VILNIUS UNIVERSITY

IEVA SLIVOVSKAJA

THE EFFECTIVENESS OF INDIVIDUAL AEROBIC TRAINING IN SUBJECTS WITH METABOLIC SYNDROME

SUMMARY OF THE DOCTORAL DISSERTATION

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Scientific Supervisor – Prof. Alvydas Juocevicius (Vilnius University, Biomedical Sciences, Medicine – 06 B)

Scientific Consultant – Dr. Ligita Ryliškytė (Vilnius University, Biomedical Sciences, Medicine – 06 B)

Doctorate Committee:

Chairperson – Prof. Dr. Vytautas Kasiulevičius (Vilnius University, Biomedical Sciences, Medicine – 06 B)

Members:

Prof. Dr. Juozas Raistenskis (Vilnius University, Biomedical Sciences, Medicine – 06 B);

Prof. Dr. Marija Tamulaitienė (Vilnius University, Biomedical Sciences, Medicine – 06 B);

Prof. Hab. Dr. Marija Rūta Babarskienė (Medical Center Elite Medicale, Kaunas Biomedical Sciences, Medicine – 06 B);

Prof. Dr. Margus Viigimaa (Tallinn University of Technology, Estonia, Biomedical Sciences, Medicine – 06 B).

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VILNIAUS UNIVERSITETAS

IEVA SLIVOVSKAJA

INDIVIDUALIOS AEROBINĖS FIZINĖS TRENIRUOTĖS VEIKSMINGUMAS ASMENIMS, KURIEMS NUSTATYTAS METABOLINIS SINDROMAS.

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Mokslinis vadovas:

Prof. dr. Alvydas Juocevičius (Vilniaus universitetas, biomedicinos mokslai, medicina – 06 B)

Mokslinė konsultantė:

Dr. Ligita Ryliškytė (Vilniaus universitetas, biomedicinos mokslai, medicina – 06 B)

Disertacija ginama viešame disertacijos gynimo tarybos posėdyje:

Pirmininkas – prof. dr. Vytautas Kasiulevičius (Vilniaus universitetas, biomedicinos mokslai, medicina – 06 B).

Nariai:

prof. habil. dr. Marija Rūta Babarskienė (Kauno kardiologijos klinika Elite Medicale, biomedicinos mokslai, medicina – 06 B);

prof. dr. Juozas Raistenskis (Vilniaus universitetas, biomedicinos mokslai, medicina – 06 B);

prof. dr. Marija Tamulaitienė (Vilniaus universitetas, biomedicinos mokslai, medicina – 06 B);

prof. dr. Margus Viigimaa (Talino Technologijos universitetas, Estija, biomedicinos mokslai, medicina – 06 B).

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CONTENT

ABBREVIATIONS

AH – arterial hypertension

aPT – aerobic physical activity

AT – anaerobic threshold

BMI – body mass index

BP – blood pressure

CCA – common carotid artery

c-fPWV – carotid-femoral pulse wave velocity

CHD – coronary heart disease

CRF – cardiorespiratory fitness

c-rPWV – carotid-femoral pulse wave velocity

CV – cardiovascular

CVD – cardiovascular disease

dBP – diastolic blood pressure

EMI-2 – Exercise Motivation Inventory-2

HADS – Hospital Anxiety and Depression Screening

HDL-Chol – high density lipoprotein cholesterol

IMT – intima-media thickness

IPAQ – International Physical Activity Questionnaire

LDL-Chol – low density lipoprotein cholesterol

MBP – mean blood pressure

MET – metabolic equivalent of task

MetS – metabolic syndrome

MOS SF-36 – Medical Outcome Study Short Form Health Survey

NCEP ATP III – National Cholesterol Education Program Adult Treatment Panel III

PA – physical activity

PT – physical training

PWV – pulse wave velocity

QCS – Quality Carotid Stiffness

QOL – health related quality of life

ROC – receiver operating characteristic

sBP – systolic blood pressure

T-Chol – total cholesterol

TG – triglycerides

VO2max – maximal oxygen consumption

WC – waist circumference

1. Introduction

Relevance of the problem. Identification of high cardiovascular (CV) risk subjects without overt cardiovascular diseases (CVD) is essential for the effective primary prevention. Physical inactivity and obesity, in particular metabolic syndrome (MetS), are increasingly recognized as growing contributors to the global burden of cardiovascular diseases [1] and type 2 diabetes mellitus [1-3]. It is especially important in the face of the increasing incidence of MetS, which is predicted to reach 40 % by 2020 globally [4]. In some populations, the prevalence of MetS is well exceeding the global average, now reaching 43.8 % [5]. According to the Lithuanian High Cardiovascular Risk (LitHiR) primary prevention programme, the incidence of MetS among middle-aged subjects in Lithuania is 28.7 % [6]. Part of the increased CV risk in MetS is attributed to the changes in the arterial wall parameters, such as arterial stiffness and increased carotid intima-media thickness [7]. These changes reflect subclinical atherosclerosis or early vascular aging [8], which eventually leads to an overt CVD, cardiac events and stroke. MetS, physical inactivity and central obesity contribute to early vascular aging, which leads to the increased CVD risk.

There is a number of publications regarding the evaluation of psycho-emotional condition in patients suffering from various diseases [9-10]. Some authors point out a link between MetS and depression, but not anxiety [11-14]. It is shown that the fear associated with obesity, arterial hypertension (AH), diabetes mellitus (DM) and CVD affects people with MetS by reducing their quality of life [15-19]. However, only a single publication was found, analysing positive aerobic exercise training and a diet effect on the quality of life in subjects with MetS [20]. Very few studies have investigated the influence of physical training on the symptoms of depression in low physical activity (PA) patients with type 2 DM, heart failure and coronary heart disease [21-25].

In 2016, European guidelines for CV prevention provided common recommendations on physical activity: at least 150 minutes of aerobic moderate intensity physical activity a week (by 30 minutes, 5 days a week) or 75 minutes of high intensity aerobic physical activity a week (by 15 minutes, 5 days a week) or their combination [26]. Joint recommendations of several scientific societies in the USA recommended a complex lifestyle intervention programme composed of nutrition, physical intervention and behaviour therapy in overweight and obese subjects [27]. Physical training (PT) could be planned as a programme that is structured, regular, dosed and controlled. This could be a method of treatment and prevention aimed at improving or maintaining one or several components of physical fitness as well as the prognosis of the disease and quality of life [28]. Aerobic physical training (aPT) is one of the most investigated modalities of training with a proven dose/response effect [29, 30]. Patient motivation is a key factor for daily PA and PT.

We hypothesized that the heart rate (HR) targeted aPT could not only contribute to the increase in physical fitness but also improve anthropometric, hemodynamic, metabolic and arterial wall parameters. Since the outcomes of CVD occur only in the long run, measuring arterial wall parameters during the PT programme could prove to be a useful tool for recurrent CV and metabolic risk assessment as well as positively affect patient's motivation for a physically active lifestyle. Our hypothesis is supported by a relatively small study, which has demonstrated a positive effect of HR targeted aPT on arterial parameters in MetS subjects [31]. Other comparable studies were limited in their scope as they analysed the effect of PT on arterial parameters in respect to a single risk factor response [32, 33]. There is limited data on the effect of individually HR targeted aPT in this population.

