensors (sensor location, P=0.8). Finally, skin heating caused leg-skin temperature to increase by 3.1±1.8°C, compared to only 1.1±0.72°C in the arm (P=0.002), and resulted in a much lower glucose profile in the leg compared to the arm (time-by-sensor location interaction, P<0.001).

CONCLUSION: These results suggest that, at rest, traditionally located ISF glucose sampling on the fat pad of the triceps may best reflect capillary blood glucose. However, during cycling exercise CGM placement on closer to the primary movers may offer greater insight to working muscle glucose concentrations, and this is likely due to greater blood-flow rather than due to the muscle contractions alone.

## SHOE CONSTRUCTION MODIFICATIONS TO REDUCE BRAKING FORCE PARAMETERS DURING RUNNING

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INTRODUCTION: Higher peak braking forces have been associated with an increased risk of running related injuries [1]. To reduce braking forces during running, alterations in gait parameters through gait retraining, such as decreasing stride length and increasing stride frequency, have been successful [2,3]. Through alterations in footwear properties such as cushioning material or outsole design, reductions in peak braking forces may also be possible. One possible change would be to increase the heel-to-toe drop of the shoe. This modification may allow for the runner to run with an increased stride frequency. Another possibility would be increasing the heel portion of the midsole to extend back further. This modification is thought to shift the center of pressure anteriorly, which would bring the orientation of the ground reaction force closer to the center of mass of the runner. To date, no research has altered footwear with the objective of reducing braking force parameters; therefore, the purpose of this study was to evaluate the previously mentioned shoe midsole modifications on braking force parameters.

METHODS: Ten individuals participated in this study, with each participant running at a self-selected speed over a force platform, completing five trials in each of four shoe conditions (Control, Drop, Extend, Combo). The Drop condition had a 20 mm heel-to-toe drop and the Extend condition had a 60 mm rearward extension of the heel from the heel cup. The Combo condition was a combination of the Drop and Extend conditions. The variables of interest were peak braking force and braking impulse. Paired T-tests were performed between each shoe condition and the Control condition.

RESULTS: Peak Braking force was significantly lower in the Extend condition (Mean: 275.98 N, SD: 55.21, $p = 0.043$) and the Combo condition (Mean: 270.29 N, SD: 53.3, $p = 0.011$) compared to the Control (Mean: 289.93 N, SD: 46.19). Braking Impulse was significantly lower in the Extend condition (Mean: 19.00 Ns, SD: 5.34, $p = 0.070$) and the Combo condition (Mean: 18.96 Ns, SD: 5.12, $p = 0.053$) compared to the Control (Mean: 19.87 Ns, SD: 4.57). There were no differences between the Control and Drop condition for peak braking force ($p = 0.325$) or braking impulse ($p = 0.656$).

CONCLUSION: This study was the first to use shoe construction modifications to reduce braking force parameters. The results from this study indicate that shoe modifications can reduce braking force parameters, potentially reducing the risk of running related injuries.

[1] Napier et al, SCAND J MED SCI SPOR, 2018

[2] Heiderscheit et al, MED SCI SPORT EXER, 2011

[3] Liebermann et al, J EXP BIOL, 2015

## THE ACCURACY OF FORM SMART GOGGLE SWIMMING MATRICES: A VALIDATION STUDY

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INTRODUCTION: Training with wearable technologies has become increasingly popular in many sports. This wearable technologies accuracy is essential for providing users or their coaches with reliable information about their progress and adjusting their training to achieve better performance. The Form smart goggle, an innovation that differs from the traditional wrist-worn aquatic wearable device, measures and delivers metrics like time and distance. Its accuracy and reliability have not been determined.

METHODS: Therefore, we recruited six college female swimmers (meanSD:22.3±1.70) to participate in a pilot study in a standard 50-meter pool. Trials consisted of two sessions (one week apart) of 4*50 m front-drawn swimming at the best of the participants ability. A GoPro Hero 8, a digital action camera, served as the gold standard for measuring temporal movement. The Pearson correlation coefficient, the intraclass correlation coefficient (ICC), and the Bland-Altman plot are used to measure the correlation and consistency between the smart goggles and the camera.

RESULTS: Results of all trials showed a high agreement of time ((r=.921; ICC=0.918) and the mean absolute error (MAE) is 0.217 seconds. Stroke counts show moderate correlation (r=.428) and low reliability (ICC=0.388). The Bland-Altman analysis revealed that the goggle underestimated the number of strokes of 8.2.

CONCLUSION: We conclude that Form Smart Swim Goggles offer good timing accuracy, but factors causing bias in stroke counts must be explored. To improve swimming training in the future, further research needs to examine its accuracy and reliability for different stroke styles and distances.

## DEVELOPMENT OF AN ALGORITHM FOR PERSONALIZED SNPE PROGRAMS FOLLOWING POSTURE ALIGNMENT EVALUATION

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INTRODUCTION: The purpose of this study was to develop a method that can lead users to self-evaluate body posture alignment using a mobile device, and to design an algorithm that enables a personalized self natural posture exercise (SNPE) program to improve posture alignment based on the evaluation. To achieve the goals, the imaging method, body region evaluated, evaluation method, diagnosis standard, and the outcomes are developed to design the final algorithm of exercise program.

METHODS: The postural alignment evaluation is performed by taking full-body images of the frontal and sagittal planes (right side) while the subject is standing upright. For the rotation evaluation, left (L) and right (R) side of eye, acromion, chest, anterior superior iliac spine, knee, and ankle of the frontal image were marked. And the horizontal distance of each body part from the body center line was measured. When the distance of each L and R was different, the body parts were considered as off-lined. For the slope evaluation, the markings during the rotation were utilized and the L and R horizontal line was assessed. When the line was not horizontal, it was considered as unbalanced. From the sagittal plane image, the anterior and posterior superior iliac spine were lined and evaluated whether it is horizontal. when the line was not horizontal, it was considered as off-lined. For the center of gravity evaluation, the side of the knee, acromion, and center of ear was marked from the sagittal plane image. After vertical lining from the ankle, the marked parts were assessed whether they were off the line. When they were off the line, they were considered as off-lined. During the three evaluations, the degree and direction were not considered.

RESULTS: After evaluating all three posture alignment, the off-lined body parts were extracted, followed by selecting and listing SNPE movements matching for the correction of the off-line parts. Since the SNPE consists of 8 motions, some motions could be listed more than

once. When listed more, it was considered as more important movement. Based on the number of listed, the intensity and duration of movements were decided and 70 min exercise program was designed.

CONCLUSION: The algorithm was developed based on the connection of evaluation, diagnosis, and individualized exercise prescription. Using this algorithm, one can easily identify body alignment and perform a optimal SNPE program. It will be used as a useful mobile-based exercise guide.

## Sports Medicine and Orthopedics

### RESULTS OF FUNCTIONAL SPINAL EXAMINATION OF PREPUBESCENT STUDENTS

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INTRODUCTION: Several studies have concluded that a sedentary lifestyle is spreading rapidly among the younger age group (Szigethy, 2020; Kun et al., 2019). A recent Health Behavior in School-Aged Children (HBSC) study found that less than one in five adolescents meet the World Health Organization's (WHO) physical activity recommendations (Jo Inchley et. al., 2020). The physical inactivity of prepubescents contributes to the development of pathological changes in the spine and to an increase in the detrimental effects of pre-existing degenerations. The aim of this research, which was launched with an emphasis on prevention, is to examine the spine of the students in the sample and to identify the postural weaknesses that contribute to the development of the lesions. In the light of the results, it is extremely important to compile a targeted prevention program.

METHODS: The study was conducted in November 2021 among 6th grade students of the Gárdonyi Géza Primary School in Győr, Hungary (n = 71). Using cross-sectional study, we studied the physiological curvatures of the spine in a standing position and under load (Matthias test). The Spinal Mouse was used to examine the spine. The instrument can examine the morphological characteristics and mobility of all vertebrae between C7 - S1 of the spine.

RESULTS: The study included girls (n = 30) as well as boys (n = 41). Their average height was 155.2 cm (girl: 156.08 cm, boy: 154.29 cm). Their average body weight was 45.5 kg (girl: 46.7 kg, boy: 44.3 kg). The vertebral segments of the lower back (Th10/11, TH11/12, Th12/L1) and the lumbar spine (L1/2, L2/3) are in the age-appropriate normal range. The Th10/11 vertebral position showed a significant difference ($p < 0.002$) between girls and boys. In the case of girls, an increased lordotic curvature is seen in the lumbar spine compared to that of boys. Based on the results of the Matthias test, it can be concluded that the curvatures of the girls spines are more maintained than those of the boys Th10/11 ($p < 0.001$), Th11/12 ($p < 0.030$), and also in the Th12/L1 transition ($p < 0.041$).

CONCLUSION: In addition to the differences due to the anatomical structure, it can be stated that the functional curvatures of the lower back and lumbar spine of boys are less maintained under load than those of girls. These segments are therefore the source of poor posture, so special attention should be paid to age-appropriate strengthening of the lower back, lumbar spine, and core muscles.

### EFFECTS OF REPETITIVE THROWING ON TRUNK MUSCLE STRENGTH AND THORAX AND SHOULDER KINEMATICS DURING PITCHING

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INTRODUCTION: Repetitive throwing has recently been a focus on risk factor for shoulder injury in baseball players (Erickson et al.,2016). In addition, Control of movement of the thorax, which is located between the lower and upper extremities, is important for smooth shoulder movement, and trunk muscle strength is necessary for preventing shoulder injury. However, there have been few reports examining changes in trunk muscle strength and thorax and shoulder kinematics with repetitive throwing. This study was performed to investigate whether repetitive throwing changes trunk muscle strength and thorax and shoulder kinematics during pitching.

METHODS: In 12 healthy baseball players, we assessed trunk muscle strength in flexion, extension, and lateral flexion using a stopwatch. Throwing motions were analyzed using a three-dimensional motion analysis system, and thorax angles (anterior tilt, lateral tilt, and rotation) and shoulder angles (horizontal adduction, abduction, and internal rotation) were calculated at stride foot contact during the early cocking phase (SFC) and at the maximum shoulder external rotation position during the late cocking phase (MER). The participants threw 135 fastballs (9 innings with 15 throws per inning) at maximum effort. Trunk muscle strength was measured before and after the repetitive throwing task, and throwing motion was measured in the first, seventh, eighth, and ninth innings. The Wilcoxon signed-rank test was used to compare the trunk muscle strength before and after throwing. One-way analysis of variance and post hoc Bonferroni analysis were used to compare throwing motion between the first inning and the seventh, eighth, and ninth innings. Statistical significance was set at $p<0.05$.

RESULTS: Trunk muscle strength was decreased after repetitive throwing (flexion, $p=0.002$; extension, $p=0.002$; lateral flexion on throwing side, $p<0.001$; and lateral flexion on non-throwing side, $p<0.001$). Regarding the throwing motion, the thorax rotation angle at SFC increased toward the throwing side in the seventh ($p=0.009$) and eighth ($p=0.016$) innings compared with the first inning. In addition, the shoulder horizontal adduction angle at MER decreased in the seventh ($p=0.016$) and ninth ($p=0.009$) innings compared with the first inning. There were no differences in other variables.

CONCLUSION: It is reported that high muscle activity of the abdominal and trunk extensors occurs to control the thorax from the SFC to ball release (Hirashima et al.,2002; Watkins et al.,1989). We considered that muscle fatigue caused by repetitive throwing led to a decrease in trunk muscle strength. Among the results of throwing motion, the change in the shoulder horizontal adduction angle was important. A decreased shoulder horizontal adduction angle at MER was associated with shoulder posterior superior impingement syndrome (Jobe,1995; Walch et al.,1992), suggesting that repetitive throwing than 100 pitches may be a risk factor for shoulder injury.

**EFFECTS OF ACUTE RESISTANCE EXERCISE WITH DIFFERENT INTENSITIES AND EQUAL TRAINING VOLUME ON IMMUNE CELL RESPONSES**

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INTRODUCTION: Previous studies have investigated the effects of different resistance training load schemes on immune cell migration, but the prescription design neglected training volume and inter-set rest, which led to inconsistent findings. Therefore, the relationship between resistance exercise prescribing variables and the immune response needs further investigation. The purpose of this study was to investigate the effect of an acute resistance exercise of varying load with equal training volume and inter-rest time on the immune response.

METHODS: Healthy young men (n = 11; age 23.0 ± 0.7 years, body mass index 21.5 ± 0.7 kg/m2) with no resistance exercise habits were recruited to perform three trials, including moderate-load RE (MOD; 4 sets of 8 repetitions at 85% 8RM), low-load RE (LOW; 4 sets of 15 repetitions at 45% 8RM) and control (CON; no exercise), in a randomized, crossover design. Blood was collected pre-exercise, 0, 30, and 60 min post-exercise for analysis of cortisol and immune cell counts. The data obtained were analyzed using a linear mixed model.

RESULTS: Total white blood cell counts and lymphocyte counts were significantly higher in MOD and LOW than in CON at immediately post-exercise ($p < 0.05$), with no significant difference between the MOD and LOW ($p > 0.05$). Cortisol were significantly higher in MOD than in CON at 30 and 60 min post-exercise ($p < 0.05$), with no significant difference between the MOD and LOW ($p > 0.05$).

CONCLUSION: Both moderate- and low-load RE induced a transient state of immune cell migration; such changes returned to basal level within 30 min after exercising. Acute stress response elicited by moderate-load RE has lasted longer, as evidenced by cortisol levels.

**CHANGES IN THE THORACIC SPINAL ROM AND SAC/HIP RATIO IN AN INTERVENTION PROGRAM AMONG ADOLESCENTS**

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INTRODUCTION: Adolescence is a critical period of growth and maturation. Rapid growth of the support system, including the skeletal system, can lead to functional problems. (STOKES, 2007). The muscles of the trunk cannot keep up with this rapid growth, so their load-bearing capacity is reduced. Some of the muscles responsible for posture weaken, while others become shortened and tense. (SOMHEGYI et al., 2003). As a result of the breakdown of muscle balance, certain muscles need more effort to maintain correct posture. In other cases, the curvatures of the spine flatten, the spine becomes inflexible, muscles along its length weaken and small joints become overloaded (BAJSZ et al, 2015). Prolonged uneven loading can lead to premature cartilage wear. (BAGI et al., 2016). The aim of the present study was to examine the impact of an intervention-related posture improvement program among school-age children.

METHODS: Adolescence is a critical period of growth and maturation. Rapid growth of the support system, including the skeletal system, can lead to functional problems. (STOKES, 2007). The muscles of the trunk cannot keep up with this rapid growth, so their load-bearing capacity is reduced. Some of the muscles responsible for posture weaken, while others become shortened and tense. (SOMHEGYI et al., 2003). As a result of the breakdown of muscle balance, certain muscles need more effort to maintain correct posture. In other cases, the curvatures of the spine flatten, the spine becomes inflexible, muscles along its length weaken and small joints become overloaded (BAJSZ et al, 2015).

Prolonged uneven loading can lead to premature cartilage wear. (BAGI et al., 2016). The aim of the present study was to examine the impact of an intervention-related posture improvement program among school-age children.

RESULTS: Pre-intervention (1) and post-intervention (2) data showed significant decreases in all assessed characteristics and similar increases in sacrum to hip ratio (Sac/Hip) (9.83±4.36 - 21.63±4.39); $p<0.000$. The greatest change was found in the Th11/12 dorsal vertebral body angles (4.50±2.05 - -0.30±0.25); $p<0.000$. As a result of the postural improvement program, the degree of pelvic tilt and, in parallel, the physiological curvature of lumbar lordosis was reduced to within the age-specific reference values.

The Hungarian Spine Societys control exercises were used to assess muscle strength and extensibility at the beginning of the intervention and repeated at the end of the intervention. The results of the 2nd measurement confirm the success of the program. We found improvements in all 12 exercises

CONCLUSION: In conclusion, our findings indicate that the flexibility training protocol performed for 16 weeks could improve the status of the spinal in pubertal children These data might be suitable for increasing knowledge about the methodology of spinal prevention gymnastics. In particular, this study showed that a specific workload pattern (set, repetitions, and type of exercise) could increase the status spinal in pubertal children.

**THE EFFECT OF EXERCISE INTERVENTION DURING PREGNANCY ON DELIVERY MODE AND MACROSOMIA RISK OF PREGNANT WOMEN WITH DIFFERENT PRE PREGNANCY BMI: META ANALYSIS**

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INTRODUCTION: To systematically evaluate the effect of exercise intervention during pregnancy on delivery mode and risk of macrosomia in pregnant women with different pre pregnancy BMI by Meta-analysis. To provide reference for the clinical formulation of reasonable and safe exercise program during pregnancy, and to provide evidence-based basis for the formulation of systematic and comprehensive exercise guidelines during pregnancy.

METHODS: As of February 28, 2022, literature searches have been conducted in CNKI, WanFang, Web of Science and PubMed databases, with "pregnan *", "exercise", "physical activity" and "control group" as the subject words. Formulate the inclusion and exclusion criteria of documents, and eliminate the documents that do not meet the requirements of the inclusion criteria, duplicate data results and no full text.

RESULTS: A total of 59 RCT studies were included in this meta-analysis, from 5 continents (Asia, North America, South America, Europe and Oceania) and 18 countries, including 10833 people in the control group and intervention group. Exercise interventions during pregnancy include aerobic exercise, resistance exercise, meditation exercise (yoga) and specific exercise (pelvic floor muscle training). The overall methodological quality was high. The overall results showed that exercise intervention during pregnancy did not increase instrumental delivery (OR: 0.89 [0.76, 1.02], $P>0.05$), and helped to reduce the incidence of caesarean section (OR: 0.88 [0.80, 0.96], $P<0.01$) and macrosomia (> 4000g) (OR: 0.78 [0.65, 0.93], $P<0.01$). Subgroup analysis showed that exercise intervention during pregnancy not only

reduced the risk of instrumental delivery in pregnant women with normal BMI before pregnancy (OR: 0.80 [0.67, 0.94], P<0.01), but also inversely increased the probability of instrumental delivery in pregnant women with overweight or obese BMI before pregnancy (OR: 1.50 [1.01, 2.22], P<0.05). In addition, for pregnant women with overweight or obese BMI before pregnancy, exercise intervention did not affect the incidence of macrosomia (>4000g) (OR: 0.71 [0.44, 1.14], P>0.05), but reduced the risk of caesarean section (OR: 0.80 [0.67, 0.96], P<0.05).

CONCLUSION: Exercise intervention during pregnancy can significantly improve the delivery mode of pregnant women and the incidence of macrosomia (> 4000g), but the effect of exercise intervention in pregnant women with overweight or obese BMI before pregnancy is slightly lower than that in pregnant women with normal BMI before pregnancy. Due to the reduction of the incidence of caesarean section, pregnant women with overweight or obese BMI before pregnancy also have the risk of increasing the risk of instrumental delivery. It is suggested that this group should advance exercise intervention to the preparation period, Through the "pregnancy preparation + +pregnancy" double cycle exercise, strive to reduce the weight to normal value during pregnancy preparation, so as to reduce the risk of instrument delivery.

## IN VITRO EVALUATION OF DECELLULARIZED TENDON GRAFTS

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INTRODUCTION: The incidence of various tendon injuries are increasing all over the world. The most common lesions are the anterior cruciate ligament, Achilles tendon, rotator cuff, hand flexor and extensor tendon ruptures. Understanding the disadvantages of auto- and allograft utilization and to avoid infection transfer and graft rejection, we predicted decellularized tendons may become an ideal graft choice for tendon reconstruction surgeries. Thus, in our studies we aimed to create decellularized tendon grafts with optimal mechanical properties and minimal antigenicity for clinical tendon reconstructions in the future.

METHODS: Our experiments were performed and validated by the Regional Comittee of Science and Research Ethics at the Univeristy of Pécs Medical School. Cadaveric human Achilles and hamstring tendons were harvested and divided into two groups. One group was fixed and underwent histological analysis (control group), the second group was decellularized by utilizing the following chemical decellularization protocols: (1) 1% tributyl-phosphate (TBP) for 24 hours, (2) 1% TBP for 48 hours, (3) 2% TBP for 24 hours, (4) 1% sodium-dodecyl-sulphate (SDS) for 48 hours and (5) 2% TBP for 48 hours. We performed histological analyses (hematoxilyn-eosin, picrosirius red staining) on the decellularized tendons, and compared them to the control group by nuclear counting and collagen structure investigation. We applied Friedman's Two-Way Analysis of Variance for statistical analyses.

RESULTS: We detected significant (p<0.001) decrease in the number of cell nuclei following decellularization. When applying protocols (1)-(4), beside a significant decrease in the number of cell nuclei, we observed celluar debris between the collagen fibres. Moreover, when utilizing 2% TBP for 48 hours (5), we detected severe collagen damage in semitendinosus tendons.

CONCLUSION: We conlude that all applied decellularization protocols were effective demonstrating a significant decrease in the number of cell nuclei. We haven't detected collagen lesion via 2% TBP for 48 hours treatment on Achilles tendons, however, a tensile strength testing should be still performed. If the mechanical parameters prove to become optimal, we suggest 2% TBP treatment for 48 hours may be a suitable decellularization protocol for human Achilles tendons.

## ARRHYTHMIA CLASSIFICATION USING DEEP NEURAL NETWORKS

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INTRODUCTION: The electrocardiogram (ECG) is a technique that portrays the human heartbeat and aids in the diagnosis of certain cardiovascular illnesses. ECG has been increasingly popular in sports medicine in recent years. ECG can be used to investigate exercise cardiology not only for diagnosis, but also to examine and determine the hearts adaptability to high-intensity training and significant volumes of exercise.

METHODS: We used datasets from the MIT-BIH arrhythmia database and the CSPC2021 competition. There are 48 dual-channel ambulatory ECG records in the MIT-BIH arrhythmia database. A total of 109,500 heartbeats are recorded, with irregular heartbeats accounting for around 30% of the total. Variable-length ECG record fragments derived from lead I and lead II of long-term dynamic ECGs, each sampled at 200 Hz, are provided in the CSPC2021 challenge datasets. These datasets contain the classes N, S, V, F, and Q, which stand for Nonectopic, Supraventriculr ectopic beat, Ventricular ectopic beat, Fusion beat, and Unknown beat.