Primary purpose and tasks of the study. The primary purpose of this study was to evaluate the effectiveness of the 2-month duration individually heart rate targeted aerobic physical training programme in subjects with metabolic syndrome by assessing their cardiovascular risk factors, metabolic syndrome components, arterial wall functional and structural parameters, psycho-emotional status, quality of life, physical activity, cardiorespiratory physical fitness and motivation for physical training.

The tasks of the study were as follows:

1. To estimate, evaluate and compare the effect of the 2-month duration aerobic physical training programme in the intervention group and in the control group of individually followed recommendations for physical activity by exploring the changes in cardiovascular risk factors, components of metabolic syndrome, arterial wall functional and structural parameters.

2. To estimate, evaluate and compare the effect of the 2-month duration exercise training programme in the intervention group and in the control group of individually followed recommendations for physical activity by assessing psycho-emotional status, quality of life, physical activity, cardiorespiratory physical fitness and motivation for physical training.
3. To estimate and evaluate a long-term effect of the exercise training programme in the intervention group after 8 months, by assessing the changes in cardiovascular risk factors, components of metabolic syndrome, arterial wall functional and structural parameters and physical activity, cardiorespiratory fitness, motivation for physical training and quality of life.

Principal statements for defence.

1. The individually heart rate targeted 2-month duration aerobic physical training programme in subjects with metabolic syndrome not only improves cardiorespiratory fitness and anthropometric parameters, but also positively affects cardiovascular risk parameters, components of metabolic syndrome, arterial wall functional and structural parameters as well as improves the psycho-emotional status of a subject, physical activity, motivation for physical training and quality of life.
2. The arterial wall response to aerobic physical training assessed by measuring pulse wave velocity and central mean aortic pressure enables to evaluate the effect of training on cardiovascular risk and metabolic syndrome and to prognosticate the preventive effect of physical training in the objective quantitative way.
3. The individually heart rate targeted 2-month duration aerobic physical training programme in subjects with metabolic syndrome has a long-term effect after 8 months on the improvement of cardiovascular risk, metabolic syndrome components, arterial wall parameters, improvement of quality of life, physical activity, cardiorespiratory fitness, and motivates subjects more for further physical activity and training, while recommendations on physical activity provided only individually lack such effect or it is weaker.

Novelty of the research. For the first time, according to a published research available, a complex assessment of cardiovascular risk factors together with components of metabolic syndrome, physical activity, cardiorespiratory fitness, motivation for physical training and quality of life was conducted at baseline, after 2 months of the aerobic physical training programme, and the long-term effect assessed after 8 months. It was established that the individually heart rate targeted aerobic physical training programme in subjects with metabolic syndrome not only improves anthropometric parameters (body mass index, waist circumference), blood pressure, components of metabolic syndrome, blood lipids and cardiorespiratory fitness, but also positively affects arterial stiffness and central mean arterial pressure, the findings that are considered to be associated the with lower cardiovascular risk.

2. Study subjects

Study subjects were randomly recruited from the 45–64-year-old participants of the ongoing national LitHiR primary prevention programme [5] whose comprehensive baseline cardiovascular assessment was carried out at Vilnius University Hospital Santaros Klinikos within 2014–2017. The study included 170 individuals with MetS. The subjects were recruited in a random way using a 1:1 random sampling method, and were divided into the intervention aPT group of 85 subjects and the control group of 85 subjects, to whom only recommendations on PA were provided. Metabolic syndrome subjects in both groups were age and gender matched and followed the exact study protocol, except for the HR targeted aPT. The diagnosis of MetS was based on the updated NCEP ATP III criteria [34]. Patients with overt cardiovascular disease or type 2 DM were excluded from the study. All the study subjects received detailed recommendations on the reduction of CV risk factors, including PA and home based training. Subjects of the intervention group additionally participated in an individually supervised 2-month duration HR targeted aPT programme 5 days a week. Antihypertensive treatment was not changed during the whole study. Most of the subjects were statin naive. Subjects in both groups were investigated for 3 times: at baseline, after 2 months and after 8 months in order to evaluate the long-term effect of 2-month aPT (Fig.1). \