This research offers a two-stage deep convolutional neural network (CNN) model for arrhythmia classification, with three highlights:

1.We discovered that the sample numbers of different heartbeat types are substantially diverse in these datasets. The sample size of the N type, for example, is 81468, while the sample size of the F type is only 723. The consistency of learning cannot be guaranteed by the model during the training phase. This is why the majority of the models exist. Although it has a near-perfect accuracy rate, it is unable to properly understand many sorts of characteristics in actual applications. As a result, we suggest the sample equalization approach, which we will train until the number of five sample types is not significantly different.

2.We discovered that just choosing a sample size was ineffective, therefore we extracted five types of R peak lengths and plotted them on a scatter plot, discovering that the lengths of different types were significantly varied. As a result, we try to choose different sizes for sampling and retraining based on the R peak length division intervals.

3.We observe that categories S and V are more similar and difficult to differentiate when we do simple training. As a result, we offer a method for both forms of secondary training. After the five classes have been trained for classification together, the samples and labels from the two classes S and V are recombined for the second training, which enhances classification accuracy.

RESULTS: When we didnt use the above three methods for simple training, the accuracy of arrhythmia classification was as high as 98.5 percent, but when we used the second method to balance the five types of samples, the accuracy rate dropped to only 89.4 percent, indicating that our samples arent balanced, which leads to highly accurate conjectures. As a result, we integrated the other two approaches on the basis of sample balance, and arrhythmia accuracy reached 93.5 percent. Calculate S and Vs forecast accuracy independently, ranging from 91 percent to 95.01 percent.

CONCLUSION: While no sample equalization algorithm can achieve high accuracy, it cannot learn the features of each class of samples thoroughly. After the sample has been balanced, the training is divided into intervals based on the length of the R peak, with secondary training for the categories that have poor outcomes improving the flexibility and accuracy of arrhythmia categorization.

This research proposes three concepts for arrhythmia classification based on the standard convolutional neural network. These ideas are successful and correct earlier flaws. This method is well suited to the practical application of ECG in sports medicine, and it is hoped that it will help researchers better understand athletes heart problems.

## CHARACTERIZATION OF THE EXERTIONAL HEAT STROKE CASES IN THE FRENCH ARMY: ANALYSIS OF PATIENTS PROFILE AND OF THE TYPE OF EXERCISE

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INTRODUCTION: Exertional heat stroke (EHS) is an association of hyperthermia (>39°C) and central nervous system disturbances occurring during a strenuous physical exercise affecting therefore athletes, laborers, and military personnel. The identification of risk factors is a complex task since multiple extrinsinc (thermal conditions and clothing) and intrinsinc (sociodemographic, anthropometric, fitness, genetic, and behavioral characteristics) factors may be involved. EHS is a main hazard in the French army (27 per 100000 person years) and identification of specific risk factors appear very important to limit EHS occurrences.

METHODS: We conducted a retrospective study among military personals after an EHS between 2013 and 2021 (n = 203). After an individual interview, body composition (bioelectrical impedance scale) and maximal oxygen uptake (VO2max on ergocycle) were measured. Then a subgroup (n = 107) filled a questionnaire assessing the perception of the exercise during which EHS occurred (10-cm visual analog scales).

RESULTS: 93% of patients were male and 74% were from army. Patients were mostly young (min = 18, 1st quartile = 22, median = 24, 3rd quartile = 28.8 yo, max = 41), had healthy BMI (19.0, 23.3, 24.8, 26.7, and 32.3 kg.m-2, respectively) and fat mass (4, 14, 17, 21, and 39% of BM, respectively) and had high fitness level based on VO2max (26.8, 38.6, 44.3, 49.5 and 69.8 mL.min-1.kg-1, respectively) or on performance during a “marche-course” (a 8-km race in battledress; 31, 37, 40, 43, and 60 min, respectively). Most of the EHS occurred in France metropolitan area (83%) and one quarter in June (24%) and 70% between May and September. Ambient temperature repartition (3, 15, 19, 23, and 32 °C) indicated that despite being very heterogeneous, thermal conditions were mostly considered as safe (heat index < 26 °C). Most of the EHS occurred during a “marche-course” (74%) and during an exercise with military clothing (92%). 67% of the exercises inducing EHS had a main importance for the military personnel. The motivation (0, 3.2, 5.7, 8.0, and 10.0, respectively) and stress levels (0, 2.3, 5.0, 6.7, and 10.0, respectively) were mainly perceived as moderate and the level of importance of this test was mostly perceived as high (0, 5.8, 7.2, 9.0, and 10.0, respectively).

CONCLUSION: These observations do not reveal a specific profile of personnel at risk to suffer from EHS. However they indicate that lean fit and young soldiers seems not specifically protected against EHS. However EHS seems to occur mostly during “marches-courses” with battledress, between June and September and high levels of objective and perceived importance strongly suggesting that this kind of exercises should be avoided as possible during these months or that medical support should be reinforced when these conditions are gathered. Sharper analysis of intrinsic factors is now required and particularly psychological profile related to the stake perceived.

## THE RESPONSE OF SALIVA AMYLASE ACTIVITY IN UNIVERSITY ATHLETES AFTER RETURNING TO TEAM TRAINING

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INTRODUCTION: The COVID-19 pandemic repeatedly disrupted sports activity. A prior study reported that detraining increase injury risk and cause rapid loss of training-induced physical and performance adaptation. [1] . Furthermore, suddenly interrupting training plan might be burden, in terms of physical and mental stress upon returning to regular training.

Therefore, an interruption in training may affect athletes condition upon return to training. Consequently, we focused on the salivary alpha-amylase activity (sAA), one of the physiologic stress markers, to assess university athletes’ condition after returning to team training. The sAA is associated with blood catecholamine level, which can evaluate the sympathetic nervous adrenomedullary system [2] . Therefore, this study aims to investigate the response of sAA whether there was an effect of interruption in team training on athletes still returning to training.

METHODS: Seventeen university track and field university athletes staying in a college dorm participated in this study. The measurement was performed before morning training, once a week, on Monday. They did not eat breakfast before measurements. Subjects took their own saliva on test strips. Their coach measured their sAA with an amylase monitor (NIPRO Co., Japan). Then, they reported their evaluation of subjective conditions from a scale of 1(bad) to 10(excellent). There were three examination periods was set, (I) after quarantine period, (Ⅱ) after team practice interruption, (Ⅲ) regular style training. The periods were each 5 weeks long.

RESULTS: The university athletes body characteristics and age were 171.0±5.4 cm and 55.8±5.7kg, and 19±1.0 years. Thirteen athletes participated in all the measurements, and these data were analyzed. Week 1, the sAA of I was significantly higher than the sAA of Ⅱ and Ⅲ（31.4±24.6 vs. 15.5±13.9 vs. 10.2±5.2 klU/L; p<0.05）. Week 2, sAA of I was significantly higher than the sAA Ⅱ and Ⅲ（29.4±20.5 vs. 9.3±6.2 vs. 9.8±5.7 klU/L; p<0.05）. Week 3, the sAA of I was higher than Ⅲ (15.7±17.0 vs7.1±5.1 klU/L; p<0.05). The subjective rating of the condition did not differ in the three periods.

CONCLUSION: Although the subjective condition scale did not differ in each period, the response of sAA was different in the detraining situation. Therefore, sAA may prevent underestimation of an athlete’s condition.

References:

1. Michele, G, et al., Detraining Effects Prevention: A New Rising Challenge for Athletes. Front Physiol, 2020. 15; 11:588784.

2. Yamaguchi M, et al., Hand-held monitor of sympathetic nervous system using salivary amylase activity and its validation by driver fatigue assessment. Biosens Bioelectron. 2006.15;21(7):p1007-1014.

### ELITE ATHLETES HAVE SIGNIFICANTLY ELEVATED SERUM BILIRUBIN CONCENTRATIONS

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INTRODUCTION: Bilirubin is a potent endogenous antioxidant and immunomodulating substance, implicated also involved in cell signalization and various metabolic pathways. Mild elevation of its systemic concentrations provides substantial protection against numerous oxidative stress and inflammation-mediated diseases. Rare reports in the literature suggest that serum bilirubin might also be relevant to physical performance. The aim of the current study was to evaluate serum bilirubin concentrations and prevalence of Gilbert syndrome in elite athletes.

METHODS: The study was carried out in 536 consecutive healthy elite athletes and in 2,594 individuals of the Czech post-MONICA study randomly selected from the Czech general population. Serum bilirubin concentrations, prevalence of benign hyperbilirubinemia >17 umol/L (1 mg/dL, a phenotypic sign of Gilbert syndrome, GS), and variant of the UGT1A1 promoter gene (rs81753472) were evaluated in study subjects.

RESULTS: As compared to Czech general population, significantly higher serum bilirubin concentrations were found in elite athletes (9.6 vs. 11.6 umol/L, $p<0.001$), and this difference was observed in both men (11.3 vs. 12.6 umol/L, $p<0.001$) and women (8.3 vs. 10.5 umol/L, $p<0.001$). In addition, also the prevalence of a phenotypic GS was significantly higher in elite athletes (9.6 vs. 22%, $p<0.001$). Serum bilirubin concentrations in elite athletes were positively correlated with serum total antioxidant status ($p<0.05$).

CONCLUSION: Elite athletes have significantly higher serum concentrations of serum bilirubin, the most potent endogenous antioxidant substance. Simultaneously, also the prevalence of GS syndrome is much higher in elite athletes, suggesting that mild elevation of serum bilirubin might predispose to better physical performance.

### WHICH STIFFNESS INDEX COULD IDENTIFY SINGLE-LEG VERTICAL JUMP ASYMMETRY IN ACLR ATHLETES: A PILOT STUDY?

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INTRODUCTION: Stiffness comes from Hooke's law and considers the body as a spring, the ability of the body to absorb force and transfer it to movement. Several factors could affect stiffness, including muscle, tendon, ligament, cartilage, and bone. In addition, the asymmetries of kinetics and kinematics characters influence injuries as well. Limb asymmetry still could be found in patients with ACLR (anterior cruciate ligament reconstruction, ACLR) after one year of rehabilitation. Research indicates that the asymmetries of vertical stiffness could represent by ankle joint stiffness calculated from the landing mechanism in healthy men. However, the ankles critical impact on vertical stiffness asymmetries in the ACLR group was still unknown. This study aimed to discuss which joint stiffness index is essential to the ACLR group during single-leg vertical jump.

METHODS: There were 3 ACLR male athletes participated in this study. A 9 camera motion capture system (Vicon, 200Hz) and a force plate (Kistler, 1000 Hz) were synchronized to collect kinematic and kinetic data from single-leg vertical jump protocol. The vertical stiffness index (Kvert) was calculated from the ratio of peak ground reaction force (N) to peak center of mass displacement (m) and normalized by body weight (Kg). The joint stiffness index (Kjoint) of ankle and knee joints was calculated as the ratio of the change in joint moment (Nm) to the change in joint angular displacement. Asymmetries were calculated using the method of absolute symmetry index (ASI). Data was presented in a descriptive format.

RESULTS: All ACLR participants' affected side are left. Left Kvert (55.0) was smaller than right Kvert (61.2). Left ankle Kjoint (1.7) was smaller than right ankle Kjoint (1.9). Left knee Kjoint (2.4) was smaller than right knee Kjoint (3.6). The ASI of Kvert was 10.4. The ASI of ankle Kjoint was 11.1. The ASI of knee Kjoint was 45.8.

CONCLUSION: The present results of this study indicated that ACLR limbs demonstrated smaller stiffness in Kvert and Kjoint index. In addition, the results of ASI showed a similar pattern between Kvert and ankle Kjoint. The ACLR participants were able to return to sports normally. However, from the stiffness and asymmetry index, we could still discover differences between affected and non-affected limbs. ASI of Ankle Kjoint was similar to Kvert, which indicated ankle joint might play an essential role for ACLR athletes in single-leg vertical jump tasks. Therefore, in the future, rehabilitation for the ACLR group maybe not only focus on the knee but on the functional performance of the ankle joint as well.

### DYNAMIC POSTURAL CONTROL DURING SINGLE-LEG LANDINGS IN ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTED INDIVIDUALS AFTER RETURN TO PLAY- A PILOT STUDY

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INTRODUCTION: Dynamic postural control is a complicated coordinating result of individuals accepting signals from the visual, vestibular, and somatosensory systems, then processing them through the central nervous system and finally responding. It is known as the ability to transit from moving the action to a static state while maintaining stability. Landing tasks are often used as a screening procedure for dynamic postural control. Landing tasks provide more stimulation of feedforward components in sensorimotor control and higher ground reaction force than static balancing. They can also reflect our moving patterns in sports better. Anterior cruciate ligament injury is one of the most common non-contact injuries in sports. Patients with anterior cruciate ligament reconstruction (ACLR) have been found with altered landing strategies in injured legs even after return to sport and risk of re-injury due to the deficit of dynamic postural stability. Thus, this study would like to discuss dynamic postural control between legs of ACLR athletes through time to stabilization (TTS) and dynamic postural stability index (DPSI) during single-leg drop landing tasks.

METHODS: There were 3 ACLR male athletes participated in this study. A 9 camera motion capture system (Vicon, 200Hz) and a force plate (Kistler, 1000 Hz) were synchronized to collect kinematic and kinetic data from a 30cm height single-leg drop landing (SLDJ) and single-leg vertical jump (SLVJ). Three successful trials were conducted from each leg during tasks. TTS was defined as the time from landing to static state and was collected and calculated from ground reaction force (GRF) in 3 directions (anteroposterior (AP), mediolateral (ML), and vertical (V). DPSI was a combination measurement of mean squared deviations of GRF in 3 directions (AP, ML, and V). Data was presented in a descriptive format.

RESULTS: The AP_TTS, ML_TTS, V_TTS, and DPSI of ACLR limb in SLVJ were 2.78±1.03, 2.73±0.43, 1.36±0.64, and 0.13±0.01; and of healthy limb were 3.01±1.38, 3.12±1.11, 1.12±0.45, and 0.17±0.00 respectively. The AP_TTS, ML_TTS, V_TTS, and DPSI of ACLR limb in SLDJ were 2.14±1.04, 3.10±0.34, 0.97±0.51, and 0.18±0.03; and of healthy limb were 2.80±1.46, 3.61±1.47, 0.87±0.21, and 0.19±0.01 respectively.

CONCLUSION: There was no tendency of difference of AP_TTS, ML_TTS, V_TTS, and DPSI between healthy limbs and ACLR ones in both SLVJ and SDJL. More ACLR participants should recruit for this study for further analysis.

**DEVELOPMENT AND VALIDATION OF AN OVERUSE INJURY QUESTIONNAIRE FOR YOUTH ATHLETES: THE YOUTH OVERUSE INJURY QUESTIONNAIRE**

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INTRODUCTION: Current overuse injury registration methods may underestimate the prevalence and severity of overuse injuries for youth athletes. This study developed and validated a new injury registration method for youth athletes based on the improved Oslo Sports Trauma Research Centre Overuse Injury Questionnaire (OSTRC-O2), termed as the Youth Overuse Injury Questionnaire (YOvIQ).

METHODS: A repeated measures study design with two time points (T1 and T2) was conducted (minimum interval of 7 days) among 42 competitive youth volleyball athletes between the ages of 12 to 18. Content validity, construct validity, and test-retest reliability were ascertained. Prevalence of “time loss” and “medical attention” injuries were also investigated.

RESULTS: In both T1 and T2, YOvIQ captured 5.1% more shoulder overuse problems and reported higher severity scores than OSTRC-O2. A substantially lower number of “time loss” and “medical attention” shoulder overuse problems were reported than YOvIQ in both T1 (n = 3, n = 1, n = 9) and T2 (n = 2, n = 2, n = 11), respectively. McNemar’s test for prevalence rates reported non-significant differences for construct validity (n = 39, p = .50) and test-retest reliability (n = 29, p = 1.00). Severity scores were valid and reliable (n = 39, rs (37) = 0.89, p < .001; n = 29, ICC = 0.86, 95% CI [0.72, 0.93]).

CONCLUSION: The YOvIQ is a valid instrument to determine the prevalence and severity of overuse injuries in youth athlete populations.

**INFLUENCES OF ELECTRICAL STIMULATION AT DIFFERENT TIMES ON FEMORAL BONE LOSS IN HINDLIMB-SUSPENDED RATS**

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INTRODUCTION: It is desirable to keep the duration of electrical stimulation as short as possible, considering the influences of electrical stimulations on the body. This study aimed to investigate the influences of electrical stimulation at different times using hindlimb-suspended rats in order to obtain an effective electrical stimulation time for bone loss associated with weight reduction.

METHODS: Forty-eight male rats (wistar strain, 7-week-old) were used as materials. They were divided into a hindlimb suspension group (HS), an electrical-stimulated group that received the electric stimulation during the period of hindlimb suspension (VP), and a control group (CO). Furthermore, VP were subdivided into 15, 30, 60 and 90minute groups (VP15, VP30, VP60 and VP90, respectively) according to stimulation time.

VP was stimulated electrically under the conditions of AC, voltage 67 mV, 0.13 mA, 20 kHz, for 5 days/week for three weeks, using an electric stimulation device (Sumida Electric Co., Ltd.). The electrical stimulation time of VP15, VP30, VP60, and VP90 was 15, 30, 60, and 90 minutes, respectively.

Femurs in each group were removed and histologically analyzed after the experimental period.

RESULTS: The thickness of the HS bone trabeculae was thinner than that of the CO. The trabecular bone of VP15 was as thin as HS, and the trabecular width of VP30, VP60, and VP90 was maintained. There was no difference between VP90 and VP60 in the thickness of the trabecular bone. In VP, trabecular width and density were maintained at energization times above VP30, with little difference between VP60 and VP90.

CONCLUSION: It was suggested that bone loss due to mechanical unloading might be suppressed by the electrical stimulation for 30 minutes or more a day.

**INFLUENCE OF TRANSCUTANEOUS ELECTRICAL STIMULATION ON THE HEALING PROCESS AFTER BONE INJURY**

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INTRODUCTION: The purpose of this study is to histologically investigate the effect of transcutaneous electrical stimulation on the initial repair process of bone from the inflammatory phase to the callus formation phase among these repair processes.

METHODS: Seven-week-old male rats (wistar strain) were used as materials and divided into a bone injury / natural healing group (NH), a bone injury / transcutaneous electric stimulation group (TE), and a control group (CO). Bone injuries with a diameter of 2.0 mm were created in the tibia in NH and TE and they were euthanized on days 0, 1, 3, 5 and 7 after the bone injuries. TE was electrically stimulated Using a low-frequency treatment device (BioTrainer1 manufactured by Oshima Co., Ltd.), the electrical stimulation was performed from the left and right of the distal thigh under anesthesia. The electrical stimulation conditions were 60V direct current, frequency 50Hz, 200μsec, and carrier frequency 80kHz. Under these conditions, the electrical stimulations were performed for 10 minutes /day, every day for 1, 3, 5 or 7 days.

The tibia in each group was removed and various specimens were prepared for histological observation.

RESULTS: On days 1 and 2 of bone injury（NH1）, A small hematoma was seen in the injured area and a fibrous network formed around the hematoma. On day 3, the hematoma was extensive and the fibrous network was similarly extensive in NH3. On the other hand, it was recognized that the hematomas and cells tended to accumulate near the center of the bone injury in TE3. On day 5, a hematoma was seen near the center of the bone injury, but fibrous bone was formed in the fibrous network surrounding the hematoma that showed a pale purple color by toluidine blue staining in NH5. In TE5, bone tissue was formed to fill the bone injury as seen in NH7. Then, on day 7, the hematoma disappeared and the fibrous bone seen on day 5 was seen throughout the injured area in NH7. On the contrary, in TE7, the thickness of the bone that fills the injury part increased.

CONCLUSION: Hematomas formed at the site of bone injury with inflammation, which were shown to be more pronounced on day 3. On day 5, the hematoma tended to disappear, which was accompanied by the formation of fibrous bone in the fibrous network around the hematoma. In contrast to the repair by natural healing, the electrical stimulation shifted to the phase two days earlier, and it is considered that the energization stimulus increased the activity of the tissue. It was suggested that the electrical stimulation during the initial repair process of bone injury may have a repair-promoting effect.

### INJURIES AMNONG YOUTH EQUESTRIAN RIDERS – NORMS, ATTITUDES AND RISK-TAKING IDEALS ON SOCIAL MEDIA

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INTRODUCTION: Further research on injuries among youth athletes is needed not the least in relation to specificity in age, level and sport (Bergeron et al., 2015, Arvinen-Barrow et al., 2016; Finch & Donaldson, 2010; Verhagen et al., 2010). Cultural predispositions and values towards injuries can be dependent on what type of sport is studied (Arvinen-Barrow et al., 2016). Equestrian sport is a high-risk sport (Buckley et al., 2004) and the risk for injuries is highest among riders between 10-19 years old (Loder, 2008; Moss, 2002). Equestrian sport is divided into different disciplines such as showjumping, dressage, eventing and it is possible that values related to injury and risk for injury could vary between different disciplines. So far, injury risk assessment and risk-taking in equestrian sports has been studied using interviews with adult equestrians in eventing. Ekberg et al., (2011) found that attitudes to risk taking was the only predicting factor leading to injury. Furthermore, being in a competitive setting can encourage risk-taking (Thompson & Nesci, 2016). Attitudes towards the use of helmets were also related to risk-taking and a feeling of the inability to control the likelihood of accidents (Haigh & Thompson, 2015). However, there is sparse research on attitudes towards risk-taking (Thompson et al., 2015) in youth riders and their coaches and how this could influence the onset of injuries. This study will focus on values towards injuries, risk-taking attitudes and cultural ideals represented on social media in relation to equestrian sport and injuries.

The purpose of this study is to identify social media ideals, values towards injuries and in risk-taking attitudes among youth equestrian riders in relation to injuries in different disicplines.

METHODS: Netnography of multiple digital platforms will be conducted on digital content related to injuries in equestrian sport and children and adolescents. Relevant and commonly hashtags will be targeted as well as, at the moment, most popular influencers and coaches in the equestrian community. The media content is analyzed using a deductive thematic analysis (Graneheim & Lundman, 2004; Sparkes, 2014).

RESULTS: This study is still ongoing, but preliminary results show that a divide in the discussion about helmet-wear during elite level dressage is still ongoing. Photos and videos show a romanticized picture, literary, of riding on beaches without helmet. Moreover, children managing to stay put on difficult horses that misbehave is praised in the commentary section.

CONCLUSION: So, by looking on values towards injuries, risk-taking attitudes and cultural ideals in several disciplines and especially in the youth equestrian community on social media we hope to achieve a deeper understanding on how this influence the high risk for injuries among youth.

### EVALUATION AND RELATIONSHIP BETWEEN PAIN, FUNCTIONALITY AND MRI FINDINGS IN PATIENTS WITH PATELLOFEMORAL PAIN ACCORDING TO GENDER.

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INTRODUCTION: Pathogenesis of patellofemoral pain (PFP) has been attributed in part to structural abnormalities of the patellofemoral joint. There is still concern about the role of degeneration of the retropatellar cartilage in PFP. To distinguish pathological features of early knee osteoarthritis from thise related with aging continues to be a great challenge. Women with PFP exhibited greater peak cartilage stress than males, which could possibly account for the greater prevalence of PFP in women. However, other biological and mechanical factors could definitely play an important role in this complex anterior knee pain. It is hypothesized that changes pain, functionality, and kinesophobia are not related to structural changes measured by quatitative MRIs. To evaluate the differences pain, functionality, and kinesophobia in patients with PFP and examine the relationship of each parameter to MRI findings.

METHODS: A cross-sectional study was design including 100 subjects with PF . There were 60 males (mean age, 45,52 years ± 11,59 SD; weight, 84,30 ± 14,67 SD and height 1,76 ± 0,07 SD) and 40 females (mean age, 47,56 years ± 12,83 SD; weight, 70,04 ± 15,13 SD and height 1,64 ± 0,06 SD). The Western Ontario and Mcmaster Osteoarthritis (WOMAC) index, Visual Analogue Scale (VAS) of 10 mm length, and the Tampa Scale of Kinesiophobia (TSK-11) were used to assess clinical findings of osteoarthritis in this sample. Knee cartilage T2 mapping images using 3.0 MRI system were also obtained. Analysis by gender was carried out.

RESULTS: Significant gender differences were found in most clinical variables (mean VAS: p=0.020; peak VAS: p=0.028; WOMAC pain: p=0.010; WOMAC stiffness: p=0.043; WOMAC functionality: p=0.004). Differences in TSK-11 scores were not statistically significant (p=0.052). No correlation were found in the measurements obtained of the osteochondral structure by MRI and the rest of variables. (Fig 1).

CONCLUSION: According to these findings, the cartilage state obtained through MRI did not differ between males and females, but significant differences were found between gender in the rest of the parameters. Furthermore, it appears that there is no strong association between MRI images and functional parameters among patients with PFP.

### LONG-COVID SYNDROME AND ITS INFLUENCE ON EXERCISE CAPACITY AND QUALITY OF LIFE

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INTRODUCTION: Long-Covid syndrome is defined as the persistence of symptoms beyond 4 weeks after severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. The most common symptoms include reduced exercise tolerance and capacity, fatigue, neurocognitive problems, muscle pain and dyspnea (1). The aim of our work was to investigate the exercise capacity and quality of life (Qol) in patients with diagnosed Long-Covid syndrome.

METHODS: We examined a total of 53 patients (19 male/ 34 female; age 46.1 ± 11.2 years; height 170.9 ± 9.6 cm; weight 84.4 ± 21.2 kg; BMI 28.8 ± 6.6 kg/m2) in whom we assessed exercise testing on a cycle ergometer, a 6-minute walk test, the extent of fatigue by Fatigue Assessment Scale (FAS) and QoI with the SF-36 questionnaire.

RESULTS: On average the FAS was 34.7 ± 7.4 points, VO2max/kg: 22.5 ± 6.0 ml/kg/min, the 6-min walk distance: 526 ± 88m, the physical QoI score 35.0 ± 9.0 points and the mental QoL score 40.8 ± 12.7 points. Compared with normative values the VO2max/kg was reduced by 28.0%, the 6-minute walk test by 12.2%, the QoI physical sum score by 30.3% and the mental score by 20.9%.

There was no significant linear correlation between the FAS and the percentage of Vo2max/kg: ($r = -0.20$, $p = 0.16$), There was a significant correlation between the performance of the 6-minute walk test ($r = -0.40$, $p < 0.01$) and the FAS as well as in the percentage to the norm of QoI (physical score: $r = -0.41$, $p < 0.01$; mental score: $r = -0.37$, $p < 0.01$)

CONCLUSION: Patients with diagnosed Long-Covid syndrome had reduced exercise performance and QoI compared to normative values, which implicates the need for a targeted treatment. This emphasises the necessity for further research into the resumption of daily activities and regular exercise that play an important role in individual well-being and health-related quality of life.

1: Crook H et al.: Long covid-mechanisms, risk factors, and management. BMJ. 2021 Jul 26;374:n1648. doi: 10.1136/bmj.n1648

## RESEARCH ON THE STATUS AND HOT RESEARCH TOPICS OF THE PREVENTION IN SOCCER INJURY FROM 2001 TO 2021: A BIBLIOMETRIC ANALYSIS

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INTRODUCTION: To analyze the status and research focuses of the prevention in soccer injury, this paper used bibliometric softwareVosviewer v. 1.6.17 to analyze the data from Core Collection Database of the Web of Science by clustering analysis

METHODS: The data from Core Collection Database of the Web of Science was performed for the topic “soccer injury” and “prevention”, limited to document type (article or review) from 2001 to 2021.

RESULTS: 1.There are 2387 documents related to the prevention in soccer injury,the number of annual outputs has exceeded 300 per year.

2.The production of relevant articles in 79 countries between 2001 and 2021.The country with most publications was the United States (720, 20.6%),with an average of 46.97 citations, followed by the United Kingdom (293, 8.3%) Australia (232, 6.6%).

3. 2836 research institutions were included in this research. The University of North Carolina is in the first place with 74 publications(TLS=171),followed by the University of Cincinnati(TLS=234),with 66 publications and Ohio State University(TLS=140),with 65 publications.

4.The research on prevention in soccer injury is contained in 387 journals, among which the number of documents published of the top 10 journals accounted for about 38%. The top three journals in terms of number of publications are British Journal of Sports Medicine(163,TGCS=5060), followed by American Journal of Sports Medicine (156,TGCS=5041),Scandinavian Journal of Medicine & Science in Sports (100,TGCS=2333).

5.There are currently 54 subjects in the field of prevention in soccer injury. The area with the highest percentage of documents was Sports Science (1775,74.5%) followed by Orthopedics(548, 22.9%), and Rehabilitation (205, 8.6%).

6.High frequent keywords are: soccer 1072, prevention 821, risk-factors 796,injury589,training-program 115,neuromuscular control 93,acl 78.

CONCLUSION: 1.The research in this field has entered a stage of rapid development.Because of the COVID-19 epidemics,future research should focus on virtual training, players monitoring, taking more rigorous and long-term monitoring of clinical test results for soccer players.

2. About 74.36% of the papers are concentrated in sports science, orthopedics, rehabilitation and other fields, which shows that the research is not enough in other fields. Research institutions on football injury prevention are mainly concentrated in universities and scientific research institutions led by the United States, so this is one of the reasons why the United States has become the country that publishes the most articles in the field of football injury prevention.

3.The current hot researches mainly focus on training methods and monitoring methods of risk factors, such as Nordic hamstring training, FIFA11+ warm-up training, neuromuscular training, monitoring risk for injuries and machine learning, GPS medical treatment, data monitoring,so in the context of the COVID-19, future research should focus on how to develop better prevention methods with AI or VR.

## EFFECTS OF ELECTRICAL STIMULATION AT DIFFERENT FREQUENCIES ON STRUCTURAL CHANGES OF THE ARTICULAR CAPSULE OF RATS KNEE JOINTS BY IMMOBILIZATION

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INTRODUCTION: A life in which joint activity is restricted due to cast fixation after a fracture or joint surgery leads to joint contracture. Moreover, meta-analysis reports that long-term fixation causes irreversible range of motion limitation and reduces the patients activities of daily living (ADL) and athletic performance. Therefore, the development of therapeutic and preventive methods is of great significance. Previous studies have shown that energization stimulation suppresses the progression of joint contracture. However, it has not yet been clarified how the frequency of energization is changed and how it affects the fibrosis of the joint capsule. On the other hand, immobilization causes a hypoxic state in the joint capsule and also begins to secrete the fibrosis-promoting cytokine TGF-β1, which acts on fibroblasts to myofibroblasts with high collagen-producing ability. The purpose of this study was to clarify the systematic changes in joint contracture caused by immobilization of different frequencies and the status of cytokines in the joint capsule.

METHODS: Using 30 7-week-old rats, they were divided into 5 groups, IM group CO group VP2kHz group, VP20kHz, VP200kHz (6 animals each). In this experiment, the immobility device is attached to the rat, and the immobility device is attached to both legs for 3 weeks. Furthermore, at the same time as immobilization treatment, continuous energization stimulation is performed for 30 minutes a day using a VP device. After the experiment was completed, he was euthanized and the knee joint was removed. Using them, decalcified paraffin sections and non-decalcified resin-embedded polished specimens were prepared, subjected to general staining and immunostaining, and observed with an optical microscope.

RESULTS: The fibrous layer of the IM group increased and adipocytes regressed. No increase in the fibrous layer was observed in the VP2kHz group and the VP20kHz group. On the other hand, in the VP200kHZ group, it was observed that the fibrous layer increased and

adipocytes regressed. As a result of immunostaining, the appearance rate of α-SMA positive cells in the immobile group was significantly higher than that in the control group. On the other hand, the appearance rates of VP2kHz and VP20kHz α-SMA positive cells were not significantly different from those of the control group.
CONCLUSION: Myofibroblasts in the posterior capsule proliferate due to activity restriction, but it was speculated that low-frequency electrical stimulation has the effect of suppressing the proliferation of myofibroblasts.

## Statistics and Analyses

### 1/F SCALING IN THE DYNAMIC BEHAVIOR OF TENNIS PLAYERS AS A SELF-ORGANIZING SYSTEM

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INTRODUCTION: The behavior of dual sports such as squash and tennis showed a systematic fashion as self-organized complex systems [1, 2]. Tennis players demonstrate coupled oscillators that layers tried to come back to the position near the center mark repetitively. The aim of this study was to investigate the dynamic behavior of elite tennis players in a competition, comparing the behaviors between the players in terms of the distance from the center mark as a nonlinear complex system.
METHODS: Three matches of male elite tennis players, including (1) top-ranked vs. low-ranked players, (2) top-ranked vs. top-ranked players, and (3) junior top-ranked vs. junior top-ranked players, were selected for assessment. From every match, we captured the frames (634, 1538, and 687 frames, respectively) using Kinovea. Displacements of tennis players on the court were tracked using the Matlab program. We calculated the distance from the player to the center mark on the baseline and built a distance-time series. There were two different time series when player #1 receives and player #2 hits. Another is when player #1 hits and player #2 receives. Detrended fluctuation analysis (DFA) has proved useful for detecting long-range correlations in time series [3]. DFA alpha between $0<\alpha<0.5$ indicates more rough and random fluctuations. The alpha values between $0.5<\alpha<1.0$ indicate a long-range correlation.
RESULTS: In a match between top-ranked and low-ranked players, the mean distance of the winner was 2.88 (SD = 1.74) meters, whereas 2.96 (SD = 2.00) meters for the loser. DFA revealed a distance-time series for the winner was 0.53 and 0.47 for the loser. In a match between top-ranked players, the winner had a mean distance of 2.72 (SD = 1.28), and the loser had 2.57 (SD = 1.66). Both players showed random correlations as 0.45 and 0.47, respectively. In a match between junior players, the mean distance of the winner was 2.43 (SD = 1.44) and 2.58 (SD = 1.49) for the loser. DFA alpha for the winner was 0.58, while the loser exhibited 0.41.
CONCLUSION: Partially consistent with Kim et al.'s study, the behavior of top-ranked professional players did not exhibit long-term correlations [4]. In contrast, the winner of the junior match showed a long-term correlation in the distance-time series, indicating the winner stays near the center mark. In addition, the top-ranked player displayed a long-term correlation when competing with the low-ranked player. This result might show DFA alpha differs depending on the level of expertise. Future studies should consider female players at different levels of expertise, and more sample matches are required.
References:
[1] Palut & Zanone, Journal of Sports Sciences, 2005
[2] McGarry et al., Journal of Sports Sciences, 2002
[3] Peng et al., Chaos, 1995
[4] Kim et al., International Journal of Sport Psychology, 2015

### EXTERNAL AND INTERNAL MATCH LOAD OF INTERNATIONAL FEMALE FIELD HOCKEY PLAYERS ACROSS QUARTERS OF MATCH-PLAY

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INTRODUCTION: The change in the format of international field hockey matches has led to a scarcity of research concerning match load for female field hockey players across quarters of match-play. The main aim of this study was to examine whether there are positional- and between-quarter differences in match load for international female field hockey players.
METHODS: Twenty-three international female field hockey players were equipped with Global Positioning Systems and heart rate monitors while competing over nine international matches. Players were categorised according to playing position, namely forwards, midfielders and defenders.
RESULTS: Players covered a mean relative distance, relative player load, and distance covered in the form of low-, moderate-, and high intensity activities of 107.5 m/min, 10.3 AU/min, 41.6%, 47.9%, and 9.9%, respectively. Defenders achieved significantly ($p \leq 0.05$) lower relative player load and covered the least distance in the form of high-intensity activities. Forwards and midfielders achieved the greatest relative load. Players spent a majority of match-play engaged at >85% of their maximal heart rate. Reductions in relative load were observed from quarters 1–4 across all positions. No significant between-quarter differences in internal load were observed.
CONCLUSION: The present findings provide a unique description of the work-rate profile of international female field hockey players, especially with regards to positional- and between-quarter match load. Findings highlight the need for coaches and conditioning coaches to implement conditioning programs that address the positional work-rate profile of players by closely replicating match activities. Therefore, training drills for Forwards and Midfielders should consist of repeated high intensity activities over shorter distances, incorporated with multiple accelerations, decelerations, and changes in direction, which closely replicate relative distance and relative player load observed during match-play. Although differences in external match load were observed from quarters 1–4, greater distances covered in the form of high intensity activities during quarter 4 compared to quarter 1 suggest that pacing strategies could be present. Findings highlight the importance of a well-developed aerobic- and anaerobic capacity to sustain bouts of high intensity activities as match-play progresses. No significant differences were observed for internal load between positional groups throughout match-play. This could be an indication that although the amount and intensity of work decrease as the match progresses, the physiological effect remains relatively stable. Findings on relative load from the current study allow coaches and conditioning coaches to prescribe conditioning programs specific to intensity zones of match-play.

## A PRELIMINARY OVERVIEW OF RESEARCH HOTPOTS IN SPORTS ARTIFICIAL INTELLIGENCE BASED ON KNOWLEDGE GRAPH

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INTRODUCTION: Artificial intelligence (AI) has been evolving in the last few years, and it represents the transform of the focus in sports domain. Thanks to the invention of various sensors, such as wearable sensors and video-based tracking system, a large amount of spatial and temporal location data and event data were collected. Therefore, AI has been of great importance in sports data analysis. In this paper, we investigated the research hotpots in the field of sports and AI based on knowledge graph algorithms since 2010. Recent research efforts into implementation of AI in sports have demonstrated great promise in recognizing action of athletes in games, physical education, monitoring healthcare and sports medicine.

METHODS: First, we searched for manuscripts across different knowledge fields that have been reported in the last decade in database of Web Of Science. The keyword was defined as Sports and Artificial Intelligence. The topic was selected because it was observed in the current applications of sports research. Then we obtained 860 related papers. After removing the less relevant terms, we picked out 261 terms occurred more than ten times and above 60% correlation of a total of 21,246 keywords. We used VOSviewer bibliometrics software to illustrate the most recurring terms found.

RESULTS: From knowledge graph we obtained by VOSviewer, four different groups were found: data-set (red), sensor (yellow), artificial intelligence (blue), machine learning (ML) (green). Among these recurrence terms, ML accounted for 24.7% and sensors 19.2%. ML performed better on the area of predicting results [1] and potential risk [2]. Wearable equipment and sensing devices have been widely used in collecting data in real-time. Compare to the date of papers, we can observe that the number of publication showed an exponential increase after 2016, before that there is little change in volume. From the time-coverage map, Research highlights in sports AI before 2018 were human action recognition and sports video, while physical education, sports medicine, the internet of things, human computer interaction and deep learning(DL) algorithm have become the new hotpots after that.

CONCLUSION: In conclusion, the number of articles published in the field of sports artificial intelligence has grown exponentially in recent years. The core topics are sensor technology, machine learning algorithms, classification and recognition accuracy. The applications of AI in sports are gradually changing from competitive sports to mass sports and school sports and DL are increasingly used in sports data analysis. In application scenarios, sports training and sports performance analysis were gradually transformed to sports prescription[3].

1.Phatak, A. A., et al. (2022) 2.Harada, G. K., et al. (2021) 3.Zhang, B., et al.(2021)

## THE RELATIONSHIP BETWEEN ACUTE:CHRONIC WORKLOAD RATIO AND INJURY RISK DURING THE IN-SEASON IN ELITE JAPANESE RUGBY UNION PLAYERS

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INTRODUCTION: Absolute weekly workloads (1-4 weekly) and acute workloads relative to chronic workloads have been investigated. However, the association between workload and injury may vary from sport to sport and competition league. Therefore, the purpose of this study was to investigate the association between workload and injuries in elite Japanese rugby union players.

METHODS: Fifty-two rugby union players (mean±SD; age, 27.7±3.2 years; height, 179.4±8.3 cm; body weight, 97.7±13.9 kg) from one elite Japanese rugby team were used as subjects during one in-season study. Training and match workloads were recorded as external loads (total distance, high-speed running (>5m/sec), acceleration and deceleration) using GPSPORTS-EVO (Catapult sports, Australia). All time-loss injuries were recorded during the period by a senior athletic trainer. Acute:chronic workload ratio (ACWR) was calculated by dividing acute workload (i.e. 1-week workload) by chronic workload (i.e. coupled and uncoupled rolling average 4-weekly workload). Players completed a Bronco test to assess injury risk in relation to fitness level. Generalized linear mixed model (GLMM) was used to analyze the relationship between ACWR and injury during the following week. These analyses can handle panel data (repeated individual measures). Model predictive accuracy was determined by area under the curve (AUC).

RESULTS: Greater association was found between high-speed running and injury than total distance, acceleration, or deceleration. High ACWR (>1.5) at high-speed running exhibited the greatest injury risk (Odds ratio = 7.14, 95% CI = 1.91 – 26.65) in the subsequent week.

Based upon the Bronco test performance, players with poor aerobic fitness had a greater risk of injury than players with better-developed aerobic fitness. Body fat percentage showed U-shape and was highly associated with an increased risk of injury for both high and low body fat percentage players.

CONCLUSION: We recommend that strength and conditioning coaches, involved in planning training for performance and injury prevention, monitor the ACWR, and avoid rapid changes of high-speed running that approach or exceed 1.5 in elite Japanese rugby union players.

## ESTABLISHING THE WEIGHTING OF POSSESSION ENDING FREE THROWS FOR FIBA MEN'S WORLD CUP

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INTRODUCTION: In basketball, points per possession measures the performance efficiency. Although the number of possessions in a game is not usually recorded on the box scores, the number of field-goal-attempts (FGA), offensive-rebounds (OREB), turnovers (TOV), and free-throw-attempts (FTA) found on common box score data can be used to estimate the number of possessions in a game. The possession-ending free throws is only a fraction of the number of free throws that is not identifiable from the box score, and the commonly used weighting (λ) of 0.44 was based on the data from NBA (Kubatko et al., 2007). The purpose of the study was to examine the ratio of possession-ending free throws to the total number of free throws in a game for the FIBA men's world cup and to compare the recorded number of possessions to the estimated number of possessions from the box score data.

METHODS: Seventy-six games (48 games from the preliminaries) of 2019 FIBA men's World Cup were analyzed. The number of possessions and free-throw occurrences were recorded for both teams of every game by 2 independent observers. The Cohen's Kappas were 0.92 and 0.9 for the intra- and inter-observer reliability, respectively. Data were analyzed separately for the preliminary and advanced rounds. Paired Sample t-test was used to compare the number of FTA between data recorded and in box-score published from FIBA. Linear regression was used to derive λ values from the recorded data and the independent t-test was used to compare the λ values. In addition,

Wilcoxon Signed-rank Test was used to compare the recorded number of possessions with the estimated number of possessions based on the derived λ and the box score data.

RESULTS: There were no significant differences for the number of FTA between recorded and box-score data for the preliminary and advanced rounds. The λ values of 0.47 and 0.45 were found for preliminary and advanced rounds with R2 higher than 0.96 for both groups and they were not significantly different (p=.22). No significant differences were observed for the number of possessions between the recorded data and the estimations based on the λ values and the box score data for the preliminary and advanced rounds.

CONCLUSION: The λ values derived for the preliminary and advanced rounds of 2019 FIBA men's world cup were higher than 0.44 of NBA derived value. Although the λ values of the two phases did not reach significant difference, there is a trend of higher ratio for less advanced level. We suggest that the λ value for estimating the number of possessions from the box score data should be empirically established for different levels of basketball games.