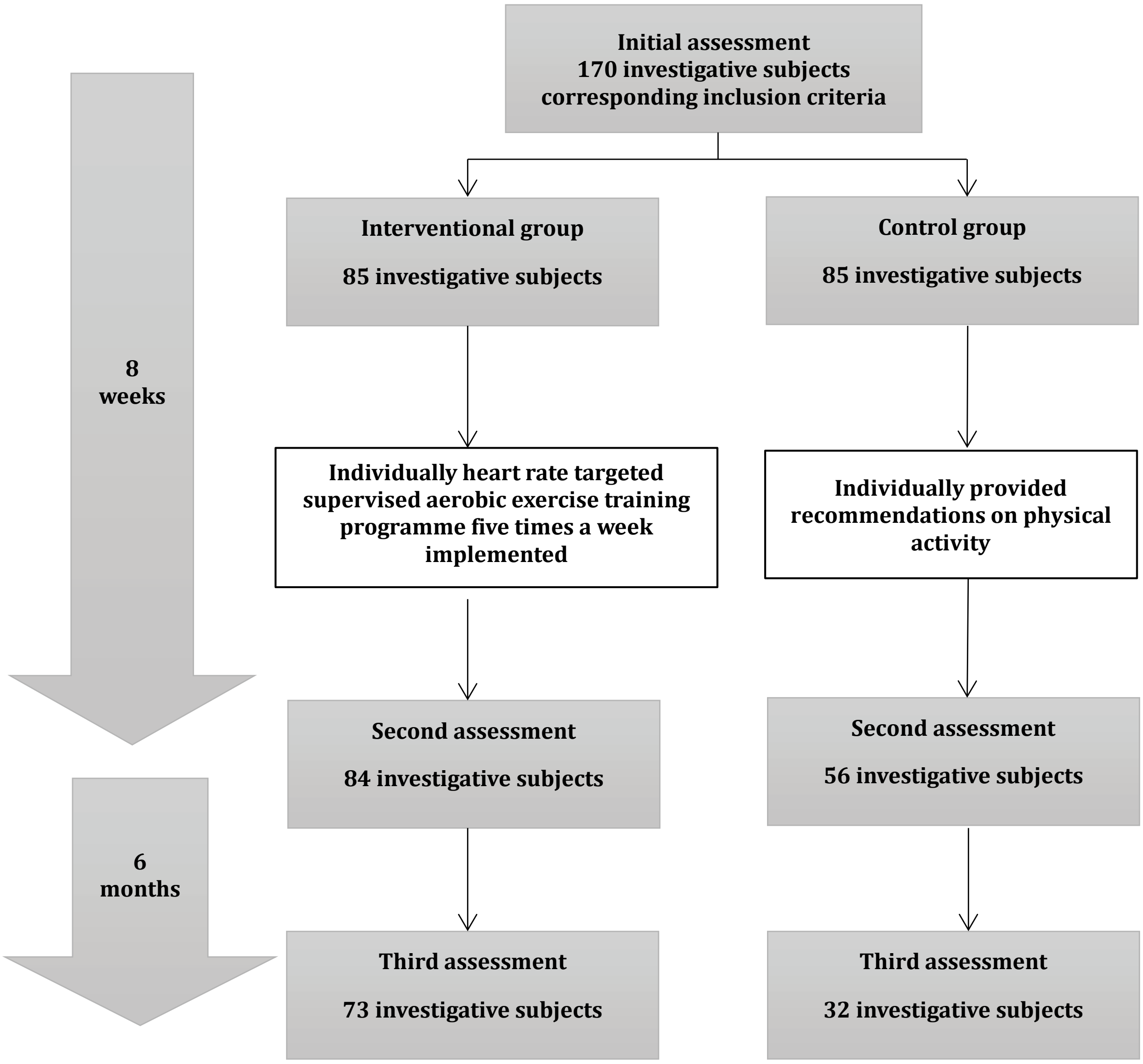

Fig. 1. Flowchart of the study

All the participants were not physically active prior to the inclusion into our study: at the baseline, they indicated having less than 30 minutes of moderate intensity PT five times a week. Management of the risk factors by diet or drug therapy was not changed throughout the whole period of the study. The mean age of the subjects was 53.3 ± 6.9 years, in the intervention group – 53.9 ± 6.468 and in the control group – 52.1 ± 7.1 years. Gender distribution was 45 % vs. 55 % in the favour of female subjects. Central obesity and poor aerobic physical fitness were present in all the subjects. AH was present in 91.3 %, dyslipidaemia – in 97.6 %, and fasting dysglycemia – in 62.7 % of cases. Out of 170 individuals, 30 (21.4 %) of the subjects missed the second appointment: 1 from the intervention group and 29 – from the control group. Data of these subjects was not included into further analysis. So, after 2 months, 140 individuals were investigated – 84 from the intervention group and 56 – from the control group. Informed consent was obtained from all the participants included into the study. The study protocol was approved by the local ethics committee.

3. Methods

Anthropometric parameters, such as body mass index (BMI), waist circumference (WC), BP, venous blood sampling for blood lipid levels, fasting glucose, arterial wall functional and structural parameters, assessment of anxiety-depression, physical activity, cardiorespiratory fitness (CRF), QOL, motivation for physical training were obtained both in the study and control groups at baseline, after 2 and 8 months. All measurements were obtained at rest, between 7 AM and 12 PM after overnight fast and abstinence from caffeine and at least 2 hours after smoking. Comprehensive non-invasive assessment of arterial markers reflecting the subclinical atherosclerosis was carried out by measuring arterial stiffness parameters by several methods, as well as common carotid artery intima-media thickness.

Arterial stiffness and wave reflection measurement by applanation tonometry. Parameters of arterial stiffness and wave reflection were assessed by the applanation tonometry system (SphygmoCor v.8.0; AtCor Medical) with a high-fidelity micromanometer (Millar R; Millar Instruments, Houston, TX, USA), placed on the skin surface at the projection of radial, carotid and femoral arteries to obtain pulse pressure wave curves [4]. Brachial BP was recorded and the distance between the surface markings of the sternal notch and the femoral artery was measured. These data and the simultaneously recorded ECG allowed the system to use pulse wave curves to compute the main parameters of arterial stiffness: aortic (carotid–femoral pulse wave velocity, cfPWV), peripheral (carotid-radial pulse wave velocity, crPWV) and aortic augmentation index (AIxHR@75), mean blood pressure in the aorta (MBP in the aorta).

Common carotid artery wall assessment. Common carotid artery (CCA) intima media thickness (IMT), cross-sectional carotid artery distensibility (both calculated in µm), and non-dimensional index Quality Carotid Stiffness (QCS) of common carotid artery (CCA) [35] were measured using high-resolution echo-tracking technology (Art. Lab, Esaote Europe B.V.) at 1 cm proximal to the carotid bifurcation along the 4 cm arterial segment. Mean values of the right and the left side CCA measurements of IMT and QCS were used in the analysis.

Assessment of anxiety and depression. HAD (*Hospital Anxiety and Depression*) is a screening test for depression and anxiety that helps to evaluate the level of depression and anxiety in patients treated for other various diseases in general profile or specialized non-psychiatric medical institutions. The test is widely used because of its reliability and simplicity for both: a patient and an investigator. HADS does not require special knowledge of psychology or psychiatry [36], therefore it is appropriate for MetS subjects [11, 13, 37]. The HADS is a fourteen item scale in which seven of the items relate to anxiety and seven – to depression. Each item is scored from 0 to 3. A person can score between 0 and 21 for either anxiety or depression: 0–7 score is considered to be normal, 8–10 points – mild, 11–14 – moderate, and 15–21 – severe anxiety or depression.

Assessment of physical activity and physical fitness. Physical activity of the subjects was assessed by using IPAQ (*International Physical Activity Questionnaire*) [38]. The IPAQ is a 27-item self-reported measure of physical activity to be used by individual adult patients aged from 15 to 69 years old. The IPAQ can be used clinically or for a population research study that compares physical activity levels between populations internationally.

Duration (minutes) and frequency (days) of physical activity in the last 7 days were measured in the domains of:

1) Job-related time;
2) Transportation;
3) Housework, house maintenance, caring for family members;
4) Recreation, sports, and leisure time;
5) Time spent while sitting.

The overall score was calculated using the responses to all the questions.

Sub-scores were calculated for:

1) Walking;
2) Moderate-intensity activity;
3) Vigorous-intensity activity.

Physical activity was calculated by MET (Metabolic Equivalent of Task) minutes a week (MET-min/week); using the formula: MET x minutes a day x days a week.

Assessment of cardiorespiratory physical fitness and target HR for exercise training. Spiroergometric system Vmax® Encore 229, SensorMedics was used to test physical fitness by performing a progressive incremental exercise test on a cycle ergometer. The cycle ergometer was set to a ramp mode from 15 to 30 W per minute, and was chosen according to the anticipated physical capacity, gender, age, body mass, and a self-reported physical activity status. After 2 minutes of cycling without resistance, the load was constantly increased until voluntary or symptom-limited exercise termination occurred. The exercise protocol was designed to last approximately 8–12 minutes. Throughout the test, BP and constant electrocardiographic monitoring were maintained. The ventilator anaerobic threshold (AT) was estimated by the “V-slope” method (VCO2/VO2 ratio), the first curve inflection. Ventilatory equivalents for O2 (VE/VO2, where VE – maximal minute ventilation) and CO2 (VE/VCO2) were used as additional criteria for the establishment of AT: the start point of the increase in VE/VO2, while VE/VCO2 reaches a plateau or is still decreasing. HR registered at AT was taken as a recommended level for initial training. Peak oxygen consumption (VO2peak = VOSmax in our case) was considered to be achieved if VO2 reached a plateau in the presence of a growing power output (W). If the subject was exhausted before the attainment of VO2peak, the VO2 value was accepted as a reasonable maximum and a respiratory quotient (RQ) > 1.00 was recorded. CRF was described by oxygen consumption (VO2max ml/kg/min) [39-43].

Assessment of Quality of life (QOL). SF-36 (MOS SF-36; *Medical Outcome Study Short Form Health Survey*) is a multidimensional questionnaire, which is designed to assess the condition of general health. This questionnaire is widely used globally and can be applied to patients suffering from various diseases [44, 45], including subjects with established MetS [46]. Moreover, the test is used to evaluate the effect of physical exercise [20, 47]. The questionnaire consists of 36 questions that reflect the eight domains of life: physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue, pain, assessment of general health, social functioning, and emotional well-being, and two integrated measurements of physical and mental health that combine these different domains. The questionnaire assists in the evaluation of well-being over the last 4 weeks. The participants filled out the SF-36 questionnaire on their own. The answers were evaluated in points and each domain of the questionnaire was assessed according to an established algorithm. The numerical value of each domain was from 0 to 100 (100 points show the best estimate).