Key word：box scores, notational analysis

References

Kubatko, J., Oliver, D., Pelton, K., & Rosenbaum, T. D., (2007). A Starting Point for Analyzing Basketball Statistics, Journal of Quantitative Analysis in Sports, 3(3), 1-22.

### EFFECTS OF RACE DEVELOPMENT AND ORDERING STRATEGIES IN TRIATHLON MIXED RELAY

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INTRODUCTION: Triathlon mixed relay (MR) is characterized by the rapid race development and frequent changes of positions. However, the characteristics of MR race have not yet been fully clarified. The analysis of the race development and relay order of the 2019 World Triathlon MR Series indicated that 1) it is effective to maintain or improve the ranking in the third leg in order to finish at the top, and 2) it is effective to assign MR-specific members in the order formation. (Moriya, 2020).

This study aimed to examine to clarify the race development in MR in the Tokyo Olympics, and to obtain basic data regarding the strengthening strategy for the Paris Olympics.

METHODS: This study used Tokyo Olympic MR Results, Tokyo Olympic Individual Race Results, Olympic Qualification Rankings (OQR), and World Triathlon Rankings (WTR) published on the World Triathlon HP to analyze the relationship between them.

RESULTS: Race Development

1) As the race progressed, the time gap between leader and chaser increased.

2) The time difference increased significantly in run part of all legs.

3) In third leg, the time difference increased significantly in all three parts ($p<0.01$).

Relay Order

1) A tendency was observed to place higher performance athletes in first leg for female and in fourth leg for male.

2) The relationship between individual race, OQR, and WTR revealed that the correlation was higher in the order of individual race ranking < WTR < OQR.

3) The OQR total of two female athletes was found to have the highest correlation with MR ranking ($r=0.727$).

CONCLUSION: 1) The fact that no noticeable change in the race development appeared in two males legs can be attributed to the fact that two male from each country each had a high performance.

2) The performance difference between the contestants was greater for female than male. Therefore, many countries ordered athletes with higher performance in the first leg. This is thought to have led to a large time difference in the third leg.

3) The males and females legs are scheduled to be switched due to the revision of the WT competition rules starting in 2023. Therefore, the above trend is expected to change significantly.

## Training and Testing

### EVOLUTION OF PHYSICAL PERFORMANCE THROUGHOUT AN ENTIRE SEASON IN FEMALE SOCCER PLAYERS

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INTRODUCTION: Female soccer is becoming worldwide, however, researchers related with its physical and physiological demands are still scarce, with a reduced prevalence respect male soccer (1). In this regard, abilities as change of direction, acceleration capacity, muscle strength and endurance performance are frequently assessed in men soccer (2). Thus, knowledge of the evolution of these parameters would allow to coaches improving training methodology and optimize physical performance in women soccer. Therefore, the purpose of the present study was to analyze the evolution of physical performance throughout an entire season in female soccer players.

METHODS: Twenty-seven young women soccer players (21.2 ±7.6 years) participated in this longitudinal study, which consisted of examining the evolution of physical performance during an entire season. The following battery of tests was performed at pre-season (PS), end of pre-season (EP), half-season (HS), end of season (ES): change of direction (V-cut test), 20-m running sprint time (T20), vertical countermovement jump (CMJ), maximal dynamic strength (1RM) in squat exercise, and intermittent fitness test (30-15 IFT). The values are reported as mean ±SD. Statistical significance was established at the level of $p\leq 0.05$. Normality of the data was verified using the Shapiro-Wilk test. One-way repeated ANOVA measures was used to detect differences between the different time-points in the assessed variables. Bonferroni t-test was used for all pairwise multiple comparison procedures.

RESULTS: A significant increase in V-cut performance was observed throughout the season ($p=0.032$; PS: 10.07±0.52; EP: 10.03±0.06; HS: 10.11±0.47; ES: 9.89±0.48 s). However, no significant changes were observed for CMJ height ($p= 0,457$; PS: 21.6±3.7; EP: 21.9±4.2; HS: 21.5±3.6; ES: 22.3±3.4 cm). With regard to sprint performance (T20) a significant "time effect" was observed through the season ($p=0,023$; PS: 3.57±0.18; EP: 3.58±0.16; HS: 3.53±0.16; ES: 3.54±0.17 s), with an improvement in performance at HS. In incremental test was observed significant improvements throughout the season ($p=0,001$; PS: 29.6±9.02; EP: 31.07±8.2; HS: 35.5±9.2; ES: 38.4±10.3 kg). Significant improvements in endurance capacity (30-15 IFT) were observed throughout the season ($p=0.001$; PS: 15.2±0.9; EP: 15.6±1.3; HS: 15.6±1.1; ES: 15.9±1.2 km·h-1)

CONCLUSION: Our findings suggest that change of direction capacity and intermittent endurance performance improved through the season, whereas jump and sprint capacity did not improve and even declined at some point during the season in female soccer players. We therefore suggest that specific sprint, jump and strength training should be included during the season with this specific population, which should be easily included before technical-tactical soccer training.

**ANALYSIS OF PT, TW, IPSILATERAL AND BILATERAL RATIO IN COLLEGIATE FEMALE HOCKEY PLAYERS**

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INTRODUCTION: The purpose of this study is to diagnose and evaluate the balance ability between the left and right sides of the knee joint and the balance ability of the ipsilateral flexion force, which are important determinants of performance, by conducting an isokinetic muscle function test on H university womens hockey players of national representative level. At the same time, it aims to provide important reference points and implications for the prescription of professional physical training programs for each individual athlete.

METHODS: The subjects of this study were 16 college female field hockey players, who fully understood the purpose of this study and who actively expressed their intention to participate were selected. The physical characteristics of these athletes were age=19.79(±0.94)yrs, height=162.77(±5.75)cm, weight=57.14(±5.85)kg, body fat=25.76(±4.97)%. For the isokinetic muscle function test, the flexor force and extensor force of the knee joint were measured 5 times each at an angular velocity of 60$^{o}$/sec using Humac-Norm (USA). Preliminary measurements were performed twice in advance for the subjects adaptation. At this time, the rest time between measurements of the left and right knee joints was 1 minute to minimize the fatigue on the next measurement. For measurement variables, peak torque, total work, ipsilateral (H/Q ratio), bilateral (L/R ratio), and Left/Right Deficit were measured for isokinetic muscle function of the knee joint. For these muscle function variables, descriptive statistical techniques such as mean and standard deviation, maximum and minimum calculations were applied for each athlete using Window SPSS 17.0.

RESULTS: As a result of isokinetic knee joint function test of college womens hockey players, in extensors, peak torque was 222.88(±37.97)%BW, 225.56(±36.61)%BW, total work was 986.13(±145.85)%BW and 974.38(±131.14)%BW for the right and left sides, and the left and right deficit ratio were 8.56(±5.85)% and 10.31(±6.81)%, respectively. And in flexors, peak torque was 125.94(±25.45)%BW and 122.19(±27.74)%BW and total work was 622.38(±132.03)%BW 614.69(±110.46)%BW for right and left sides, and left and right (L/R) deficit ratio were 9.56(±7.69)% and 8.94(±7.44)%, respectively. The ipsilateral flexion/extension(H/Q) deficit was 56.88(±7.39)%, 66.81(±11.12)% for the right side, and 54.38(±8.44)%, and 65.00(±7.45)% for the left side, respectively.

CONCLUSION: In summary, the athletes participating in this study (1) the ipsilateral flexion ratio is lower than the standard value during peak torque, so hamstrings strength training that can be improved more than the current level is required. (2) Since both sides of the isokinetic muscle strength ratio in knee joints are in the normal range, it is recommended to sufficiently maintain the current muscle strength level.

**JUDO MATCH EXERCISE INTENSITIES IN THE JUDO WEIGHT DIVISIONS**

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INTRODUCTION: The determination of the exercise intensities of the Judo match can be very useful for coaches and players to optimize training sessions. Thus, the goals of the current´s study were to determine the exercise intensities of the Judo match (for the male and female divisions) and to define the type of relationship (independency or dependency) between the exercise intensities of the Judo match and the Judo weight divisions.

METHODS: Ninety-six (forty-eight males and forty-eight females) national and international level judoists were clustered on six groups considering the official weight divisions: lightweight ([ML]; -60kg, -66kg, -73kg), middleweight ([MM]; -81kg, -90kg) and heavyweight ([MH]; -100kg, +100kg) for males, and lightweight ([FL]; -48kg, -52kg, -57kg), middleweight ([FM]; -63kg, -70kg) and heavyweight ([FH]; -78kg, +78kg) for females. They participated in only one match against an opponent of the same sex and weight division. Matches were conducted following special rules to guarantee that all matches lasted 5 min (Franchini et al., 2013). Players wore an accelerometer that was located on their belly buttons with an adjustable elastic belt. Data obtained from the accelerometers were: Judo match time at different levels of exercise intensity (sedentary, light, moderate, vigorous and very vigorous) in sec.

RESULTS: Players of all weight divisions predominantly fought at moderate and vigorous intensities (ML, 184.2±40.1 sec -61.3±13.3%- and 84.3±38.3 sec -28.1±12.8%-; MM, 170.6±32.9 sec -56.9±11%- and 99.2±42.2 sec -33.1±14.1%-; MH, 157.6±33.7 sec -52.5±11.2%- and 105.1±27.5 sec -35±9.1%-; FL, 209.4±46.2 sec -69.8±15.4%- and 50.4±28.7 sec -16.8±9.6%-; FM, 184.1±31.2 sec -61.3±10.4%- and 63.1±28.4 sec -21.1±9.4%; FH, 162.3±19.6 sec -54.1±6.5%- and 107.2±27.9 sec -35.7±9.3%-, moderate and vigorous, respectively). The chi-square test suggested independency between the exercise intensities of the Judo match and the Judo weight divisions ($\chi$2=25.62, p=0.1787).

CONCLUSION: In their training, judoists of the all weight divisions should predominantly prepare for matches of moderate and vigorous exercise intensities.

**IS SIDE-SHOT SKILL IN BASKETBALL INFLUENCED BY EXPERIENCE IN SPORTS EVENTS, LENGTH OF PAST BASKETBALL EXPERIENCE, GENDER, AND STANDING HEIGHT?**

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INTRODUCTION: Skill tests are sufficiently valid to measure basic skills to be used in PE basketball classes, even in sports/PE-related universities or major courses. Favorite sports events that students in sports-related universities play every day might be involved in the measurement of the skill tests. Additionally, basketball experience so far, such as mini-basketball (basketball for elementary school boys and girls in Japan), gender, and standing height are thought to be involved in basketball skills. If these factors, in addition to learning effects in classes, are also related, grading in classes must be done taking these factors into consideration. Thus, the current study aimed to examine the associations of the side shot, one of the most important basketball skills, and these factors.

METHODS: 244 F-university students in the sports-related major course who took basketball PE classes were asked to participate a side-shot skill test. For the side-shot skill test, a shot was thrown from the side at a distant of 20.5 feet for males and 15 feet for females five times successively. This test was repeated four times. Additionally, the sports club they belonged to, gender, standing height, and

basketball experience from elementary school to high school were recorded. The sports clubs they belonged to were classified into basketball, ball games other than basketball, sports events other than ball games, and no club. However, the measurements of them were originally correlated because students to belong the same sport club practice identical training and the similar group of sports categories have similar movements. That is to say, there is a nested structure within each other. Thus, in this study, a mixed linear model was used with these factors as random effects.

RESULTS: When comparing deviance using a null model with only random effects (deviance =5100.8) and a full model with both random and fixed effects (deviance = 5072.8), significant model fitting was seen in the full model (chi-squared = 28.028, df=5, p<0.001). Variances as a random effect were 0.006 for individuals; 0.001 for clubs; 0.017 for sports categories; and 0.161 for residuals, indicating a significant difference in sport categories (p<0.001). This meant that the skill performance was thought to be determined by club categories which were grouped by roughly similar sports movements, but not individuals nor individual sports clubs. Regression coefficients as a fixed effect were -0.035 for males; 0.003 for standing height; and 0.003, 0.014, and 0.005 for basketball experience in elementary, junior high, and high schools, respectively. Among them, significant associations were found in standing height (to=2.505, df=233, p<0.05) and basketball experience in elementary school (to=3.585, df=235, p<0.001).

CONCLUSION: The side-shot skill test was involved in sports categories and was significantly influenced by standing height and basketball experience in elementary school.

## LONGITUDINAL CHANGES IN PASSING AND RUNNING SKILLS FOR AGILITY IN BASKETBALL ACCORDING TO SPECIALIZED SPORTS EVENTS

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INTRODUCTION: Skill tests have been used to measure basic basketball skills even in basketball PE classes at universities majoring in PE. However, in PE-majoring universities, since their students play their specialized sport events, their experience may influence skill tests. Simultaneously, it is thought that this also influences the effects of the PE classes. For instance, it is expected that students who play sports events similar to basketball will obtain poor PE effects and those who play different sports events will obtain good effects. Thus, this study investigated the longitudinal changes in passing and running skills for agility in basketball.

METHODS: Subjects were 244 university students (171 male and 73 female students) who take basketball PE classes in the PE-related faculty at F-university. They were asked to perform the Edgren ball handling test (Passing and running skill tests for agility, which measures the time required to throw the ball at a wall 10 times while running to the right and left within a 2m interval) twice. Then, their half-year development was examined according to their sports events and groups. The sports event groups were Basketball, Ball games except for basketball, Clubs except for ball games, No club in PE major, and No PE major. Since this repetition in each individual, sports event, and their groups was nested, a linear mixed-effect model was conducted using them as a random effect and time (before and after the classes), gender, and their interaction as a fixed effect.

RESULTS: As a result of deviance analysis of the Null model including only random effects (AIC=3777.6) and Full model including Time, Gender, and their interaction (AIC=3726.79), a significant level of fitness (Chi-square =56.81, df=3, p<0.001) was found. Through independent variable selection using likelihood ratio tests, the model (Selected mode, AIC=3719.5) removing the random effects of the slopes of the clubs and groups of clubs was chosen. Intraclass correlation coefficients were high with 0.764 and 0.798 in the intercept and slope of Individuals, but low with 0.268 and 0.486 in the intercepts of Clubs and Groups of Clubs. That is, an innate wide range variability was found in Clubs and Groups of Clubs, but a narrow range one in PE class effects, and irrespective of specified sports events, both the innate and classes effects at the individual level were large. The partial regression coefficients of Males, Time, and their interaction were -1.058, 0.033, -0.948, respectively, indicating that Males and interaction were significant. That is, a remarkable gender difference was found, males are superior to females, and only the PE class effect was found in Males, but not in the whole class.

CONCLUSION: A small impact on specified sports events was found with passing and running skills for agility in basketball and depended on individuals. In addition, a high PE class effect was detected in males, but not in females.

## EXAMINATION OF BODY TYPES OF POWERLIFTERS

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INTRODUCTION: Specific body sizes (Nádori, 1991; Balogh at all, 2015) and body types are important selection criteria for professional athletes (Biróné, 2014). The aim of this study is to determine the main body sizes and body types of competitors in the sport of powerlifting. The results are compared with those described in the international literature.

METHODS: All Szombathely-based male powerlifters aged 18 and over participated in our study (N = 18). Their mean age was 28.4 ± 9.4 years. The InBody720 Body Composition Analyser device was used for the examination of the body composition, and an anthropometric measurement (Martin & Saller, 1957; Weiner & Lourie, 1969) was performed to determine the body size, during which 24 different parameters were recorded. From the obtained data, we determined the body type of the subjects based on the 6 types developed for athletes by Mészáros (1990). Basic statistics and a correlation matrix were used to evaluate the results.

RESULTS: Athletes had an average height of 177.44 ± 7.12 cm, an average body weight of 97.01 ± 14.12 kg, an average body fat weight of 15.95 ± 6.77 kg, an average body fat percentage of 16 ± 5.12%, an average skeletal muscle weight of 47.2 ± 6.15 kg and an average BMI of 30.4 ± 2.91. A strong correlation was found between skeletal muscle mass and right and left arm mass (r = 0.99), and between skeletal muscle mass and torso mass (r = 0.99). BMI correlated with chest depth and circumference (r = 0.87) and with forearm circumference (r = 0.88). Skeletal muscle mass was significantly correlated with limb muscle mass (right arm r = 0.99, left arm r = 0.98, right leg r = 0.95, left leg r = 0.93) and torso weight (r = 0.99). The body type of the participants was endo - mesomorphic (8 individuals) and mesomorphic (10 individuals).

CONCLUSION: Since the goal in powerlifting is to move great weights, the sport assumes significantly developed musculature (Ferland at all, 2020), and the body type of athletes is characterized by the endo - mesomorphic and mesomorphic types (Mackenzie, 2001). According to the results obtained, the athletes in the study have the appropriate body type and muscle mass required for powerlifting. Half of their average body weight is muscle mass, distributed evenly to the right and left, and between the torso and the legs. From this it can be concluded that the training performed in the sample meets the criteria of the sport.

## RELATIONSHIP BETWEEN KNEE STRENGTH, CHANGE OF DIRECTION SPEED, AND LEG MUSCLE MASS AMONG ELITE YOUNG SOCCER PLAYERS

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INTRODUCTION: The Change of Direction Speed is one the most important factors that influences efficiency in ballgames. Different authors came up with varied findings while carrying out internationally standardized COD tests and studying their connection with dynamic leg strength.

METHODS: Subjects: Forty-nine elite young soccer players (U16-U17; 178.59±6.29; 69.08±7.78). Measured body parameters [1]: Height; Weight; Right Leg Lean Mass (RLLM, kg) Left Leg Lean Mass (LLLM, kg). Change of Direction Speed [3]: Illinois Agility Test (IAT, s), 505 Right and Left change (s). Isokinetic Knee Strength parameters [2]: Extension and flexion right and left leg 2 and 15 repetition (N); H/Q Right; H/Q Left (%). CMJ (cm), CMJ Concentric and Eccentric averages (N), CMJ Flight Time (s). Instruments: InBody770, Witty Wireless Training Timer; HumacNorm isokinetic dynamometer; ForceDecks. Data processing: IBM SPSS Statistics 28 ($p<.05$).

RESULTS: The young soccer players' lean leg mass turned out to be symmetric according to our research (RLLM, 10.07±1.02; LLLM, 10.01±.95). They performed at COD tests much better than the average at international level (IAT, 15.56±.40; COD505L, 2.57±.12; COD505R, 2.55±.12).

Their average performances measured with isokinetic dynamometer were well balanced: H2ER (224.43±32.27), H2EL (218.09±33.66), H2FR (148.89±29.62), H2FL (147.86±22.44), H/Q2R (63.91±12.44), H/Q2L (67.83±10.03), H15ER (125.37±16.48), H15EL (125.77±16.85), H15FR (101.17±15.21), H15FL (102.48±14.96), H/Q15R (78.70±10.06), H/Q15L (84.94±15.90). The data measured on force plate were according to their age: CMJ (32.28±3.97); CMJC (1467.90±139.07); CMJE (728.45±80.48); CMJFT (.77±.11).

The Changes of Direction Speed (IAT) showed no significant correlations with the right and left leg lean mass, or any isokinetic knee strength (extension and flexion) parameters.

The COD505 tests showed strong correlations when carried out with different legs ($r=.769$; $p<0.001$), they only related to one CMJ parameter ($r=.448$; $p<.05$), it was only related to Left Leg Lean Mass ($r=-.447$; $p<.05$). However, the CMJ Contractive averages showed strong correlations in the case of both legs ($r=.692$; and $r=.707$; $p<.001$).

The CMJ Eccentric averages and the Humac2FR, 2FL, 15ER and 15FL were also related to each other ($r=.488$ - $.744$; $p<.05$).

CONCLUSION: It is difficult to find the relations between leg dynamic strength and traditional CODS tests. That is why we suggest improving both skills at the same time.

[1] Koltai, M. Gusztafik, Á. et al. (2020). The connection between the agility of adolescent soccer players and their body composition. Facta universitatis, Series: Physical Education and Sport, 18(3), 577-588.

[2] Salguero, G. C. et al. 2021. Isokinetic Profiles and Reference Values of Professional Soccer Players. Revista Brasileira de Medicina do Esporte [online], 27(6).

[3] Young, W. B., Rayner, R., & Talpey, S. (2021). It's Time to Change Direction on Agility Research. A Call to Action. Sport Med – Open, 7(12).

## EFFECTS OF A SPRINT TRAINING PROGRAM WITH CONDITIONED BRAKING ON HAMSTRING

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INTRODUCTION: Muscle strain injuries of hamstring in sports that involve running with acceleration and deceleration are very common and affects all levels of competition; furthermore, it's very common that a relapse occurs [1]. Hamstrings injuries during sprint usually occur in explosive gestures and biceps femoris is the most affected muscle [2].

Aim

To analyze the effects of a training program, based in sprint with forced braking, in muscle of posterior musculature of thigh.

METHODS: Material and methods

22 subject participated (22.0±2.2 years; 1.78±0.08m; 75.9 ±12.5 kg). Participants were randomly distributed into control group (CG, n=10) and experimental group (EG, n=12). Participants didn't follow any complementary resistance training or physical activity oblivious to the study. Training protocol consisted of 10 weeks training where EG performed 10 meter sprints at maximum intensity with a deceleration and forced braking of 2.40 m at the end of the sprint. The following variables were recorded before and after training program. Countermovement jump (CMJ) was recorded with force platform (IBV dinascan 600M). Lower leg strength was assessed with isokinetic dynamometer (Biodex System 3); concentric and eccentric torque peak was analyzed at different angular velocities (60º/s, 120º/s and 180º/s). Electromyography (EMG) was recorded for biceps femoris and semitendinosus in both legs (Delsys Trigno Wireless System) in breaking phase during 30 m sprint test and during 1RM in hamstring curl machine.

RESULTS: EG showed statistically significant differences in knee flexor and extensor muscles strength after training in concentric movement at 60º/s of angular velocity in both legs (pre = 93.8 Nm ± 24.2, post = 106.4 Nm ± 25.2, $p = 0.009$). EG improved eccentric strength at 60º/s in hamstring muscles of right leg (CG = -7.8 Nm ± 10.3, EG = 7.2 Nm ± 15.6, $p = 0.033$). Alike, right knee extensor muscles strength, at 120º/s, improved in left leg in EG (pre = 164.6 Nm ± 29.4, post = 188.4 Nm ± 23.3, $p = 0.001$). No statistically significant differences were found in EMG data.

CONCLUSION: Based on the results obtained in the present study, it is concluded that a sprint training program, based on accelerations with conditioned braking, favors the improvement of the eccentric and concentric force of the thigh posterior musculature.

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REFERENCES

[1] G. Freckleton y T. Pizzari, «Risk factors for hamstring muscle strain injury in sport: a systematic review and meta-analysis», Br J Sports Med, vol. 47, n.o 6, pp. 351-358, 2013.

[2] C. Woods, R. Hawkins, M. Hulse, y A. Hodson, «The Football Association Medical Research Programme: an audit of injuries in professional football—analysis of preseason injuries», Br. J. Sports Med., vol. 36, n.o 6, pp. 436-44

### VARIABLES OF THE PHYSIQUE IN YOUNG BASKETBALL PLAYER GIRLS

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INTRODUCTION: In the area of female sport it is an interesting and exciting topic, to investigate the differences of the bodily development level of matured and unmatured girls. In our sample the differences of the body parameters, if any, in a group of young basketball player girls, from Sopron, in Hungary were studied.

METHODS: Anthopometric parameters were taken (N=62, aged 9 to 16 years), somatotype components (Heath and Carter 1969), Conrad's growth type (1963), Drinkwater and Ross (1980) body fractionation method and body fat content (Pařizková 1971) were characterized by the maturational status. Menarcheal age was registered retrospectively. Basic statistics, Student t-test, linear correlation analysis were used to characterize and analyze the differences between the subgroups. Biological age was assessed by the morphological age (Mészáros and Mohácsi 1982).

RESULTS: The average menarcheal age of the girls (n=18) was 12,33 (±0,98) years, lower than the Hungarian menarche median (12.79 years). All the girls were taller and heavier than the reference values. The less differences occured in the 11 and 12 year subgroups. The largest differences occured in body mass at the age of 13yrs, and in stature from 13yrs on, presumably as the result of the selection. When comparing the matured and non-matured girls some characteristic differences were found: matured girls were more endomorphic, and less ectomorphic than non-matured ones. They had higher BMI (20.63±2,19 vs.17,82±3,24), body fat content (23,11±3,80 vs. 19,79±5,04), and lower bone percentage values. There were no differences in the muscle contents, supposingly because of the high variation.

CONCLUSION: It is important to understand the differences between matured and unmatured young athletes, especially because of the planning the workload and the evaluation of their performance.

### THE PE-CLASS EFFECTS OF BALL HANDLING SKILLS IN BASKETBALL ACCORDING TO SPECIFIC SPORTS EVENTS

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INTRODUCTION: Even in basketball PE classes at sports-related universities, skill tests have been utilized to confirm the PE class effects of basic skills. However, it is thought that the fact that students in sports-related universities have on their own specific sport may possibly impact the measurements of basketball skills. The same effect may emerge in the development of skills in PE classes. For example, the PE effects of those who have played basketball or similar ball games to date may be small, and large PE effects can be expected in those who have not experienced them. So, this study aimed to investigate the PE-class effects of ball-handling skills in basketball according to specific sports events. However, since students who have experienced the same sport events regarding whether ball handling skills are used or not might be similar to each other, taking these dependencies into account, a linear mixed model was used.

METHODS: The Zone toss test was given to 171 male and 73 female university students who were taking PE basketball classes at F-university. In the Zone test, subjects tossed the basketball over a 3m 5cm-wide and 2m 15cm-high rope and caught it on the other side 1m 93cm apart from one side after running under the rope. This action was repeated 10 times and the time required was measured. This test was repeated twice per subject. The differences in the measurements after half a year were examined. Specific sport events were hierarchically categorized into Basketball, Ball games other than basketball, No club, and No PE major. When using the linear mixed model, the nested individuals, clubs, and groups of clubs were used as random effects and Time (before and after PE classes), gender, and their interaction as fixed effects.

RESULTS: The results of a deviance test between the Null model with only random effects (AIC = 4201.4) and the Full model, including fixed effects (AIC = 4169.6), showed a significant level of fitness (Chi-square = 37.8, df = 3, $p<0.001$). The selection of independent variables using a likelihood ratio test chose the model removing the fixed effects of the interaction of Gender and Time and the random effects of the slopes of the Clubs and Groups of Clubs and the intercept of Groups of Clubs AIC=4161.6). Intraclass correlations were high with 0.912 in the slope and 0.764 in intercept, but low in the intercept of Clubs. Namely, the variances of Clubs and Groups of Clubs were small but original and class effects in individual levels were both large. With fixed effects, the regression coefficients of Male and Time were significant with -1.531 and -1.308, respectively, but their interaction was not. That is, it can be said that originally the skills of males were better than those of females and PE effects were consistently found between males and females as a whole.

CONCLUSION: The PE class effect of ball-handling skills was dependent on individuals but not their specified sport events and was found in both males and females.

### DOES THE PROFICIENCY OF SERVE RECEPTION INFLUENCE THE RESULT OF ATTACK IN ELITE VOLLEYBALL AND TO WHAT EXTENT?

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Introduction

Researchers have found an essential correlation between attack and the final result of the game in elite volleyball. Although attack is performed individually, it is preceded by cooperation between the setter and the receiver of serve (Drikos, Vagenas, 2011). Hughes and Daniel (2003) have found that proficiency of reception differentiates elite teams from mediocre ones.

Methods

The aim of the current study was to analyse players' individual proficiency of serve reception and its influence on the following attack in the Estonian national team during the qualification for the European Championship in 2016. The paper analyses eight games of the Estonian national team at the qualification tournament of the European Championship where a total of 31 sets were played. In the games played at the qualification tournament, 17 sets were won and 14 sets were lost.

The following indicators were written down from video recordings of the games: number of receptions of serve, proficiency of reception, reception zone, reception type. Attacks from zones 2, 3, 4 and the back zone were also counted – number of attacks, performer, zone of attack and proficiency.

Results and discussion

The results showed that the Estonian national volleyball team was most proficient at attack from grade five receptions (50.35%). In the case of very good reception, 91 points were scored from 139 attacks; 27 balls remained in play, and there were 21 errors. After receptions performed with grade four, the proficiency of attack was 40.86%; a total of 208 attacks were performed; 118 of them ended with a point for the Estonian team; 57 remained in play, and there were 33 errors. After receptions graded three and two, the proficiency of attack was considerably lower, 21.31% and -3.57% respectively. After receptions with grade three, 51 points were scored from 122 attacks; 46 remained in play and there were 25 errors. After receptions with grade two, from 28 attacks 6 points were scored, 15 remained in play, and there were 7 errors. This showed that, in the case of more successful serve reception, the Estonian volleyball team was more proficient at attack. Reception of serves by the Estonian team was more proficient in sets won than in sets lost; in the case of more successful reception the team was more proficient at attack than in the case of less proficient reception. The receivers of the Estonian national team were most proficient in the case of reception from above; serves were best received from zone 5.

References

Drikos, S., Vagenas, G. (2011). Multivariate assessment of selected performance indicators in relation to the type and result of a typical set in mens elite volleyball. International Journal of Performance Analysis in Sport, 11(1), 85-95.

Hughes, M., Daniel, R. (2003). Playing patterns of elite and non-elite volleyball. Journal of Performance Analysis in Sport.

**IDENTIFYING THE TRAINING LOAD OF SOCCER-RELATED DRILLS**

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INTRODUCTION: The purpose of the study was to determine the internal and external load of 2 popular drills used in soccer training. Specifically, the study examined a conditioned soccer game involving the ball possession time known as rondo and the small-sided game (SSG) drills.

METHODS: Seventeen professional male football players (age =27.5 ± 5 years; weight 73.48± 7.02 kg; body fat% 9.85± 3.64; VO2max 58.11± 5.53 ml/kg/min) participated in this study. The data were collected using the Wimu Pro device (RealtrackSystems, Almería, Spain) during the annual training of the soccer players. The data analysis included comparing the average of 10 SSG versus the average of 10 rondos. The internal load variables examined was the max heart rate (HRmax) and the average Hr (AHr). The variables examined denoting the external load were: total distance(m), explosive distance(m), number of accelerations, number of decelerations, maximum speed(km/h), average speed(km/h) and metabolic power (W/kg).

RESULTS: Results were analyzed using a mixed ANOVA design to compare the mean differences between groups (playing positional differences) and the within-subjects differences in the drills as mentioned earlier internal and external load parameters. The results demonstrated that the playing position had no significant effect on either the internal or the external load parameters. Additionally, SSG resulted in higher external load in all the parameters above except the number of accelerations and decelerations that, in turn, were significantly higher ($p < 0.05$) in rondos. The internal load parameters were significantly higher ($p < 0.05$) in SSG.

CONCLUSION: Using technology, fitness coaches can now identify the physical demands of soccer-specific drills. The findings of this study demonstrated the difference in 2 popular drills in soccer. Fitness coaches may use the results of this investigation to develop exercise regimens targeting the bioenergetics systems of their soccer players accurately.

**BILATERAL AND IPSILATERAL ASYMMETRIES IN LOWER BODY STRENGTH: A COMPARISON OF PROFESSIONAL AND UNDER-17 FEMALE SOCCER PLAYERS**

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INTRODUCTION: Although the risk of injury in soccer is multifactorial, the lower-limb strength, anterior-posterior balance and inter-limb asymmetries should be monitored for both performance and injury prevention purposes. Soccer players have shown differences in strength between the dominant and non-dominant limbs, which may be due to the technical elements performed during the games and training. Therefore, this study examined the lower-limb strength, bilateral and ipsilateral asymmetries in professional and Under-17 female soccer players.

METHODS: Thirty-seven players (professional =19, Under-17= 18) volunteered to participate in this study. The isokinetic knee strength and asymmetries were assessed utilizing the Humac Norm and Rehabilitation device. Testing included three maximal concentric flexion and extension repetitions at an angle speed of 60°/s.

RESULTS: Professional female soccer players exhibited significantly greater strength levels for the left quadriceps [$t(35)=2.39$, $d=0.79$, $p<0.05$] and both left [$t(35)=2.74$, $d=0.90$, $p<0.05$] and right [$t(35)=3.87$, $d=1.28$, $p<0.05$] hamstring muscles. Concurrently, the right leg ratio [$t(35)=2.76$, $d=0.92$, $p<0.05$] was significantly greater for the professional compared to Under-17 players. Lastly, professional players demonstrated significantly greater bilateral imbalances [$t(35)=3.13$, $d=1.04$, $p<0.05$] for the quadriceps muscle group.

CONCLUSION: The results of this study indicated that professional female soccer players demonstrate greater imbalances than Under-17 players, which may be attributed to the longitudinal effects of high-level soccer. Conclusively, soccer practice and competition at the professional level may induce greater lower limb asymmetries. Therefore, the isokinetic parameters can be useful for planning strength and conditioning interventions during the pre-season and in-season periods in order to reduce or prevent those imbalances.

**COMPARISON OF MUSCLE ACTIVITY OF 108 BOWS AND BURPEE TEST**

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INTRODUCTION: The 108 bow is known as a religious ritual, but it is a full-body exercise that complements the weak balance with incorrect physical activity or lifestyle and effectively uses each part of the body. The Buffy Test was developed in 1930 by American physiologist Royal H. Buffy as a way to evaluate physical strength and was used to evaluate agility and endurance, and was lying face down in a standing position. Not only athletes but also ordinary people are in the spotlight as a whole-body exercise to improve their physical strength because they can maximize the effect of exercise in a short period of time by repeating standing up movements. Several previous studies on 108 bows and burpee test exercise have reported that it is an effective exercise for improving physical strength and muscle strength, but scientific and quantitative research on the active muscles between each exercise is insufficient. Therefore, the purpose of this study is

to compare changes in muscle activity during 108 bows and burpee test exercises, which are similar exercises performed on the floor, and to present an effective exercise method.

METHODS: This study classified 22 adult men and women into 108 bows group (A) and burpee test group (B). An average value was applied after 10 operations, and a constant speed of 30 bpm was performed using a metronome. The body composition was measured by an inbody 720 measuring instrument, and the muscle activity of four muscles was measured through Noraxon MR3.

RESULTS: The results of this study are as follows. First, the comparison results of the muscle activity of Rectus Abdominis showed high muscle activity in all the buffy tests on the left and right, and a statistically significant difference between the two populations was observed in the comparison of the muscle activity of the right rectus abdominis($p<.05$). Second, the comparison results of the muscle activity of Rectus Femoris The muscle activity of both buffy tests appeared high, and there was a statistically significant difference between the two populations on both the right side ($p<.001$) and the left side ($p<.01$).

CONCLUSION: This study compared the muscle activity of erector spinae, gluteus medius, rectus abdominis, and rectus femoris between 108 bows and burpee test exercises, and found significant differences in both 108 bows and burpee tests. Based on the difference in muscle activity between 108 bows derived from this study and the two movements of the burpee test, cardiopulmonary endurance along with pre- and post-exercise studies can be measured and provided as basic data for more effective exercise program development.

## EFFECTS OF MOVEMENT AND STRENGTH TRAINING ON RUNNING ECONOMY IN ELDER RECREATIONAL MARATHON RUNNERS.

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INTRODUCTION: Recently, the efficacy of strength training for long distance runners has attracted attention, because strength training leads to an improvement in the running economy. Many of these studies have targeted young runners in their 20s and 30s, and the effect of strength training on running economy in elder runners have not been investigated yet. The purpose of this study was to investigate the effects of movement and strength training on running economy in elder recreational marathon runners.

METHODS: Six male and six female healthy elder recreational marathon runners (age, 59.0±8.0 and 53.7±7.8 yr; height, 170.4±5.6 and 160.5±6.2 cm; weight, 66.4±7.2 and 51.5±6.9 kg, respectively) voluntarily participated in this study. The runners performed strength and movement training twice a week (for once of each in group and in individual) for twelve weeks and running economy, quantified as oxygen cost of running at a given velocity on the treadmill, was evaluated before (PRE) and after the training period (POST). The movement training consisted of the drills to improve running movements; swing back of swinging leg and landing under center of mass, body propulsion with hip and hamstrings muscles of supporting leg and transmission of power to swing leg through pelvis. The strength training constructed of self-weight trainings with trunk, hip, waist and hamstrings, which leads to the above target running movements. The runners ran at three velocities for every 4 minutes (total twelve minutes) according to their performance level chosen by each runner, followed by a 5-minute break, and 1-min step incremental running test was carried out until an exhaustion point. Pulmonary gas exchange ($VO_2$) was continuously measured throughout the running test.

RESULTS: Running economy, expressed as $VO_2$ measured at three stages of three-constant velocities, in PRE and POST showed similar values for female runners (31.9±8.0 vs. 31.3±4.2 ml/kg/min in the first stage, 32.1±8.0 vs. 32.4±5.5 ml/kg/min in the second stage and 34.4±8.3 vs. 33.7±7.6 ml/kg/min in the third stage, respectively). On the other hand, the values in male runners were slightly lower in POST but not significant (31.0±3.6 for PRE vs. 30.2±2.4 ml/kg/min for POST in the first stage, 37.2±3.6 for PRE vs. 34.7±4.4 ml/kg/min for POST in the second stage and 43.7±8.7 for PRE vs. 41.5±5.0 ml/kg/min for POST in the third stage, respectively). Furthermore, $VO_2$peak in PRE and POST were almost the same values (38.5±7.6 vs. 39.0±5.2 ml/kg/min in female runners and 47.7±5.5 vs. 47.7±5.6 ml/kg/min in male runners).

CONCLUSION: The movement and strength training performed by elder runners in this study resulted in an insignificant improvement in running economy, suggesting that more longer training period than one used in this study or another training method may be needed to improve the running economy for elder recreational marathon runners.

## THE RELATIONSHIP BETWEEN BOUNCE-SHOT SKILLS AND VARIOUS FACTORS IN BASKETBALL EXAMINED USING A MIXED LINEAR MODEL

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INTRODUCTION: To measure basic skills in basketball, skill tests are adopted in PE basketball classes, even in sports-related universities. They are utilized also for grading students. As factors affecting the skills, in addition to gender and standing height, the influence of experience in childhood might have an impact, especially on basic skills, as well as on the latest playing experience. In addition, since students in a sports-related university/faculty have their own favorite/specific sports events, their experience might also influence it. If it affects skill evaluation, grading must be done taking it into consideration. Thus, this study aimed to examine the association between bounce-shot skill tests that measure a compound skill with dribbling and shooting and related factors.

METHODS: Two hundred and forty-four university students majoring in PE at F-university in Japan (71 males and 73 females) were asked to conduct a bounce-shot skill test four sets. The bounce-shot skill test was measured using the following procedure: Subjects were asked to shoot after dribbling from two spots 18 feet from the basket oriented at a direction of 45 degrees to the end line. This is repeated 10 times, alternatively right and left, as fast as possible. The scores of getting the basket were recorded. Additionally, they were classified into the following club categories: basketball, ball games other than basketball, sports clubs other than those for ball games, and no clubs. Since the data for students who are playing identical sports events seemed to be correlated, it was analyzed with a mixed linear model using individual repetition, clubs, and club categories as random effects because they were nested in this order.

RESULTS: Deviance analysis between the null model consisting of only random effects (deviance = 12135) and the full model consisting of both random and fixed effects (deviance = 12038) revealed that the full model represented significantly better fitness (chi-squared = 96.486, df=5, $p<0.001$). The obtained variances were 0.016 in individuals, 0.009 in clubs, 0.007 in club categories, and 0.195 in residuals, indicating that significant differences were found in individuals and clubs at the 1% level and in categories at the 5% level. From the viewpoint of fixed effects, the obtained regression coefficients were 0.0084 in males (The coefficient of females is set to 0 because of reference.), 0.003 in standing height, 0.036, 0.056, and 0.012 in elementary, junior high, and high schools, respectively. Then, significant

differences were found in gender (to=3.520, df=234, p<0.001); standing height (to=2.186, df=228, p<0.05); basketball experience in elementary school (to=4.086, df=230, p<0.001); and that in junior high school (to=4.015, df=227, p<0.001).

CONCLUSION: Significant variability was found in individuals, clubs, and club categories, and significant effects were found in all fixed effects, except high school experience.

### IS THERE A "WINDOW OF OPPORTUNITY" FOR FLEXIBILITY DEVELOPMENT IN YOUTH? A SYSTEMATIC REVIEW WITH META-ANALYSIS

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INTRODUCTION: Flexibility is an important component of physical fitness for competitive and recreational athletes. It is generally suggested that flexibility training should start from childhood (6 -11 years of age) to optimize joint range of motion (ROM) increases; however, evidence is limited and inconsistent. Therefore, the aim of this study was to examine if there is a difference in the effect of stretching training on flexibility during childhood (6-11 years of age) and adolescence (12-18 years of age).

METHODS: We searched PubMed Central, Web of Science and Scopus to conduct this systematic review and meta-analysis. Randomized controlled trials and non-randomized controlled trials were eligible. No restriction in date of publication was applied. Risk of bias was assessed using Cochrane RoB2 and ROBINS-I tools. Meta-analyses were conducted via an inverse variance random-effects model. GRADE analysis was used to assess the level of the quality evidence.

RESULTS: From the 836 records retrieved, 24 studies were included in the meta-analysis (n=1676 participants). Risk of bias was low in 66% of all criteria. Confidence in cumulative evidence was moderate. We found that stretching was effective in increasing ROM in children (SMD = 1.09; 95% CI = 0.77 to 1.41; Z = 6.65; p < 0.001; I2 = 79%) and adolescents (SMD = 0.86; 95% CI = 0.65 to 1.08; Z = 7.86; p < 0.001; I2 = 82%), with no differences between children and adolescents in ROM improvements (p = 0.25; I2 = 24.8%). However, when stretching volume was considered, children exhibited greater increases in ROM with higher than lower volumes (SMD = 1.21; 95% CI = 0.82 to 1.60; Z = 6.09; p < 0.001; I2 = 82% and SMD = 0.62; 95% CI = 0.29 to 0.95; Z = 3.65; p < 0.0003; I2 = 0%, respectively; subgroup difference: p < 0.002; I2 = 80.5%), while adolescents, responded equally to higher and lower stretching volumes (SMD = 1.00; 95% CI = 0.38 to 1.62; Z = 3.17; p = 0.002; I2 = 89%, and SMD = 0.84; 95% CI = 0.63 to 1.06; Z = 7.76; p < 0.001; I2 = 77%, respectively; subgroup difference: p = 0.64; I2 = 0%).

CONCLUSION: Systematic stretching training increases ROM during childhood and adolescence. When the effect of stretching volume is not examined, flexibility can be similarly developed throughout childhood and adolescence following systematic training. However, when higher stretching volumes are applied, larger ROM gains are induced in childhood than in adolescence.

### TRAINING PROGRAMME BASED ON INCREASING INTENSITY AND REDUCING VOLUME ON PERFORMANCE IN AMATEUR SWIMMERS PARTICIPATING IN OFFICIAL COMPETITIONS.

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INTRODUCTION: In recent years, training to prepare competitive swimmers has changed, introducing longer sessions (more volume) and higher intensity (Tate et al., 2012), leading to increased swimmer fatigue as a consequence of poor recovery (Lay et al., 2014). The aim of this study is to test whether the Ultra-Short Race Pace Training (USRPT) variant, which is based on High Intensity Interval Training (HIIT) methodology, improves swimmers performance, respecting the prevailing swimming style.