Assessment of motivation for physical training. EMI-2 (*The Exercise Motivation Inventory-2)* was created in 1997 by D. Markland, D. K. Ingledew [48]. It was developed as a mean of assessing participation motives in order to examine such issues as the influence of motives on exercise participation. The questionnaire comprised 51 statement, fourteen scales and five groups of motives: revitalization and emotional (4 scales), social (3 scales), health (3 scales), appearance (2 scales) and development of physical power motives (2 scales). The questionnaire was adapted not only for physically active persons, but also for non-exercisers. In response to each statement, the participants had to choose an answer on a six-step scale from 0 points – "not at all true for me", to 5 points – "very true for me". The questionnaire was composed of motives for physical training and was divided into 14 scales and motive groups – recreational and emotional, social and health.

Heart rate targeted physical training programme in the study group. The aPT protocol was applied to investigate the influence of the 2-month exercise intervention on the anthropometric, metabolic, arterial wall parameters, CRF, psycho-emotional status, motivation for PT and QOL. HR at ventilatory anaerobic threshold was determined during cardiorespiratory testing and was taken as the recommended level for aPT (41). Specifically, the training intervention consisted of the 2-month duration supervised aerobic training for 30–40 min a day, 5 days a week. The exercise intensity was gradually increased up to the target HR [49]. The ERS-2 Ergoline bicycle based cardiac rehabilitation system was used for the HR targeted PT. It allowed to control the exercise load in the way that HR was maintained at the constant level estimated individually by the cardiorespiratory testing [50].

The control group without targeted HR training. All the MetS subjects in the control group were informed about the necessary home-based physical activity and instructed to perform it 5 times a week for 30-minutes, aiming at the intensity of cardiac workout.

Statistical analysis

Statistical analysis was performed using STATISTICA 10, IBM SPSS 20.0, R package „*party*". Descriptive statistics were presented as means, standard deviations, and frequencies expressed as absolute numbers and percentages. The Shapiro-Wilk test was applied to check for Gaussian distribution of the data. Continuous variables between the groups were compared by the unpaired Student's t-test for normally distributed data and the Mann-Whitney U-test for non-normally distributed data. Categorical variables were analysed with the χ^2 test or the Fisher's exact test. Baseline and follow-up results were compared with the paired Student's t-test for normally distributed continuous data or the Wilcoxon signed-rank test for non-normally distributed continuous data, the McNemar test – for 2 × 2 categorical data, and the marginal homogeneity test – for categorical data with more than two categories. Correlation between variables was determined by calculating Pearson's or Spearman's correlation coefficients. Multiple linear regression analyses were conducted to determine factors associated with the reduction in aortic stiffness. Linear regression and the regression trees were used to evaluate associations between the changes in pulse wave and baseline values. According to the results, the decision tree was built. This allowed to determine possible baseline PWV cut-off values for the outcome prediction. The ROC analysis was used to find out the optimal cut-off value of the changes from baseline for the considered risk factors. Optimal change cut-off was set where the best accuracy to define patient groups were met. Accuracy were evaluated with sensitivity, specificity and Youden's index (J=Sensitivity+Specificity-1) calculated for all possible cut-off values. Cut-off value with maximum Youden's index was chosen as an optimal change from the baseline cut-off value. Additionally, odd ratios according to the optimal cut-off value were calculated for every risk factor. All p values were two-tailed and the level of significance was set to 0.05.

4. Results

Baseline data comparison in the intervention and the control groups.

Homogeneity of the intervention and control groups was checked including the age, gender, main anthropometric parameters, cardiovascular risk factors, components of metabolic syndrome, arterial wall parameters and cardiorespiratory capacity at the baseline (***Table 1***). At the baseline, T-Chol and LDL-Chol were higher in the intervention group. Elevated LDL-Chol was found in 87.95 % of the subjects in the intervention group and in 76.79 % of the subjects in the control group (p = 0.082). There were no significant differences of HDL-Chol and TG between the groups studied. Dyslipidaemia was found in all investigative subjects in the intervention group and in 95 % of subjects in the control group.

Table 1. Initial characteristics of the subjects in the investigative group

Signs	Intervention group (n=84)	Control group (n=56)	p value between the groups
Age (years), M ± SD	53.9 ± 6.4	52.1 ± 7.1	0.133
Gender:			0.188
- women (%)	59.52	48.21	
- men (%)	40.48	51.79	
Assessment of AH			
sBP (mm Hg), M ± SD	132.73 ± 13.01	133.78 ± 15.32	0.667
dBP (mm Hg), M ± SD	81.56 ± 9.23	82.71 ± 10.88	0.511
AH (in %)	94.05	87.50	0.222
Stages of BP:			0.225
- optimal BP (%)	13.25	19.64	
- normal BP (%)	21.69	17.86	
- high-normal BP (%)	30.12	17.86	
- I° elevation of BP (%)	19.28	14.29	
- II° elevation of BP (%)	4.82	8.93	
- Isolated systolic hypertension (%)	10.84	21.43	
Assessment of dyslipidaemia			
T-Chol (mmol/l), M ± SD	6.41 ± 1.40	5.86 ± 1.24	**0.012**
LDL-Chol (mmol/l)**.** M ± SD	4.19 ± 1.17	3.80 ± 1.05	**0.044**
TG (mmol/l), M ± SD	2.35 ± 2.81	1.94 ± 0.91	0.231
HDL-Chol (mmol/l), M ± SD	1.19 ± 0.30	1.15 ± 0.29	0.410
Dyslipidaemia (in %)	100.00	94.64	0.062

Smoking:			
- smoking (%)	11.90	19.64	0.209
- non smoking (%)	88.10	80.36	
Assessment of obesity			
Waist circumference (cm), M ± SD	102.18 ± 9.13	104.98 ± 9.10	0.082
Abdominal obesity (proc.)	81.9	80.4	0.816
BMI (kg/m^2), M ± SD	30.86 ± 3.96	31.05 ± 3.21	0.769
Obesity:			
- no (%)	4.82	1.79	0.850
- overweight (%)	38.55	35.71	
- I degree (%)	40.96	48.21	
- II degree (%)	14.46	14.29	
- III degree (%)	1.20	0.00	
Assessment of MetS components			
Waist circumference (cm), M ± SD	102.18 ± 9.13	104.98 ± 9.10	0.082
Abdominal obesity (%)	81.9	80.4	0.816
TG (mmol/l), M ± SD	2.35 ± 2.81	1.94 ± 0.91	0.231
Study subjects with elevated TG concentration (%)	63.1	53.6	0.261
HDL-Chol (mmol/l), M ± SD	1.19 ± 0.30	1.15 ± 0.29	0.410
Study subjects with the reduction of HDL-Chol (%)	51.2	53.6	0.782
sBP (mm Hg), M ± SD	132.73 ± 13.01	133.78 ± 15.32	0.667
dBP (mm Hg), M ± SD	81.56 ± 9.23	82.71 ± 10.88	0.511
Study subjects with elevated BP (%)	94.0	89.3	0.347
Fasting glucose in plasma (mmol/l), M ± SD	5.99 ± 0.83	5.80 ± 0.59	0.340
Study subjects with elevated glucose concentration (%)	64.3	61.8	0.768
Number of MetS components:			
- 3 (%)	44.0	50.0	0.408
- 4 (%)	36.9	39.3	
- 5 (%)	19.0	10.7	
Assessment of arterial wall functional and structural parameters			
Carotid-radial a. PWV (m/s), M ± SD	9.07 ± 1.18	5.2.4	0.614
Carotid-femoral a. PWV (m/s), M ± SD	8.53 ± 1.36	8.11 ± 1.36	0.066
Carotid-femoral a. PWV:			
- ≥10 m/s (%)	14.46	7.14	0.370
- 9–9.9 m/s (%)	20.48	16.07	
- 8–8.9 m/s (%)	32.53	28.57	
- 7–7.9 m/s (%)	20.48	32.14	
- <7 m/s (%)	12.05	16.07	
AIxHR@75 (%), M ± SD	22.13 ± 12.59	21.41 ± 10.72	0.745
Aortic MBP (mm Hg), M ± SD	104.17 ± 9.49	103.54 ± 10.78	0.560
CCA IMT (μm), M ± SD	648.23 ± 104.70	636.12 ± 95.42	0.396
CCA stiffness, M ± SD	4.39 ± 1.68	4.14 ± 1.36	0.547
Assessment of anxiety and depression signs			
Anxiety (scores), M ± SD	5.21 ± 2.87	4.33 ± 3.34	0.151
Depression (scores), M ± SD	3.40 ± 2.92	2.65 ± 2.40	0.188
Anxiety			0.158

- 0–7 scores (% .)	84.6	75.5	
- 8–10 scores (%)	10.3	20.7	
- 11–14 scores (%)	5.1	1.9	
- 15–21 scores (%)	0	1.9	
Depression			0.111
- 0–7 scores (%)	88.5	98.1	
- 8–10 scores (%)	10.2	1.9	
- 11–14 scores (%)	1.3	0	
- 15–21 scores (%)	0	0	
Assessment of physical activity			
Total Physical Activity (MET-minutes/week), M ± SD	5316.41 ± 4409.31	4653.28 ± 4200.04	0.497
Physical activity at work (MET-minutes/week), M ± SD	1496.85 ± 3802.33	1244.98 ± 2566.95	0.529
Physical activity for transportation (MET-minutes/week), M ± SD	994.58 ± 1057.19	665.58 ± 1154.72	0.077
Physical activity in a domestic setting and gardening (MET-minutes/week), M ± SD	1912.67 ± 2652.40	1397.40 ± 2256.32	0.182
Physical activity in leisure time (MET-minutes/week), M ± SD	912.32 ± 1144.34	1345.32 ± 2645.06	0.699
Walking physical activity (MET-minutes/week), M ± SD	1916.85 ± 2124.19	1939.08 ± 2735.24	0.469
Moderate physical activity (MET-minutes/week), M ± SD	2512.67 ± 2616.01	1850.20 ± 2263.90	0.107
Vigorous physical activity (MET-minutes/week), M ± SD	886.90 ± 2186.70	864.00 ± 1492.38	0.725
Sitting (minutes/week), M ± SD	1927.30 ± 877.00	1620.29 ± 989.90	0.105
Assessment of cardiorespirative physical capacity			
VO_2max (ml/kg/min), M ± SD	22.28 ± 5.47	22.51 ± 4.61	0.637
AT (%), M ± SD	76.22 ± 17.63	77.98 ± 17.55	0.541
Heart rate at rest (times/min), M ± SD	63.57 ± 7.96	61.30 ± 8.04	0.173
Assessment of cardiorespirative physical capacity:			1.000
- bad (%)	97.6	100	
- satisfactory (%)	1.2	0	
- good (%)	1.2	0	
- very good (%)	0	0	
- excellent (%)	0	0	
Assessment of health-related quality of life			
Physical Health: Summary	73.57 ± 17.43	73.69 ± 15.29	0.707
Physical Functioning	81.58 ± 17.10	85.99 ± 12.40	0.185
Role: Physical	77.53 ± 33.87	76.83 ± 34.64	0.925
Bodily Pain	76.79 ± 21.44	70.73 ± 20.30	0.112
General Health	58.45 ± 15.07	61.22 ± 14.00	0.330
Mental Health: Summary	74.43 ± 15.21	76.41 ± 16.12	0.325
Vitality	62.37 ± 18.21	64.38 ± 15.57	0.693
Social Functioning	84.97 ± 17.26	86.89 ± 15.80	0.622
Role: Emotional	78.06 ± 31.53	83.74 ± 31.73	0.257
Mental Health	72.67 ± 14.51	70.50 ± 14.57	0.445
Change in Reported Health	42.53 ± 19.89	44.23 ± 17.64	0.726
Assessment of motivation for physical training			
Enjoyment and Revitalisation Motive	2.97 ± 1.26	2.98 ± 1.13	0.958

Social Engagement Motive	1.85 ± 1.47	2.16 ± 1.33	0.122
Health motive	4.09 ± 0.78	3.53 ± 1.53	0.166
Appearance / Weight Motive	3.76 ± 1.00	3.91 ± 1.05	0.229
Fitness Motive	3.63 ± 1.13	3.63 ± 1.01	0.756

Abbreviations and explanations: M ± SD – mean ± standard deviation, AH – arterial hypertension, BP – blood pressure, sBP – systolic blood pressure, dBP – diastolic blood pressure, BMI – body mass index, T-Chol – total cholesterol, HDL-Chol – high density lipoprotein cholesterol, LDL-Chol – low density lipoprotein cholesterol, TG – triglycerides, MetS – metabolic syndrome, PWV – pulse wave velocity, MBP – mean blood pressure, CCA – common carotid artery, IMT – intima–media thickness, MET – metabolic equivalent, VO2max – maximal oxygen consumption, AT – anaerobic threshold, HR – heart rate.

Changes in cardiovascular risk factors, metabolic syndrome components, arterial wall parameters, psycho-emotional status, physical activity, cardiorespiratory fitness, quality of life, and motivation for physical training after 2 months.

Arterial hypertension. Statistically significant improvement in BP was found in the intervention group: systolic blood pressure (sBP) decreased in average for 4.09 mm Hg (3.08 %, p=0.006), diastolic blood pressure (dBP) – in average for 2.51 mm Hg (3.08 %, p=0.003) (Fig. 2). There were no significant changes of BP after two months in the control group.

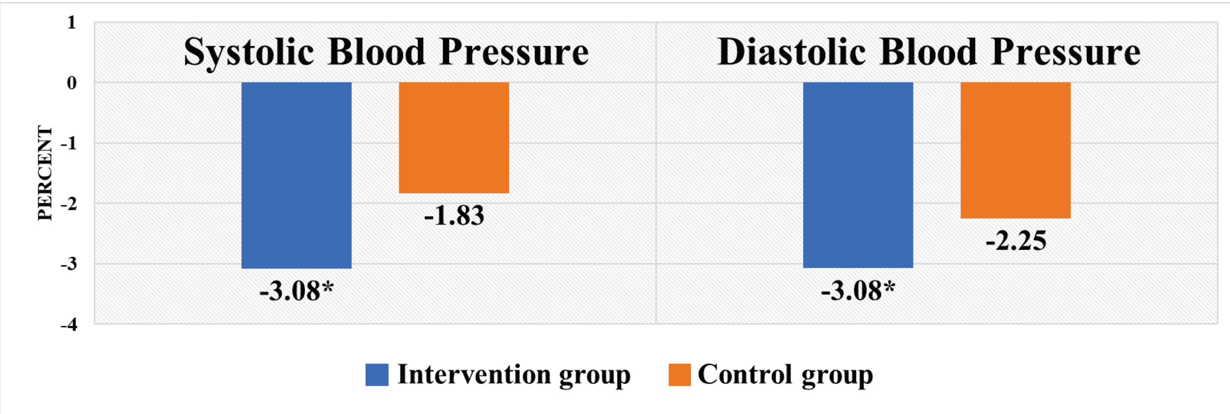

Fig. 2. Changes of blood pressure parameters in the intervention and control groups after 2 months

Abbreviations and explanations: BP – blood pressure; * – statistically significant difference (p<0.05).