METHODS: During 12 weeks, 100 amateur swimmers participating in official competitions with different swimming clubs in the "Marina Alta" (Comunidad Valenciana, Spain), took part in this research. Aged between 11 and 21 years. All swimmers performed the crawl test and the styles test before, during and after the study. They performed intervallic training of 4 hours, distributed in 3 days per week, and reduced their weekly volume by 28%. The HIIT training included two sets. Set 1: USRPT 16X25m (400m) with 30 seconds recovery every 25m. Set 1: USRPT 8X50m (400m) with 30 second recovery breaks every 50m. Between sets, 300m of active rest using smooth crawl and technique. Recovery every 25 and 50 metres decreased to 25 seconds in both sets in weeks 9 to 12. The Critical Swim Speed (CSS) test and the Swolf test were used as tools to monitor performance.

RESULTS: There were significant improvements in performance. In the crawl 80.88% of the swimmers improved their personal best times. A similar result was obtained in the 100m styles, where 75.93% of the 54 swimmers improved their personal bests.

CONCLUSION: The performance of amateur swimmers participating in official competitions improved with a 12-week series-based HIIT training programme (USRPT), despite having reduced their training volume by 28%.

### INFLUENCE OF RACE WALKING TREADMILL TEST PROTOCOL ON VENTILATORY THRESHOLDS

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INTRODUCTION: In race walking (RW) there are no standard graded treadmill tests for determination of aerobic capacity parameters as it is the case in running. Test protocols with linearly progressive load which are used for running are not suitable for walking, since in the high intensity zone there is an exponential growth of energy consumption which significantly shortens duration of the test; moreover, lower VO2peak values are reported for walking in comparison to running. The aim of the study was to establish the influence of RW treadmill test protocol on the two ventilatory thresholds (aerobic, AeT; anaerobic, AnT) and related parameters (oxygen uptake, VO2; heart rate, HR; breathing frequency, BF; tidal volume, Vt; ventilation, VE).

METHODS: 34 amateur race walkers (19 men and 15 women) preformed two different graded race walking tests to exhaustion (at 1% treadmill grade), in random order: 1. with speed increments of 0,5 km/h every 30 sec (standard protocol used for running, T05) and 2. with speed increments of 0,3 km/h every 30 sec (finely graded load increments, T03). Quark b2 (Cosmed) metabolic cart was used for breath-by-breath data collection and analysis. Data were averaged for each step, at 30 sec periods, and the AeT and AnT were defined by the modified V-slope method. The Students t-test was used to determine differences, while Pearson correlation coefficient (r) was used to determine the relationship between parameters of the two tests.

RESULTS: At the AeT, the ventilatory parameters (VO2, BF, Vt, VE) did not differ between tests ($p > 0.05$ for all parameters). However, in T03 the RW speed was slightly, but significantly lower (7.01±0.60 : 7.32±0.76, p = 0,02) as well as HR (131±15 : 136±16, p = 0.01). Significant, but moderate relationships at the AeT were found between the tests (r = 0.50-0.80, $p < 0.05$). At the AnT, the ventilatory parameters (VO2, BF, Vt, VE) as well as HR did not differ between tests ($p > 0.05$ for all) while the RW speed was higher (8.69±0.77 : 9.06±0.83, p = 0.008). The highest maximum (technically correct) RW speed achieved in T05 was also higher (10.94±0.88 : 11.21±0.98, p = 0.005). Significant, but moderate relationships at the AnT were found between the tests (r = 0.55-0.85, $p < 0.05$).

CONCLUSION: Determination of VO2 and ventilatory parameters at the ventilatory thresholds for race walking is not protocol dependent. However, caution is warranted in test protocol implementation as race walking speeds at AeT and AnT are protocol dependent.

**INFLUENCE OF RACE WALKING GXT PROTOCOL ON VO2PEAK**

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INTRODUCTION: Unlike in running, in race walking there are no standard graded treadmill tests to assess aerobic capacity. The suitability of test protocols with linearly progressive load which are used for running is questionable for race walking, since in the high intensity zone there is an exponential growth of energy consumption, which significantly shortens duration of the test. The aim of the study was to compare two different test protocols and establish the influence of race walking treadmill test protocol on VO2peak.

METHODS: Thirty four amateur race walkers (19 men and 15 women) preformed two different graded race walking tests to exhaustion (at 1% treadmill grade), in random order: 1. with speed increments of 0.5 km/h every 30 sec (standard protocol otherwise used for running, T05) and 2. with speed increments of 0.3 km/h every 30 sec (finely graded load increments, T03). Quark b2 (Cosmed) metabolic cart was used for breath-by-breath data collection and analysis. Data were averaged for each step, at 30 sec periods, and the maximal VO2 value for a single step was considered as VO2peak. Students t-test was used to determine differences in functional parameters between the tests at VO2peak and the Pearson correlation coefficient (r) was used to determine the relationship between parameters of the two tests.

RESULTS: In the finely graded test a significantly higher VO2peak was found compared to T05 (47.1±6.2 : 45.9±6.0 ml/kg/min, p = 0.037), as well as higher maximum heart frequency (183.5±13 : 186.5±13/min, p = 0.004) and maximum minute ventilation (117.1±32.1 : 111.2±29.5 L/min, p = 0.013). On the contrary, a significantly higher maximal (technically correct) race walking speed was achieved in T05 (10.94±0.88 : 11.21±0.98, p = 0.005). Significant, high relationships were found between parameters of the tests (r = 0.76-0.95, $p < 0.05$).

CONCLUSION: In comparison to running (as a load modality), a more finely graded test protocol is recommended for race walking to determine parameters of aerobic capacity.

Sentija D. et al., 2009.

**HANDGRIP STRENGTH CAN BE USED AS A PROXY FOR UPPER EXTREMITY MUSCLE STRENGTH IN OLDER ADULTS - A CROSS-SECTIONAL STUDY.**

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INTRODUCTION: Handgrip strength measurement is relatively easy to perform, requires minimum equipment and is widely used to assess physical functioning in older adults. Therefore, it would be advantageous if handgrip strength could also be used as a proxy for upper extremity strength. Although a few studies have reported these associations in younger populations, there is a need to investigate these associations in older adults (1, 2). This study aimed to investigate the association between handgrip strength and upper extremity strength and evaluate how handgrip strength predicts upper extremity strength.

METHODS: 115 older adults (70 females) with a mean age of 74.7 (SD 6.3) years commenced physical rehabilitation in a Danish municipality. Handgrip strength (SAEHAN, hydraulic dynamometer), elbow flexion strength, elbow extension strength and shoulder abduction strength (microFET2, dynamometer) were assessed bilaterally. Wilcoxon signed-rank test showed no significant differences between the left and right sides for either gender, so an average across arms was used for correlational analysis. Multiple linear regression models were conducted, with the additional predictors´ age, gender, segmental fat-free mass for upper extremity and BMI, and the residuals tested for normality.

RESULTS: The median for the handgrip strength was 19.3kg [IQR 11.8 kg] for females and 36kg [IQR 16.5 kg] for males, which was lower compared with normative values (3). Spearmans correlation for handgrip strength and elbow flexion strength was (r=.84, p<.00), for handgrip strength and elbow extension strength (r=.83, p<.00), and handgrip strength and shoulder abduction strength (r=.75, p<.00). The multiple linear regression models accounted for 78% of the variation in elbow flexion strength, 79% of the variation in elbow extension and 59% of the variation in the shoulder abduction strength in the adjusted models.

CONCLUSION: The suggested regression models can predict strength in elbow flexion, extension, and shoulder abduction in older adults. The correlational coefficients presented in this study are generally consistent with previous studies in other populations (1, 2). The clinical implication of this study is that handgrip strength is strongly correlated with upper extremity strength in older adults commencing physical rehabilitation and can therefore be used as a proxy measure for upper extremity strength.

References

1. Ekstrand E, Lexell J, Brogardh C. Grip strength is a representative measure of muscle weakness in the upper extremity after stroke. Top Stroke Rehabil. 2016;23(6):400-5.

2. Horsley I, Herrington L, Hoyle R, Prescott E, Bellamy N. Do changes in hand grip strength correlate with shoulder rotator cuff function? Shoulder Elbow. 2016;8(2):124-9.

3. Steiber N. Strong or Weak Handgrip? Normative Reference Values for the German Population across the Life Course Stratified by Sex, Age, and Body Height. PLoS One. 2016;11(10):1-14.

**EFFECTS OF POST-ACTIVATION ENHANCEMENT (PAPE) IN ELITE VOLLEYBALL PLAYERS**

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INTRODUCTION: Post-activation performance enhancement (PAPE) is a widely described physiological phenomenon showing increases in exercise performance after previous muscle activation (1). Throughout the years authors have been studying the phenomenon but so far there was not found a consensus what are the ideal parameters of a conditioning activity (CA) to induce PAPE (2). However, authors generally tend to focus on different parameters of a CA and its responses on a given test. Our approach was different - we decided to evaluate the responses of the same CA in two different jumping tests: countermovement jump (CMJ) and squat jump (SJ). Additionally, accommodating resistance via elastic band was used to induce PAPE - a training method that is widely used in the sport and was already used in PAPE research (3).

METHODS: Twelve elite volleyball players experienced in resistance training (relative 1RM in a trap bar deadlift with accommodating resistance 1.92 ± 0.12 kg/kg body mass) performed four conditions: CMJ or SJ at the baseline (after standardized general warm up) and 90 seconds post CA [3 repetitions with 80% 1RM (aproximately 15% 1RM of elastic band) of a trap bar deadlift] and control conditions without CA.

RESULTS: The CA used in the study failed to enhance performances in SJ and CMJ in a group of all players. The difference between baseline and after CA in jump height (JH) was found to be statistically insignificant ($p>0.05$): in CMJ baseline 44.9 ± 4.3 cm to post 45.3 ± 4.6 cm; in SJ baseline 42.6 ± 4.2 cm to post 43.7 ± 3.6 cm. However, analysis of individual data showed more participants positively (changes in JH ≥ 0.1 cm) responding to a CA in SJ (8 out of 11, 73%; 1 player not performed it due to an ankle injury) than CMJ (6 out of 12, 50%). Additional analysis of players who responded positively to a CA showed a significant improvement in JH in CMJ and SJ.

CONCLUSION: We observed an individual PAPE response to a given CA. Even though baseline to post changes in JH for both jumps after CA were found to be statistically insignificant for all players, we noticed a different response regarding to a jumping test performed - more participants responded positively in SJ than CMJ. Despite both jumps having an existing movement direction specificity to a CA, SJ has the same type of a muscle contraction type as a trap bar deadlift (concentric from isometric position) while CMJ is an eccentric-concentric type of movement. Therefore, selecting the same muscle contraction type of a CA to an explosive exercise could be an additional component to consider while creating an effective protocol to induce PAPE.

References:

1. Blazevich A.J. & Babault N. 2019

2. Tillin N.A. & Bishop D. 2009

3. Seitz L.B. & Haff G.G. 2016

**BALLISTIC EXERCISE VERSUS HEAVY RESISTANCE EXERCISE PROTOCOLS: WHICH RESISTANCE PRIMING IS MORE EFFECTIVE?**

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INTRODUCTION: Recent studies have shown that ballistic performance may be enhanced for up to 48 hours following resistance exercise. This phenomenon is termed “delayed potentiation,” with resistance exercises performed for delayed potentiation being termed “resistance priming.” Harrison et al. (2019) suggested that low-load (30–40% 1 repetition maximum [RM]) ballistic exercise or high-load (≥ 85% 1RM) traditional exercise appears to be most effective resistance priming. However, it remains unclear which resistance priming is more effective on the day before a competition. Therefore, the current study aimed to determine which ballistic exercise priming (BEP) or heavy resistance priming (HRP) is more effective for improving ballistic performance 24 hours after.

METHODS: 10 resistance-trained men (age: 21.9 ± 1.8 years, height: 170.0 ± 4.3 cm, body mass: 69.6 ± 7.4 kg, half squat 1RM: 149.5 ± 16.8 kg, sports training background: 13.4 ± 2.9 years, resistance training experience: 4.2 ± 1.7 years, mean ± SD) performed BEP (5 × 4 jump squats at 40% 1RM with 3 minutes rest) and HRP (1 × 2 half squats at 60% 1RM followed by 3 × 2 half squats at 85% 1RM with 3 minutes rest) conditions 72–144 hours apart in a randomized and counterbalanced order. Jump performances (0 and 40% 1RM squat jump [SJ] height, countermovement jump [CMJ] height, and drop jump [DJ] reactive strength index [RSI = DJ height/ground contact time]) were assessed before and 24 hours after BEP and HRP sessions. The normality was tested using the Shapiro–Wilk test. Paired-samples t-tests were used to compare (a) jump performances 24 hours after the priming session with baseline in BEP and HRP conditions and (b) percentage changes in jump performances from baseline to 24 hours after BEP with HRP. Statistical significance was set at $p \leq 0.05$.

RESULTS: In BEP condition, 0% 1RM CMJ height 24 hours after the priming session was greater than baseline (+3.62%, $p = 0.002$), but not 0 and 40% 1RM SJ height, 40% 1RM CMJ height, and DJ RSI ($p > 0.05$). In HRP condition, none of the jump performances were improved ($p > 0.05$). Percentage change in 0% 1RM CMJ height in BEP condition was greater than in HRP condition ($p = 0.015$), but not 0 and 40% 1RM SJ height, 40% 1RM CMJ height, and DJ RSI ($p > 0.05$).

CONCLUSION: These results suggest that BEP is more effective than HRP for improving 0% 1RM CMJ performance 24 hours after. Therefore, practitioners should consider prescribing resistance priming using low-load ballistic exercise rather than high-load traditional exercise when planning to enhance athlete performance on the following day.

**PASSIVE ISOKINETIC CYCLING COMBINED WITH ELECTROMYOSTIMULATION IMPROVES MUSCLE STRENGTH IN THE ELDERLY**

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INTRODUCTION: Regular exercise maintains and promotes physical fitness and also improves physical and mental health. However, such exercise can be a challenge for elderly individuals who are not good at, do not like, or are too frail to exercise. Exercise itself can discourage exercise habits if it involves physical exertion or mental anguish. Therefore, we investigated whether passive isokinetic cycling (PIC) combined with electromyostimulation (EMS) can improve muscle strength in the elderly without physical exertion or mental anguish.

METHODS: Participants were 4 healthy men aged 64 to 78 years who performed PIC 3 times a week for 3 weeks followed by a 1-week break and then performed PIC combined with EMS (PICE) for 3 weeks. They were instructed not to pedal voluntarily and to completely relax their muscles during 10 min of cycling at 40 rpm. The EMS intensity used in the second 3-week period was based on the current value

at which the knee extension torque began to be increased by the EMS applied to the anterior thigh muscles in the supine position with the knee joint fixed at 90 deg. The intensity was set at 100% of the baseline value in week 4, 110% in week 5, and 120% in week 6. Morphometric parameters, jump parameters, muscle strength parameters, and kinesthetic sensation during exercise were measured to evaluate the effects of training before the start of the training period, 3 days after the end of week 3, and 3 days after the end of week 6.

RESULTS: PICE decreased body fat percentage by 4.0%, increased counter movement jump height by 8.2%, and increased maximal isometric knee extension and flexion torque by 19.5%–26.0% and 11.3%–60.6%, respectively, at all measured knee joint angles (20 deg, 45 deg, and 70 deg). In contrast, PIC decreased maximal isometric knee flexion torque by 23.2% at a knee joint angle of 20 deg. Both PICE and PIC increased the scores of the 30-sec chair stand test by 11.2% and 23.5%, respectively. All participants showed similar changes in the above areas, and the percent changes are the averages values for each measurement item. Despite the improvement in maximal strength after PICE, the participants did not perceive it as the kinesthetic sensation.

CONCLUSION: The results suggest that PICE with low-intensity EMS applied to all thigh muscles may improve physical fitness and body composition with only a short duration of training. Such an approach without physical exertion or mental anguish could be of benefit to a number of different populations. However, the finding that participants hardly perceived any improvement is not desirable for enhancing intrinsic motivation to develop and maintain exercise habits through physical competence. Therefore, combining PICE with a method for such competence may improve the effectiveness of the present method.

## COMPARISON OF SHOULDER MUSCLES ACTIVITY BETWEEN BARBELL PULLOVER AND CABLE PULL-DOWN EXERCISES

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INTRODUCTION: The barbell pullover (BPO) is a popular exercise which emphasizes the muscle action of the pectoralis major compared with the latissimus dorsi (LD) [1]. However, other exercises that involve the same movement but different force lever arm could imply changes in muscle participation, as the cable straight-arm pull-down (CPD). Since the shoulder extension is the prime movement of the BPO [2] and the CPD, other muscles besides the PM and LD act during this exercises due to their role during shoulder extension [3]. Considering that assessment of muscle activity is a necessary step before selecting the appropriate exercises for physical conditioning, we aimed to compare the electromyographic activity (EMG) of 8 muscles during 2 exercises with the same movement but with different body positions.

METHODS: Ten volunteers performed 5 repetitions of both BPO and CPD at 50% of the estimated one repetition maximum (RM). EMG activity was obtained for the LD, the clavicular (PMc) and sternal portion (PMs) of the Pectoralis Major, Anterior (AD) and Posterior deltoid (PD), Serratus Anterior (SA), superior part of the Trapezius (ST) and the long head of the triceps (LHT). Root mean square (RMS) was calculated for the concentric and eccentric phases and normalized with the value obtained during maximum voluntary contractions for each muscle (nRMS). Paired T-test was used to detect significant differences ($p<0.05$) between the 50%RM load used in both exercises. Separate two-way ANOVAs were used to detect differences in nRMS among exercises during the concentric and eccentric phase.

RESULTS: No statistical differences were observed among the averaged 50%RM load determined for each exercise ($p>0.05$). Except for the SA, significant exercise effect was observed for all muscles. The post-hoc analysis revealed higher nRMS values during BPO for PMc, PMe and DA muscles ($p\leq0.009$). In contrast, significant greater activity was observed in LD, TS, TR and DP during CPD ($p\leq0.033$). The phase effect resulted significant for PMe, SA, LD, TR and DP, that showed higher values during the eccentric phase ($p<0.008$). Furthermore, a significant interaction was found for PMe, LD, TR and DP, with a higher activity during the concentric phase of the CPD ($p\leq0.001$) and during the eccentric phase of the BPO for the TR ($p=0.002$).

CONCLUSION: The same movement performed in different positions induces differences in the activity of the muscles that act on the shoulder joint, possibly because of the differences in the moment arm. From a practical perspective these observations should be considered during resistance training programs when selecting each one of these exercises in a "pulling" or "pushing" session.

REFERENCES:

1. Marchetti, P.H. and M.C. Uchida, J Appl Biomech, 2011. 27(4): p. 380-4.
2. Leavy, C.M., Strength & Conditioning Journal, 2004. 26(2): p. 48-49.
3. Borges, E., et al., Journal of Physical Education and Sport, 2018. 18(2): p. 648-653.

## RELATIONSHIPS BETWEEN AEROBIC AND ANAEROBIC PARAMETERS AND THE CRITICAL POWER MODEL IN MALE JAPANESE COLLEGIATE ATHLETICS

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INTRODUCTION: The critical power (CP) model has been proposed as a method of assessing both aerobic and anaerobic work capacity in athletes. There are, however, few reports on the application of this model to all track and field athletics events. In this study we examined the relationships between parameters describing aerobic and anaerobic work capacity and those of the CP model, as well as the application of the CP model to each event group with respect to young male Japanese track and field athletes.

METHODS: We recruited 20 male Japanese track and field athletes with a mean age of 20 ± 1 y: five sprinters, four jumpers, and two decathletes (the SJC group); four middle- and long-distance runners (the ML group); and five throwers (the T group). They performed the CP test, the maximal anaerobic power test, and the 30-second Wingate test (WT) with a cycle ergometer. The CP test was performed at four exercise intensities (100%, 110%, 125%, 200% of $VO_2$ max) until exhaustion. We estimated CP and work capacity above CP (W') based on the linear relationship between time to exhaustion and total work. We measured maximal oxygen uptake ($VO_2$ max) as a parameter of aerobic work capacity and maximal accumulated oxygen deficit (MAOD), maximal anaerobic power, peak power, mean power, and percent decrease in power during WT as parameters describing anaerobic work capacity. We used correlation coefficients to determine the relationships between parameters of the CP model and those describing aerobic and anaerobic work capacity for each group of athletes.

RESULTS: The CP was significantly higher in the ML group than in the other groups, while W' was significantly lower in the ML group than in the other groups. There were significant differences in $VO_2$ max, maximal anaerobic power, peak power, and mean power during WT, but not in MAOD, among the groups. The percent decrease in power in the ML group was significantly smaller than in the T group. CP was strongly associated with $VO_2$ max in the SJC ($r = 0.774$, $p < 0.01$) and ML ($r = 0.958$, $p < 0.05$) groups, but not in the T group. W was strongly correlated with the peak power ($r = 0.999$, $p < 0.01$) and percent decrease in power ($r = 0.965$, $p < 0.05$), but only in the ML group.

CONCLUSION: These results suggest that the CP test is useful for assessing the aerobic work capacity of young male Japanese track and field athletes, excluding throwers. W may be useful for predicting anaerobic work capacity in middle- and long-distance runners.

**RELATIONSHIP BETWEEN LOWER LIMB MECHANICAL CAPABILITY OBTAINED FROM FORCE-VELOCITY RELATIONSHIP DURING THE BRAKING PHASE OF COUNTERMOVEMENT JUMPS AND JUMP FORCE-TIME CHARACTERISTICS**

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INTRODUCTION: The mechanical outputs (i.e., force, rate of force development: RFD) during the braking phase of the countermovement jump (CMJ) are related to the force of the start of the concentric phase and horizontal deceleration ability. Recently, these have been considered to be important because these lead to improved jump and change of direction performance. However, there is no known index of the mechanical capability (i.e., maximum power obtained from the force-velocity relationship: Pmax) of the braking phase to generate the mechanical outputs. It is important to understand the mechanical capability when designing training program to improve the mechanical outputs. The purpose of this study was to quantify the mechanical capability index during braking phase of CMJs and to investigate its relationship to CMJ mechanical outputs.