Lipid profile. Statistically significant improvement in some lipid parameters, such as decreasing T-Chol, on average, by 0.52 mmol/l (8 %, p=0.001) and LDL-Chol – by 0.39 mmol/l (9 %, p=0.002) in the intervention group but not in the control group was found after 2 months. There were no statistically significant changes in TG and HDL-Chol, although in the intervention group there was a trend of HDL-Chol increase and reduction of TG. (Fig. 3).

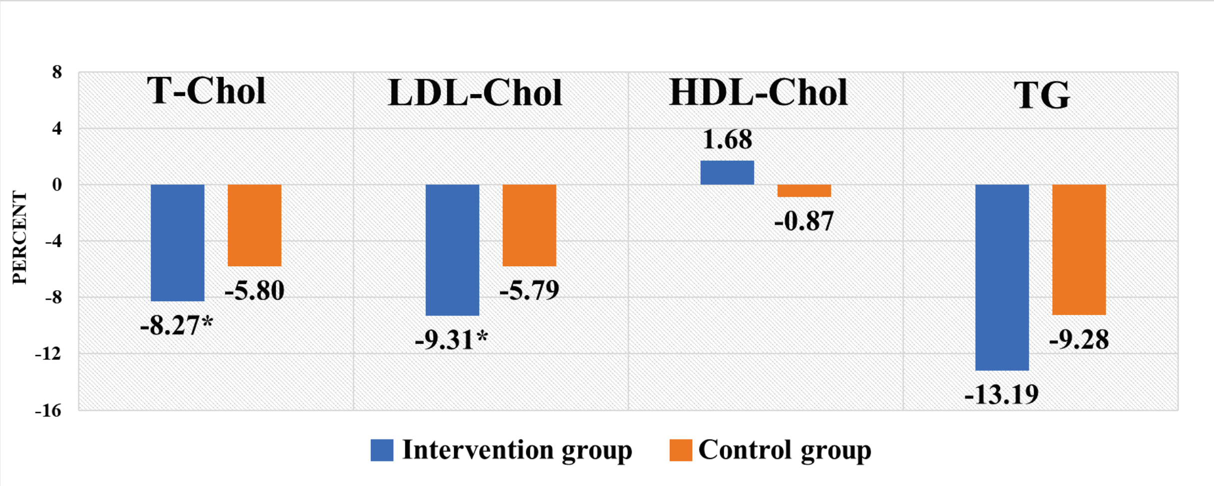

Fig. 3. Changes of lipid parameters in the intervention and control groups after 2 months

Abbreviations and explanations: T-Chol – total cholesterol, HDL-Chol – high density lipoprotein cholesterol, LDL-Chol – low density lipoprotein cholesterol, TG – triglyceride; * – statistically significant difference (p<0.05).

Obesity. Statistically significant reduction in BMI was found in both groups: in the intervention group – on average, by 0.37 kg/m^2 (1.2 %, p<0.001), in the control group – on average, by 0.34 kg/m^2 (1.1 %, p=0.011). WC significantly decreased only in the intervention group, on average, by 1.34 cm (1.31 %, p<0.001) (Fig. 4).

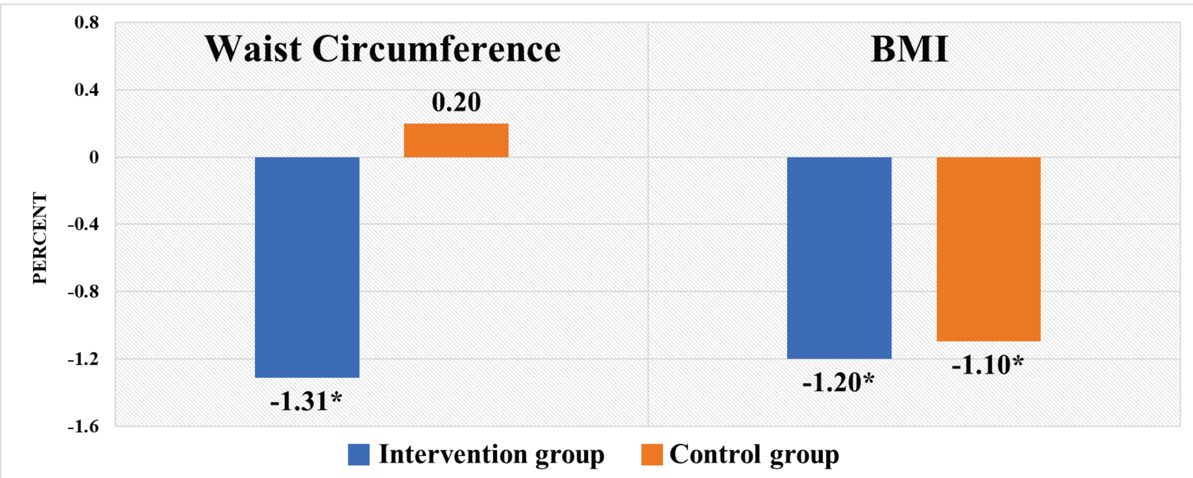

Fig. 4. Changes of waist circumference and body mass index in the intervention and control groups after two months

Abbreviations and explanations: BMI – body mass index; * – statistically significant difference (p<0.05).

Components of metabolic syndrome. The baseline evaluation of MetS components revealed that abdominal obesity (WC in men ≥102 cm and in women ≥88 cm) was present in 81.3 % of the subjects, BP ≥130/85 mm Hg – in 92.1 %, fasting glucose ≥5.6 mmol/l – in 63.3 %, elevated TG ≥1.7 mmol – in 59.3 %, reduced HDL-Chol (<1.03 mmol/l – in men and <1.3 mmol/l – in women) in 47.9 % of all investigated subjects (Fig. 5). Three components of MetS were present in 46.4 %, four – in 37.9 %, all five components – in 15.7 % of all the investigated subjects (Fig. 6).