METHODS: The subjects were 16 healthy males. They performed CMJs on a force plate with 0%, 32 kg, 60, 80, 100, and 120% body weight. The mean force and mean velocity during the braking phase of each CMJs were calculated and scatter plots were drawn. The small sample unbiased Akaike information criterion (AICc) was calculated by fitting each to a linear regression equation, a quadratic regression equation, and a cubic regression equation, and a one-way analysis of variance was conducted to investigate which regression equation was the best fit and Bonferroni's post-hoc test was used to check pairwise comparisons. The x and y intercept values (V0 and F0, respectively) were obtained using the regression equation with the best fit one, and the mechanical capability (Braking Pmax) was calculated as Braking Pmax = V0 × F0 / 4. Furthermore, Pearson's correlation analysis was performed to evaluate the relationships between the Braking Pmax and the CMJ variables at body weight. A p value of 0.05 was accepted as the level of significance.

RESULTS: The regression equation for mean force and velocity during the braking phase was a significantly better fit of the linear regression equation than a quadratic regression equation and a cubic regression equation ($p = 0.047$, $p < 0.001$, respectively). The Braking Pmax obtained from the linear regression equation was significantly correlated with peak force and RFD during the braking phase of CMJ at body weight ($r = -0.94, -0.88$; $p < 0.001$, respectively).

CONCLUSION: Mechanical capability of the braking phase during the CMJs may be quantified by linear regression equation, and the Braking Pmax obtained from it was strongly related to the mechanical outputs during the braking phase of CMJ at body weight. Further studies are required to examine why force-velocity relationship during the braking phase of CMJ is likely to be quasi-linear. As a practical application, decelerate training at various velocity ranges from high to low may improve Braking Pmax, which in turn may effectively improve the mechanical outputs during the braking phase of CMJ at body weight.

**MUSCLE ACTIVATION PATTERNS IN TRIAL RIDERS**

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INTRODUCTION: Sport Science research has paid little attention in motor sport, particularly concerning motorbike racing. Some investigations focused in physiological demands (1, 2) and speed racing (3). Nevertheless, other motorbike competition disciplines, such as trial, have not been investigated so far. Knowledge about the interplay of muscular activity when handling the motorcycle in real condition, should be considered as a prior step before designing specific programs of physical conditioning.

The objectives of the study were: 1) comparing muscles activity levels among different sectors of a pre-conditioned trial´s trail and 2) comparing activity levels among the solicited muscles.

METHODS: Nine elite trial riders of international level took part in the study. Surface EMG (sEMG) was used to analyze the root mean square (RMS) from eight muscles: Rectus Femoris (RF), Biceps Femoris (BF), Flexor Digitorum superficialis (FD), Extensor Digitorum (ED), Pectoralis Major (PM), Triceps Brachii (TB), Biceps Brachii (BB) and Anterior Deltoid (AD). Muscle activity recorded when riding a standardized obstacle trail was normalized with a maximal voluntary contraction whose tests were designed to be representative of the maximal solicitation for each muscle. The trail was divided in six sectors categorized according to three types of global riding gestures: single jump (sectors 1 & 2), single landing (sectors 3 & 5) and successive jumps (sectors 4 & 6). Three trials were allowed with a resting period of 2 min in between. Multivariate analysis of variance was used to: 1) detect differences in sEMG activity of each muscle among the sectors, 2) compare overall sumated muscle activity in each sector separately. When a significant effect was found, Sidak post-hoc procedures were carried out. Significance was set at $p<0.05$.

RESULTS: While activity of the forearm muscles did not differ among the sectors, significant differences were observed in RF, BF, PM, BB and AD: 1) Landing sectors were less demanding ($p\leq0,048$), particularly with the BF ($p=0,032$), 2) The higher RF activity correspond to single jump sectors ($p\leq0,035$) which are even more demanding than successive jumps ($p=0,022$). In sector 2 and 3, AD is more activated than BB ($P\leq0,049$). Activity of RF and BF is similar in all sectors.

CONCLUSION: Each type of sector induces different degrees of muscle activity. Forearm muscles are highly activated during the whole trail because riders must to steer the handlebar continuously. Activity of inferior limb muscles is not as high as expected, especially in landings. Possibly the absorption capacity of the motorcycle suspension and the propulsive effect of the gas handle technique could explain these relatively low levels of muscle activity with the inferior limb.

REFERENCES

1. Ascensão A, et al. J Sports Med Physical Fitness. 2008;48(3):311-9.

2. Gobbi AW, et al. Br J Sports Med. 2005;39(12):927-31.

3. Torrado P, et al., ijerph. 2021;18(15).

### RELIABILITY AND CORRELATION BETWEEN TWO PHYSICAL TESTS DOING SPECIFIC MOVEMENTS BY PARAKARATE ATHLETES

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INTRODUCTION: Nowadays, it is very common to find athletes with intellectual disability (ID) practicing karate. To assess their physical fitness, it is necessary to use appropriate tools which allow the assessment of their physical capacities taking into account their specific characteristics (Cabeza-Ruiz, 2020). The aim of this work is to study the reliability and correlation of two tests doing specific movements applied to karate for people with intellectual disabilities.

METHODS: Thirteen athletes with ID of both sexes, who train in the Karate Federation of Madrid between the ages of 18 and 32, participated in this study. The athletes performed two attempts of the hand grip dynamometry (takei Ltd.) making use of both sides in order to evaluate the manual force and the countermovement jump (CMJ) (Chronojump, Boscosystem) to calculate the height of the jump. In addition, they performed a punch (giaku tsuki) and a kick (mae geri) to analyze the time of execution using the Kinovea software (v. 0.8.15) in order to find a correlation with the tests mentioned above. Intraclass correlation coefficient (ICC), with a confidence interval (CI) of 95%, and the standard error of measurement (SEM) were used to analyze the Intrasession reliability. Pearson correlation was used to relate the two tests with the execution time of punch and the kick.

RESULTS: The ICC intrasession values obtained were 0.91 and 0.87 for CMJ and dynamometry, respectively. SEM was lower than 0.01 m for CMJ and 0.61 N for dynamometry. Additionally, the relationship between the execution time of the dominant side of the punch as well as the force of the hand of the same side had a correlation of $r = 0.908$, $p < 0.01$. Furthermore, the relationship between the execution time of the dominant side of the kick and the height of the jump had a correlation of $r = 0.892$, $p < 0.01$.

CONCLUSION: ICC intrasession was excellent in both tests. Taking into account the data found in our study, it can be concluded that CMJ test and the hand grip dynamometry test are highly recommended to evaluate the height jump and the force of the upper and limbs of people training Karate, due to it presents very significant levels of correlations according with the time of execution of a kick and a punch when practicing this sport. This information may be helpful in order to plan training through simple and low cost tests as well as to detect talent.

REFERENCES

Cabeza-Ruiz, R., Sánchez-López, A. M., Trigo, M. E., & Gómez-Píriz, P. T. (2020). Feasibility and reliability of the Assessing Levels of Physical Activity health-related fitness test battery in adults with intellectual disabilities. Journal of Intellectual Disability Research, 64(8), 612-628.

### SEX DIFFERENCES BETWEEN HIP THRUST AND DEADLIFT IN LOAD-VELOCITY PROFILE.

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INTRODUCTION: Velocity Based Training (VBT) has been developed to provide accurate and objective data to support resistance training prescription [1]. The interest by VBT is increasing in recent years, but some studies have shown differences in the velocity-profile between men and women in exercises as squat, bench press or shoulder press [2,3]. Due to these, current evidence about the validity of using bar velocity to estimate relative load in women in exercises not analyzed until now can be questioned. Although Men's equation applied to women showed a high level of agreement [2], it would be more reliable use equation validated for women. This study aimed to examine the differences in the load-velocity profile between hip-thrust and deadlift exercises in men and women.

METHODS: Fourteen men and fourteen women were tested during the Hip-Thrust (HT) and deadlift (DL) exercises. The individual load-velocity profiles were determined by means of an incremental loading test (from 20% to 100% of the one-repetition maximum [1RM] in approximately 5% increments). Relationship between mean propulsive velocity and each percentage of 1-RM were analyzed. A second-order polynomial equation for predicting the corresponding velocity of each percentage of 1-RM was developed for men and women. We used the nonparametric Mann-Whitney U test to compare each % 1-RM between hip-thrust and deadlift exercises in men and women. Significance was set at $P < 0.05$.

RESULTS: The results of the nonparametric Mann-Whitney U test showed the mean propulsive velocity was significant lower in woman than men ($p < 0.05$) with loads <85% in hip-thrust and <70% in deadlift. Close relationships between bar velocity and relative load were observed in both sexes for hip thrust and deadlift. 〖(R)〗^2:0.88-0.93)

CONCLUSION: These results reveal that load-velocity relationship during HT and DL is markedly steeper in men than in women. The same result (i.e., lower velocities at low % 1RM in women) has been reported in other studies when compared bench press, squat or shoulder press exercises [2,3]. In summary the results confirm that men present higher mean propulsive velocity, especially under 85% 1-RM, compared to women during hip-thrust and deadlift exercises.

### THE SIMULATION OF TRANSIENT FATIGUE IN RUGBY LEAGUE

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INTRODUCTION: Transient fatigue, defined as a temporary reduction in the ability to maintain high-intensity running, is a common phenomenon in team sports [1]. In rugby league, this transient fatigue is also accompanied by reduced skill quality, which could have important implications for match outcomes [2]. The large match-to-match variability in running metrics in rugby league has meant that simulation protocols are often used to explore changes in performance owing to an intervention. However, to our knowledge, no simulation has attempted to replicate transient fatigue. Accordingly, the aim of this study was to determine if rugby league transient fatigue can be simulated, and whether this fatigue is associated with a reduction in skill.

METHODS: Nine sub-elite rugby players consented to participate in the study (age = 21 ± 2 yrs, stature = 178.4 ± 6.8 cm, body mass = 86.2 ± 14 kg). With institutional ethics approval, participants completed two abbreviated (~23 min) versions of the Rugby League Movement Simulation Protocol for Interchanges (RLMSPi) in a randomised cross-over design. One trial involved 4x ~5.7 min blocks of repeated activity (CON), as previously described [3]. In another trial (INT), the second ~5.7 min block was intensified to incorporate six more sprints and

three more contacts. Participants wore a 10Hz GPS throughout the protocol, and completed a passing test (comprising 12 passes to different targets) every ~5.8 min.

RESULTS: Heart rate (~5.2 b/min), rating of perceived exertion (~2.7), blood lactate (~4.7 mmol/L), distance covered (~115.9 m) and high-intensity running > 14 km/h (~56.1 m) all increased during the intensified ~5.7 min relative to CON ($P < 0.05$). The intensified period resulted in a decline in high-intensity running in the subsequent ~5.7 min compared to CON (~17.7 m), as well as a greater time to compete the rugby passing test (CON = 51.5 ± 3.6 s, INT = 57 ± 5.7 s; $P < 0.05$).

CONCLUSION: This study has demonstrated that the transient fatigue reported in rugby league matches can be simulated using an adapted rugby league simulation protocol. Furthermore, as with matches, this transient fatigue was accompanied by an impairment in technical performance. Future studies can use this simulation to explore the effects of training and nutritional interventions on transient fatigue in rugby league.

1. Waldron and Highton (2014) 2. Kempton et al. (2013) 3. Waldron et al. (2013)

**MAXIMAL STRAIGHT SPRINT SPEED OF AUSTRIAN SOCCER PLAYERS COMPETING AT DIFFERENT LEVELS**

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INTRODUCTION: Sprinting skills are becoming increasingly important in modern soccer (Haugen et al., 2014). Straight sprinting is the most frequent action in goal situations in professional football (Faude et al., 2012). This study aimed to analyse the maximal straight sprint speed of Austrian soccer players competing at different levels.

METHODS: 130 Austrian soccer players (age: 23.0±4.5 yrs; height: 179.0±5.8 cm; BMI: 23.5±1.9 kg) performed a 30 m straight sprint test. Maximum running speed was calculated on split times for meters 20 and 30. The best of two attempts counted. The players were divided into groups by league: professional (n=29), semi-professional (n=44), amateur (n=33) and hobby players (n=24). Data were analysed by one-way ANOVA und Tukey post-test.

RESULTS: Body height and BMI did not differ between groups ($p>0.05$). The maximal sprint speed was 31.2±1.1 km/h, 30,8±1.3 km/h, 29.7±1.5 km/h and 29.6±1.3 km/h, respectively and revealed significant differences between groups. Players competing at higher levels show higher maximal straight sprint speed, statistically significant differences were given between professional players and hobby ($p<0.001$) and amateur players ($p<0.001$), and semi-professional and hobby ($p<0.01$) and amateur players ($p<0.01$), respectively.

CONCLUSION: Most players competing at a semi-professional level in Austria are former professional players and/or skilled players trained in a national soccer academy. This may explain the lack of a difference in maxima straight sprint speed performance between professional and semi-professional players. In Austria, professional and semi-professional players may differ in other physical characteristics (e.g. endurance performance) or technical skills.

REFERENCES:

Faude, O., Koch, T., & Meyer, T. (2012). Straight sprinting is the most frequent action in goal situations in professional football. Journal of sports sciences, 30(7), 625–631

Haugen, T., Tønnessen, E., Hisdal, J., & Seiler, S. (2014). The role and development of sprinting speed in soccer. International journal of sports physiology and performance, 9(3), 432–441.

**SOMATIC DETERMINANTS OF THE SPORT PERFORMANCE OF ELITE POLISH SPRINTERS**

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INTRODUCTION: Sprint running is considered to be a relatively simple sport competition despite the fact that many different factors influence its outcome. An important role in short-distance running, which is the result of a number of scientific investigations, is attributed to somatic structure parameters of sprinters and their relationship with sports performance [1].

The aim of this study is to determine the determinants of somatic physique evaluation at different levels of sport performance (international - elite, national and club). Moreover, to determine the correlations between the results in the 100 m and 200 m runs and the examined somatic parameters in sprinters and comparison groups (students).

The study involved a selected group of athletes, which consisted of sprinters (n=113). They were members of the Polish National Team (n=17), Polish National Team reserves (n=14) and competitors of the Club Champion of Poland - AZS AWF Krakow Sports Club (n=20). The athletic level of the competitors, according to the athletic standards of the Polish Association of Athletics (PZLA), was determined by the sports class (master - international level, first - national level, second - club level). The comparison group (n=62) consisted of male students of the second year of full-time studies in physical education at the University of Physical Education in Kraków.

METHODS: The scope of the study included measurements of the somatic body build features: body height (BH) and body mass (BM), trunk and leg length, shoulder and hip width, thickness of skin-fat folds on the arm (R - over triceps skin-fold), abdomen (B - on abdonmen skin-fold), subscapular skin-fold (L), width of ankle, knee and elbow, circumference and amplitude of chest mobility, circumference of arm, neck and hip, circumference of the largest forearm, shank and thigh.

RESULTS: Of the 23 somatic traits studied, in our study only a significant effect (7 at 100 m and 3 at 200 m) of selected parameters characterizing body constitution on sports performance was observed depending on the sports level.

CONCLUSION: The results indicated a significant effect on the improvement of the 100 m score in sprinters have parameters such as: "shoulder width", "hip width", "lower limb length", "skin-fold B" (on abdonmen skin-fold), "skin-fold L" (subscapular skin-fold), "skin-fold R" (over triceps skin-fold), while at 200 m "circumference of largest lower leg", "skin-fold R" and "sum of skin-fold R+L" (over triceps + subscapular skin-fold). There is little intergroup variation among the sprinters with regard to the somatic build traits such as "Hip width", "Elbow width", "Arm circumference", "Greatest thigh circumference". In the vast majority of cases of the examined somatic traits, the non-training group (students) deviates statistically significantly from the athletes.

1. Sozanski et al. (2015)

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### RELATIVE AGE EFFECT IN FRENCH ALPINE SKIING : PROBLEM AND SOLUTION

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INTRODUCTION: The objective of this study is to identify the potential bias of the relative age effect (RAE) in French alpine skiers and to propose a mathematical correction adjustment for such bias.

METHODS: All performances and birthdates of skiers on the national and international circuit were collected from the 2004 up to 2019. A goodness-of-fit chi-square test and the residuals were used to study distribution of birth trimesters in youth competitors. A linear relationship between the distribution of performances and the months obtain a calibration coefficient allowing to rebalance the performance by considering the effect of RAE.

RESULTS: Individuals born at the beginning of the year are over-represented in the elite young selections in all disciplines for both genders. A coefficient based on the relationship between month of birth and performance adjusts individual performance and cancels out the effect of RAE.

CONCLUSION: The RAE is present in French alpine skiing. We present a method allowing to consider the effect of the RAE in the performances realized in each gender and discipline. This method allows coaches to have a more objective opinion on performance and to reduce selection bias.

### COMPARISON OF VO2/KG BETWEEN THE FRONT AND REAR RIDERS IN A 6-MIN TANDEM BICYCLE RIDE USING THE DOUGLAS BACK METHOD

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INTRODUCTION: In tandem bicycle exercise, the exercise intensity for the front rider is larger than that for the rear rider. In the present study, experiments were conducted using the Douglas back method so that statistical results could be obtained. We hypothesized that, in a tandem bicycle ride, the front rider has more VO2/kg than the rear rider. The purpose of this study was to test and prove this hypothesis.

METHODS: Six healthy Japanese men participated in a 6-min tandem bicycle ride. The course was laid out as 6 laps around a 400-m tartan track. During the ride, the participants' heart rate was measured using a heart rate monitor, and VO2/kg was measured using the Douglas back method. The rear rider operated the cock of Douglas back. The unpaired t-test was used to calculate the difference between each of the data, and the statistical significance level was less than 5%.

RESULTS: Each pair of participants cycled 6 laps around the 400-m track for 6 min. The average speed was 18.3 km/h for each lap. The average heart rates of the front riders and the rear riders were 166 ± 19 beats per minute and 156 ± 29 beats per minute, respectively ($P<0.05$). The average VO2/kg values of the front riders and the rear riders (each pair of three) were 27.0 ± 3.58 ml/kg/min and 22.9 ± 4.76 ml/kg/min, respectively.

CONCLUSION: The study hypothesis was proved by statistical analyses. Our results showed that the exercise intensity for the front rider during tandem bicycle exercise was larger than that for the rear rider in terms of VO2/kg. The results of previous study support those of the present study. The difference between the front and rear riders was considered to be caused by handle, brake, and gear operations and wind pressure. These results indicate that the relative physiological stress of front riders is greater than that of rear riders during a tandem ride. Acknowledgment; This work was supported by JSPS KAHENHI Grant Number 17K10950.

### A RAMP SPRINT TEST TO ASSESS MAXIMAL OXYGEN CONSUMPTION AND CRITICAL POWER

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INTRODUCTION: Maximal oxygen uptake (V'O2max) is widely considered to be the gold standard measurement for the assessment of physiological adaptations to exercise [1]. It is usually determined during an incremental maximal test when no increase in V'O2 respect to power or speed occurs but a V'O2 plateau is not always observed [2]. A subsequent constant work-rate test (CWR) has been suggested as verification trial [1] but the best exercise intensity of CWR has not been defined yet [3]. It is known that all-out exercise lasting 1.5–3 min yields V'O2max, representing also a valid method of estimating the boundary between the heavy and the severe exercise intensity domains (critical power, CP) [4]. A previous study showed that CP and V'O2max can be estimated from a maximal sprint at the end of a ramp incremental test (RST) by setting the flywheel resistance on body mass [5], but calculations were based on the variable relationship between body mass and CP. The aim of this study was to evaluate a RST with the maximal sprint performed with an individualized flywheel resistance based on physiological parameters as a valid approach.

METHODS: Twenty-one highly trained endurance subjects (26±5ys; 70±11kg) attended three separate testing sessions. On the first day, subjects completed an RST composed by a ramp incremental phase (25W*min-1) until exhaustion followed by a 2 minutes maximal sprint. The flywheel braking force was set according to the power output attained between gas exchange threshold (GET) and V'O2max (50%GET-V'O2max) at the preferred cadence by the known equation [6]. The average power attained in the last 30 seconds of maximal sprint was defined as sprint power (SP). On two separate occasions, in a randomized order, two CWR to exhaustion were carried out at 90%SP and 110%SP, respectively. Breath-by-breath pulmonary gas exchange, hear rate (HR) and capillary blood lactate (Lab) were monitored.

RESULTS: Peak power output (PPO) and V'O2max were 358±66W and 52.4±7.9ml*min-1*kg-1, respectively. Maximal sprint resulted in a SP of 272±57W, corresponding to 75±4% of PPO. The highest V'O2 of maximal sprint was not different from V'O2max (52.4±8.3ml*min-1*kg-1, $p>0.05$). Time to exhaustion was significantly lower in 90%SP than 110%SP (1965±605s vs 399±158s, $p<0.01$). A delayed steady state in V'O2 was attained only in 90%SP whereas is linearly increased up to V'O2max in 110%SP. At the end of exercise, V'O2, HR and Lab were significantly lower in 90%SP than 110%SP (3.26±0.67 vs 3.62±0.70L*min-1; 171±9 vs 175±8bpm; 5.74±2.3 vs 9.87±2.7Mm, respectively; all $p<0.01$).

CONCLUSION: Our results suggest that a maximal sprint performed within severe domain is a valid approach to verify V'O2max and it estimates the boundary between the heavy and the severe exercise intensities.

## EFFECT OF TIME DURATION ON OUTPUTS OF WINGATE AND FUNCTIONAL POWER THRESHOLD TESTS IN FEMALE CYCLISTS

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INTRODUCTION: Currently, there are many studies about the validation of cycling tests, but few involve female cyclists. Therefore, there is a lack of knowledge about if these tests are optimized to their women's characteristics. For this reason, the aim was to analyse the effect of modification of the duration of two different functional tests: Wingate (WAnT) and Functional Power Threshold (FTP); over performance and perceptual variables in female cyclists.