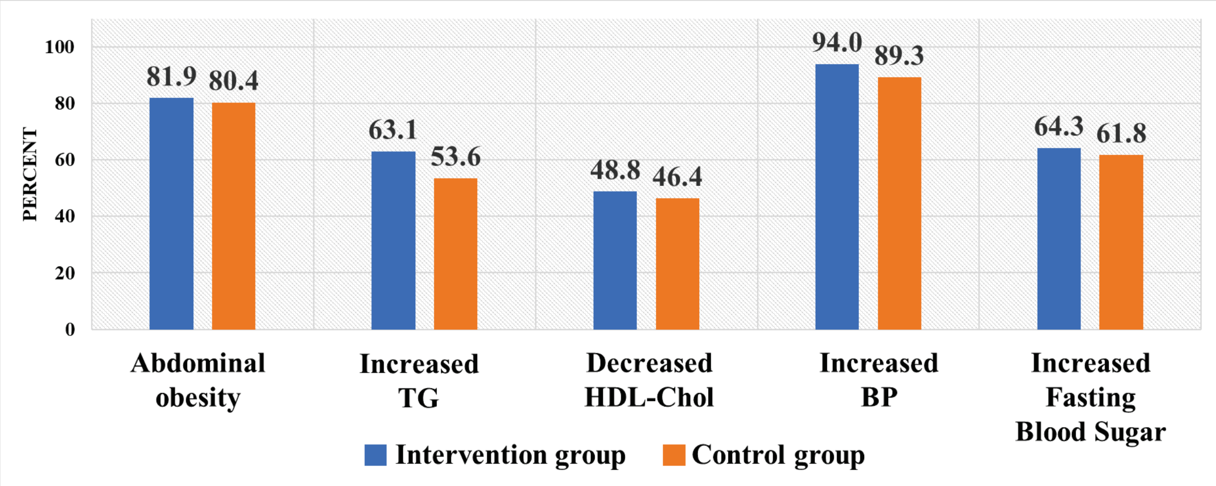

Fig. 5. The distribution of the metabolic syndrome components in both groups at baseline

Abbreviations and explanations: HDL-Chol – high density lipoprotein cholesterol, BP – blood pressure.

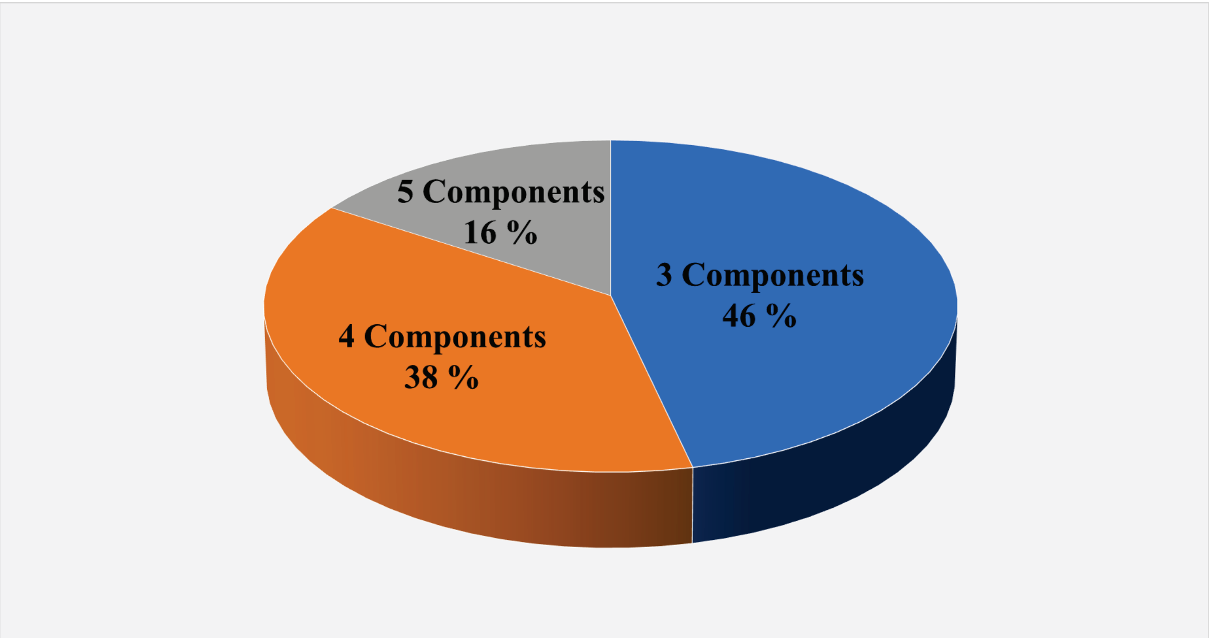

Fig. 6. The number of MetS components in both groups at baseline

After 2 months, statistically significantly improved values in 2 of 5 components – waist circumference, that decreased, on average, by 1.34 cm (1.31 %, $p<0.001$), and blood pressure – sBP 4.09 mm Hg (3.08 %, $p=0.006$) and dBP 2.51 mm Hg (3.08 %, $p=0.003$) were found in the intervention group. There were no significant changes in the values of MetS components in the control group after 2 months (Fig. 7 and Table 2).

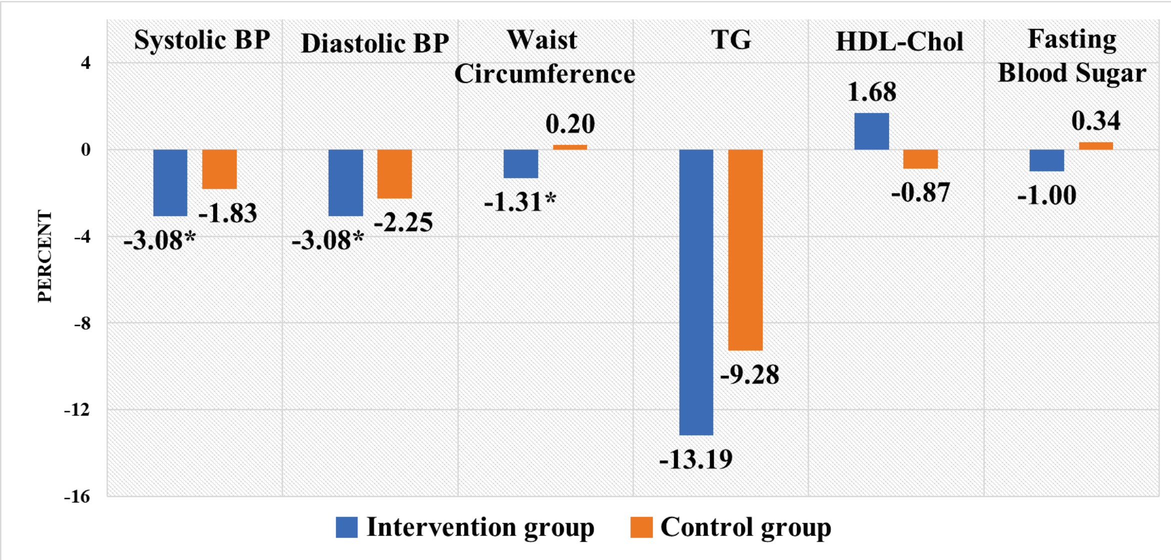

Fig. 7. Changes in the values of the MetS components after 2 months

Abbreviations and explanations: BP – blood pressure, TG – triglyceride, HDL-Chol – high density lipoprotein cholesterol; * – statistically significant difference (p<0.05).