METHODS: Fourteen female cyclists (27 ±8 years, 1.66 ±0.08 m, and 60.6 ±7.2 kg) performed a protocol consisting of 2 test days with a 48-hour of recovery between tests, varying the functional test duration randomly (WAnT 20- or 30-sec, and FTP 8- or 10-min). During the tests, eumenorrheic women were in the early follicular phase and contraceptive pill users in abstinence week. Cadence (rpm), relative power output (W.kg-1), heart rate (bpm), lactate (mmol.L-1), rating perceived exertion (Borg Scale 6-20) were assessed. Moreover, the muscle oxygen saturation (%SmO2) on the vastus lateralis (Moxy) was extracted and the execution inclination was calculated [1].

RESULTS: Time duration did not affect the relative power output and the mean cadence at the entire test in WAnT and FTP tests ($p>0.05$). However, WAnT of 20-sec, compared with the test of 30-sec, resulted in a lower cadence decrease in the last 5-sec ($p<0.01$, ES=1.3), lower heart rate peak ($p<0.01$, ES=0.7), and higher execution inclination of local oxygen saturation ($p<0.05$ and ES=1.0). Modification of FTP duration did not alter any of the outcomes assessed ($p>0.05$), except in the execution inclination that was higher at the shorter duration ($p<0.05$ and ES=1.1).

CONCLUSION: Conclusion

In conclusion, the time variation assessed did not alter power outcomes in female cyclists. Regarding the FTP, we suggests use the short version for time economization reason, as to the WAnT test suggests the use of the test of 20-sec because of the less acute fatigue observed.

References

1. Castillo et al. (2016)

## PHYSIOLOGICAL, PERCEPTUAL AND NEUROMUSCULAR RESPONSES TO DIFFERENT WORK DURATIONS DURING SHORT HIGH INTENSITY INTERVALS

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INTRODUCTION: The duration of the work interval is a key variable influencing the response to high intensity interval training (HIIT). The aim of this study was to examine the physiological, perceptual and neuromuscular responses of team sport athletes to two short (i.e. < 60 s) cycling HIIT sessions comprising the same total exercise volume but different work interval durations.

METHODS: With ethics approval, seven male team sport athletes (20.5 ± 0.8 years, 181.3 ± 5.5 cm, 72.6 ± 6.3 kg) visited the laboratory on three separate occasions. After an incremental test to exhaustion on a cycle ergometer to establish VO2max (48.2 ± 7.0 ml/kg/min) and peak power output at VO2max (pVO2max; 286 ± 62 W), two HIIT sessions (15 s effort: 15 s passive recovery [15 s trial] and 30 s effort: 30 s passive recovery [30 s trial]) were completed in a randomised order. HIIT comprised 2 x 6 min bouts of 15 s or 30 s efforts at 120% pVO2max, with bouts separated by 5 min active recovery at 40% pVO2max. VO2, time spent >90% VO2max and heart rate (HR) were monitored throughout exercise. Blood lactate concentration (B[La]) was taken at 5 min and differential RPE for overall exertion (dRPE-O), leg exertion (dRPE-L) and breathlessness (dRPE-B) was taken 15 min after exercise. Maximal voluntary contraction (MVC) of the knee extensors was measured before and immediately after each HIIT session. Data were analysed using effect sizes (ES) ± 95% confidence intervals and p-values.

RESULTS: Trivial differences in mean VO2 (36.3 ± 4.7 cf. 36.4 ± 3.8 ml/kg/min, ES = 0.02 ± -1.03 to 1.07, P = 0.851) and time >90% VO2max (117 ± 129 cf. 106 ± 115 s, ES = -0.09 ± -1.13 to 0.96, P = 0.162) were observed between 15 s and 30 s trials, respectively. Mean HR (159 ± 12 cf. 165 ± 11 b/min, ES = 0.52 ± - 0.58 to 1.55, P = 0.007) and B[La] (6.1 ± 2.0 cf. 10.1 ± 2.6 mmol/L, ES = 1.72 ± 0.40 to 281, P = 0.001) were higher in the 30 s trial. dRPE-O (53.6 ± 18.0 cf. 66.4 ± 20.8 AU, ES = 0.66 ± -0.46 to 1.68, P = 0.09), dRPE-L (55.4 ± 17.0 cf. 69.9 ± 21.4 AU, ES = 0.75 ± -0.38 to 1.78, P = 0.02) and dRPE-B (45.7 ± 22.1 cf. 60.3 ± 21.5 AU, ES = 0.67 ± -0.45 to 1.70, P = 0.132) were all higher in the 30 s trial. MVC was lower after both trials (ES = -0.74 ± -1.77 to 0.39, P = 0.001), albeit reductions in force were similar between 15 s and 30 s trials (-78.5 ± 52.4 cf. -88.7 ± 44.2 N, ES = 0.21 ± -1.25 to 0.85, P = 0.540).

CONCLUSION: Team sport athletes using short duration cycling-based HIIT can use 15 s or 30 s work intervals to elicit similar aerobic and neuromuscular responses. However, where lower blood lactate accumulation and perception of effort are required, 15 s intervals might be more appropriate for athletes when using short duration HIIT.

## OPTIMAL LOAD FOR MAXIMAL POWER OUTPUT DURING THE JAMMER PRESS IN WELL-TRAINED RUGBY UNION PLAYERS.

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INTRODUCTION: Rugby union (RU) is a contact sport that involves high-intensity bouts of exercise exertion, contact, tackling, acceleration and scrummaging (Duthie et al. 2006). To meet the physical demands of RU, high levels of strength and power are required (Furlong et al. 2021). Indeed, the ability to produce high levels of mechanical power is strongly associated with athletic performance and can also differentiate between playing standards (Argus et al. 2012). As a result, it is important that practitioners are aware of training methods which they can use to maximise this quality. Whilst previous research has widely investigated and subsequently reported the loads which can maximise mechanical power during lower-body resistance training exercise (Soriano et al. 2015) there is a paucity of information regarding upper-body resistance training exercises. Research which has actually focused on upper-body exercises, however, has largely only focused on the bench press exercise (Soriano et al. 2020). This may limit the transfer to sporting actions during sports such as RU which involve standing activities as well as unilateral upper body movements. Therefore, this study investigated the optimal load to maximize mechanical power during a more functional upper-body, unilateral, horizontal exercise called the Jammer Press.

METHODS: Ten well-trained rugby union players were included in this study. All participants were free from injury and had over two years of resistance training experience. A repeated measures study design was used in which all participants performed the Jammer Press

exercise using a range of loads corresponding to their 1 repetition maximum unilateral bench press score (i.e. 20%, 40%, 60% & 80% 1RM). Using their dominant arm, the participants performed three repetitions at each load in a randomized order with 15 seconds rest provided between repetitions and five minutes rest provided between conditions. A GymAware device (Kinetic, Canberra, Australia) was attached to the Jammer Press handle with peak and mean power (W) as well as peak and mean velocity (m.s-1) recorded for each repetition. The average of the three repetitions for each load were then used for data analysis.

RESULTS: All data were normally distributed. A one-way ANOVA found that the optimal load for mechanical mean and peak power was achieved at 60% 1RM.

CONCLUSION: This is the first study to investigate the optimal load for mechanical power during the Jammer Press exercise. The % loading found here to maximize power is higher than those previously reported for the traditionally used bench press throw exercise (e.g. 20-40% 1RM). This has important implications for practitioners as these results demonstrate that different upper-body exercises have different optimal power loads and therefore each exercise requires a tailored approach. Accordingly, for athletes aiming to increase their upper-body unilateral horizontal power, the Jammer Press can be prescribed with a load corresponding to 60% their 1RM.

## COMPARISON OF EFFECTS OF STATIC STRETCHING AND FOAM ROLLING ON PAIN AND LOWER EXTREMITY FUNCTION IN PATIENTS WITH ITFS

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INTRODUCTION: Background: Studies have confirmed that static stretching (SS), as a traditional relaxation technique, and foam rolling (FR), as a relatively new relaxation technique, can relieve iliotibial band and the tension of the surrounding muscle groups. However, which one is more advantageous for alleviating symptoms in patients with iliotibial tract friction syndrome (ITFS) is still controversial. Objective: To compare the effects of SS and FR on pain and lower extremity function in patients with ITFS.

METHODS: On the campus of the Sports University, a total of 43 college patients were recruited through advertisements, 30 of whom (15 males and 15 females) met the inclusion criteria and agreed to participate in the experimental study throughout. The 30 patients with ITFS were randomly divided into 3 groups for 6w-intervention: FR, SS, and control groups of 10 patients each. The intervention was as follows: (1) group FR: A bout consisted of rolling the iliotibial band, adductors, quadriceps, hamstrings, and glutes with rollers for one minute each, a bout/day, 7 days/wk. (2) group SS: A bout consisted of statically pulling the iliotibial band, adductors, quadriceps, hamstrings, and glutes for 30 seconds each, 2 bouts/day, 7 days/wk. (3) group C: maintained the same level of physical activity as group FR and group SS without extra exercise. The pain level and lower extremity function were measured before and after 6 weeks of intervention. The pain levels of patients were assessed using the visual analogue scale (VAS). Lower extremity function was assessed using the lower extremity functional scale (LEFS).

RESULTS: After 6 weeks of intervention, (1) compared to the C group, the pain level was significantly reduced in both FR and SS groups (FR: from 3.80±1.14 to 1.80±1.03; SS: from 3.90±0.99 to 2.20±1.01; both $P<0.01$). (2) compared to the C group, lower extremity function score was significantly improved in both FR and SS groups (FR: from 65.30±3.30 to 78.00±1.33; SS: from 66.20±2.70 to 76.30±1.57; both $P<0.01$). (3) There was no significant difference in pain level or lower limb function score between FR group and SS group (both $P>0.05$).

CONCLUSION: Conclusion: Both foam rolling and static stretching intervention for 6 weeks relieved pain and improved lower extremity function in patients with ITFS, and there was no difference in efficacy between the two. Acknowledgment: This work was supported by the Qinghai province science and technology project (Grant No. 2021-SF-156).

## AEROBIC EXERCISE FOR EIGHT WEEKS PROVIDES PROTECTIVE EFFECTS TOWARDS LIVER AND CARDIOMETABOLIC HEALTH AND ADIPOSE TISSUE REMODELING UNDER METABOLIC STRESS FOR ONE WEEK: A STUDY IN MICE

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INTRODUCTION: Aerobic exercise training significantly alleviates the symptoms of multiple metabolic disorders [1-4]. However, the underlying mechanisms that modulate metabolic homeostasis in response to exercise training remain poorly understood. Most previous studies concentrated on identifying the effectiveness of exercise interventions in alleviating the symptoms of metabolic disorders or skeletal muscle functions. The findings from these studies, however, do not delineate the role of exercise in reducing obesity and metabolic disorders. Hence, the preventive effect of exercise training on fatty diet-induced metabolic dysregulation is yet to be explored.

METHODS: Our experimental design involved initial exercise training followed by a high-fat diet (HFD) challenge. Eight-week-old male was trained under voluntary wheel running aerobic exercise for eight weeks to determine the systemic metabolic changes induced by exercise training and whether such changes persisted even after discontinuing exercise. The mice were given either a normal chow diet (NCD) or HFD ad libitum for one week after discontinuation of exercise (CON-NCD, n = 29; EX-NCD, n = 29; CON-HFD, n = 30; EX-HFD, n = 31).

RESULTS: Our study revealed that metabolic stress following the transition to an HFD in mice that discontinued training failed to reverse the aerobic exercise training-induced improvement in metabolism. We report that the mice subjected to exercise training could better counteract weight gain, adipose tissue hypertrophy, insulin resistance, fatty liver, and mitochondrial dysfunction in response to an HFD compared with untrained mice. This observation could be attributed to the fact that exercise enhances the browning of white fat, whole-body oxygen uptake, and heat generation. Furthermore, we suggest that the effects of exercise persist due to PPARα-FGF21-FGFR1 mechanisms, although additional pathways cannot be excluded and require further research. Although our study suggests the preventive potential of exercise, appropriate human trials are needed to demonstrate the efficacy in subjects who cannot perform sustained exercise; this may provide an important basis regarding human health.

CONCLUSION: In summary, we identified exercise training as an effective antidote against metabolic stress. Our data showed that exercise altered insulin sensitivity, oxidative capacity, and browning capacity, as well as induced the activation of the PPARα-FGF21 axis to ensure metabolic homeostasis, which persisted in mice regardless of training cessation. Although the mouse model suggests the possibility of exercise-induced alterations, appropriate human trials are needed to demonstrate the efficacy and safety in subjects who cannot perform sustained exercise training, such as injured, hospitalized, and elderly populations, as well as healthy populations.

**EVALUATION OF A STANDARDIZED TEST PROTOCOL TO MEASURE THE WHEELCHAIR-SPECIFIC ANAEROBIC AND AEROBIC EXERCISE CAPACITY IN HEALTHY NOVICES ON AN INSTRUMENTED ROLLER ERGOMETER**

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INTRODUCTION: This study aims to evaluate whether a test protocol with standardized, yet individualized resistance settings leads to valid wheelchair Wingate and graded exercise tests (GXT) in healthy novices.

METHODS: Twenty (10M/10F) able-bodied individuals performed -in a fixed sequence- an isometric strength test, sprint test, Wingate test and GXT on a computer-controlled wheelchair ergometer. Based on earlier established relations, the individual's isometric strength outcome was used to estimate the Wingate result (P30est), from which an effective individual Wingate resistance was derived. The subsequently measured Wingate test outcome (P30meas) was used to estimate the GXT outcome (POpeakest) and to scale the individual GXT resistance steps. Estimated outcomes were compared with measured outcomes. The Wingate test protocol was considered valid when peak velocity < 3m·s-1. The GXT protocol was considered valid when test duration was between 8-12min.

RESULTS: The P30est did not differ from the P30meas and one participant did not have a valid Wingate test. The POpeakest was 10% higher than the POpeakmeas and six participants did not have a valid GXT.

CONCLUSION: The isometric strength test can be used to individually scale the test protocol for the Wingate test in able-bodied individuals. The Wingate outcome scaled the protocol for the GXT less accurate, resulting in shorter than desired test durations. The participants mainly ended the GXT because of local fatigue in their arms, not cardiorespiratory fatigue what could be due to the lack of wheelchair propulsion experience. Future research should evaluate this standardized, yet individualized test protocol in an (athletic) wheelchair-dependent population.

**NEUROMUSCULAR ACTIVITY OF YOUNG SOCCER PLAYERS IN SSGS WITH AND WITHOUT GOALKEEPERS**

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INTRODUCTION: Football research, notably in training load monitoring, has made great advances as a result of technological development (1). GPS and accelerometers parameters allow quantifying external load values (2). Accelerometry is a recent method to quantify the workload (3), providing important information of neuromuscular demands (4). The objective of our research is to analyze neuromuscular demands in SSGs, with and without GK, in three age groups through different Ac/Dec zones and PL.

METHODS: Twenty-four football players participated in the study. The players belong to the U-12 (n=8), U-15 (n=8) and U-23 (n=8) age groups and play in clubs certified as formative entities by the Portuguese Football Federation. Participating players compete in the district football championships 7 and 9, national under-15 championship and U-23 Revelation League.The data were collected through GPS devices, certified by FIFA, Wimu ProTM, placed on the upper back of the trunk, using wimu-specific vests for this purpose. The tasks analyzed were The SSG1 - 4x4 and SSG2 - GK+4x4+GK, in a game space 20 x 30 meters. The data were analyzed using the Wimu Spro computer program.We used descriptive statistics (mean and standard deviation), t-test to compare between SSG and Anova One Way to compare between age groups. It was still the effect sizes.

RESULTS: The use of GK promoted a higher neuromuscular intensity, being evident with the increase of Ac (U-12, SSG1 - 6.02±6.02, SSG2 - 12.58±10.00; U-15, SSG1 - 12.83±6.90, SSG2 - 21.99±14.18) and Dec (U-12, SSG1 - 11.71±7.97; SSG2 - 17.84±4.41; U-15, SSG1 - 14.65±7.61, SSG2 - 20.90±10.30) >3 m/s2.The effect size, with the use or not of GK, is large in the U-12 in Max Dec (ES=1.44), in the U-15 in Dec 1-2 m/s2 (ES=1.39) and Dec 2-3 m/s2 (ES=1.26) and in U-23 for PL (ES=1.49). There was also a very large effect on the use of GK in the age groups U-15 for Ac 1-2 m/s2 (ES=2.46) and PL (ES=2.41).Players age has a large effect size on SSG1 at Ac 1-2 m/s2 (ES=0.43), Ac >3 m/s2 (ES=0.59), Dec 1-2 m/s2 (ES=0.60), Dec 2 -3 m/s2 (ES=0.18), Dec >3 m/s2 (ES=0.27), Max Ac (ES=0.19) and PL (ES=0.24), in SSG2 to Dec 1-2 m/s2 (ES=0.22), Dec 2-3 m/s2 (ES=0.18), Max Ac (ES=0.20) and PL (ES=0.23).

CONCLUSION: GK intrusion in 4x4 SSG is a promoter of higher neuromuscular activity of high intensity (>3m/s2), as a result of more accelerations/decelerations, with more evidence in the U-12 and U-15 levels. The use of GK has a big effect on PL in the U-15 and U-23 tiers. The age of the players is influencing the values in the different zones of accelerations/decelerations and PL in SSG1 . In SSG2 the age effect is not as evident in accelerations, but is more evident in decelerations, Max Ac and PL.

1.Rago et al. (2020) 2.Bourdon et al. (2017) 3.Gómez-Carmona et al. (2020) 4. Reche-Soto et al. (2020)

**MAXIMAL AND SUB-MAXIMAL POWER GENERATION CAPACITY AND PHYSIOLOGICAL RESPONSES IN JAPANESE INTERNATIONALLY COMPETITIVE SPEED SKATERS**

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INTRODUCTION: The force and power generation capacities of the lower limb muscles are improved by speed skating training in speed skaters (Nemoto et al. 1990, de Koning et al. 1991). There are differences in aerobic and anaerobic power output between short-distance and middle- to long-distance skating (de Koning et al. 2005). On the other hand, there is little knowledge about the age-related differences in such physical fitness characteristics in speed skaters. Especially, there is very little knowledge about the difference between senior athletes and junior skaters regarding maximal and sub-maximal power generation capacity among top athletes. This study therefore evaluated the maximal and sub-maximal power generation capacity and physiological responses of senior and junior Japanese internationally competitive speed skaters.

METHODS: Participants were Japanese female all-round speed skaters. They were divided into two groups according to age category: senior skaters (SS; 19 years old and over) and junior skaters (JS; 18 years old or younger). Their maximal and sub-maximal power generation capacity was evaluated by incremental bicycle pedaling tests. The subjects gradually increased the power output from 40w by 20w every minute and recorded the time to exhaustion and the maximum power. And, Oxygen consumption (VO2) and heart rate (HR) were continuously measured. The aerobic threshold (AT) was calculated from the regression equation of oxygen uptake and carbon dioxide emission, and the power at AT (P@AT) were calculated.

RESULTS: The power at all-out was significantly higher in SS skaters than in JS skaters. In addition, SS skaters had significantly higher VO2max per body weight than JS skaters. On the other hand, P@AT did not show a significant difference between the SS and JS skaters.

CONCLUSION: From these results, it became clear that senior speed skaters have superior maximum power output to junior skaters. It can be inferred that such a difference in maximum athletic performance is caused by the enhancement of high-quality high-intensity training conducted after the junior period.

### MUSCLE MECHANICAL AND METABOLIC RESPONSES TO HYPERTROPHIC- AND POWER-TYPE RESISTANCE EXERCISE TRAINING

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INTRODUCTION: This study quantified differences in acute mechanical and metabolic strain response to hypertrophic- versus power-type resistance exercise. Depending on the type and mode of resistance exercise regimens, trained skeletal muscles undergo structural and functional changes in response to the exercise stimulus.

METHODS: Seven previously untrained men performed two different leg press exercises: hypertrophic (HYP, 5 × 10 x 80% of 1RM with 2 min rest between sets) and power (POW, 10 × 5 x 60% of 1RM with 3 min rest between sets) before (Pre) and after 12-week (Post) hypertrophic-maximum strength type resistance training period (RT). During the leg press sets, fascicle shortening of m. vastus lateralis (VL) and patella tendon elongation were measured with ultrasound, the muscle oxygenation level of VL was measured with near-infrared spectroscopy, and blood lactate concentration was determined. Maximum leg press strength and cross-sectional area of VL by ultrasound were measured at baseline and Post-RT. At Post-RT, muscle biopsies were obtained before and after both leg press exercises from VL to assess changes in phosphorylation of Erk1/2(p44/p42), p38 MAPK, p70S6K, and rpS6 signaling proteins.

RESULTS: Muscle strength (+24±13%) and cross-sectional area (+10±6%) increased ($p<0.05$) by RT. A significant difference ($p<0.05$) in muscle oxygenation (-8.9 ± 6.3% vs -3.0 ± 1.8%) between HYP and POW was observed in Pre-RT, but not in Post-RT (-8.2 ± 5.1% vs -4.7 ± 3.6%). In addition, the responses in blood lactate (+10.6 mmol/L vs +1.7 mmol/L) were statistically significant ($p<0.05$) after both HYP and POW exercises in Pre-RT, but only after HYP (+7.9 mmol/L; $p<0.05$) exercise in Post-RT (POW +0.9 mmol/L; ns.). Patella tendon elongation and VL fascicle shortening varied logically with the amount of load to be lifted. However, statistically significant differences were not observed in patella tendon elongation or VL fascicle shortening, or the activity of signaling proteins between HYP and POW. No changes were observed from Pre- to Post-RT.

CONCLUSION: Although fascicle shortening and tendon elongation did not statistically differ between HYP and POW, the present study suggests that they are feasible methods in detecting mechanical strain in the muscle. HYP induced more significant metabolic stress indicated by decreased muscle oxygenation, which might be an essential stimulus for exercise-induced muscle adaptations.

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