Table 2. Changes in the values of the MetS components in the intervention and control groups after 2 months

Intervention group				**p value between the groups**	**Control group**			
At baseline	**After 2 months**	**Change**	**p value**		**p value**	**Change**	**At baseline**	**After 2 months**
Waist circumference (cm), M ± SD					**Waist circumference (cm), M ± SD**			
102.18 ± 9.13	100.84 ± 9.15	-1.34 ± 3.89	**<0.001**	0.086	0.705	0.20 ± 3.94	104.98 ± 9.10	105.19 ± 9.88
TG (mmol/l), M ± SD					**TG (mmol/l), M ± SD**			
2.35 ± 2.81	2.04 ± 1.31	-0.31 ± 2.85	0.302	0.635	0.082	-0.17 ± 0.73	1.94 ± 0.91	1.76 ± 0.71
HDL-Chol (mmol/l), M ± SD					**HDL-Chol (mmol/l), M ± SD**			
1.19 ± 0.30	1.21 ± 0.28	0.01 ± 0.18	0.455	0.068	0.545	-0.02 ± 0.19	1.15 ± 0.29	1.14 ± 0.29
sBP (mm Hg), M ± SD					**sBP (mm Hg), M ± SD**			
132.73 ± 13.01	128.64 ± 11.58	-4.09 ± 12.99	**0.006**	0.465	0.146	-2.45 ± 12.33	133.78 ± 15.32	131.33 ± 12.67
dBP (mm Hg), M ± SD					**dBP (mm Hg), M ± SD**			
81.56 ± 9.23	79.05 ± 8.02	-2.51 ± 7.26	**0.003**	0.687	0.151	-1.85 ± 9.44	82.71 ± 10.88	80.85 ± 10.39
Fasting glucose in plasma (mmol/l), M ± SD					**Fasting glucose in plasma (mmol/l), M ± SD**			
5.99 ± 0.83	5.93 ± 0.81	-0.06 ± 0.53	0.226	0.409	0.740	0.02 ± 0.43	5.80 ± 0.59	5.82 ± 0.60

Abbreviations and explanations: M+SD – mean plus minus standard deviation, TG – triglyceride, HDL-Chol – high density lipoprotein cholesterol, sBP – systolic blood pressure, dBP – diastolic blood pressure.

The number of MetS components after 2 months statistically significantly decreased in both intervention and control groups (Fig. 8) from the average of 3.75 components in the intervention group and 3.61 – in the control group at baseline to 3.38 (decrease of 0.38, p=0.001) and 3.31 (decrease of 0.29, p=0.016), respectively. After 2 months, 3 of 5 MetS components were no more present in 18.8 % of the intervention group subjects and in 16.7 % – in the control group subjects.

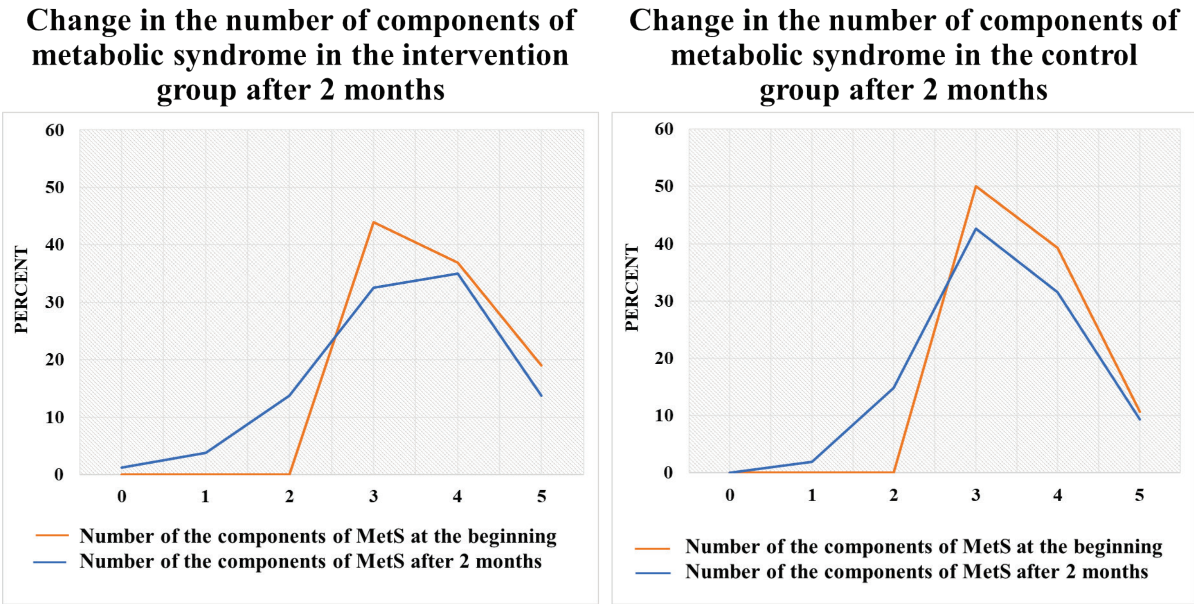

Fig. 8. Change in the number of MetS components after 2 months – *p=0.001* (in the intervention group) and *p=0.016* (in the control group)

Abbreviations and explanations: MetS – metabolic syndrome.

Arterial wall functional and structural parameters. After 2 months, we have observed the decrease of aortic stiffness in the reduction of c-f PWV, on average, by 0.54 m/s (6.33 %, p<0.001) in the intervention group. The significant difference of the change of c-f PWV between the groups (p=0.034) was revealed. The reduction of MBP in the aorta, on average, by 3.73 mm Hg (3.58 %, p=0.001) was found. No reduction of the parameters was found in the control group. (Fig. 9 and 10).

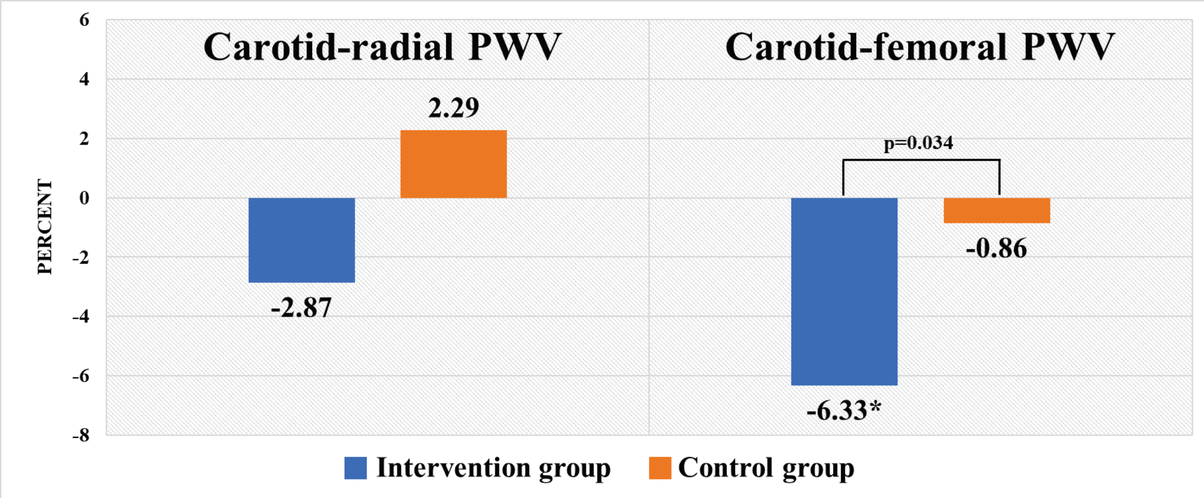

Fig. 9. Carotid-femoral and carotid-radial pulse wave velocity changes after 2 months

Abbreviations and explanations: PWV – pulse wave velocity; * – statistically significant difference (p<0.05).

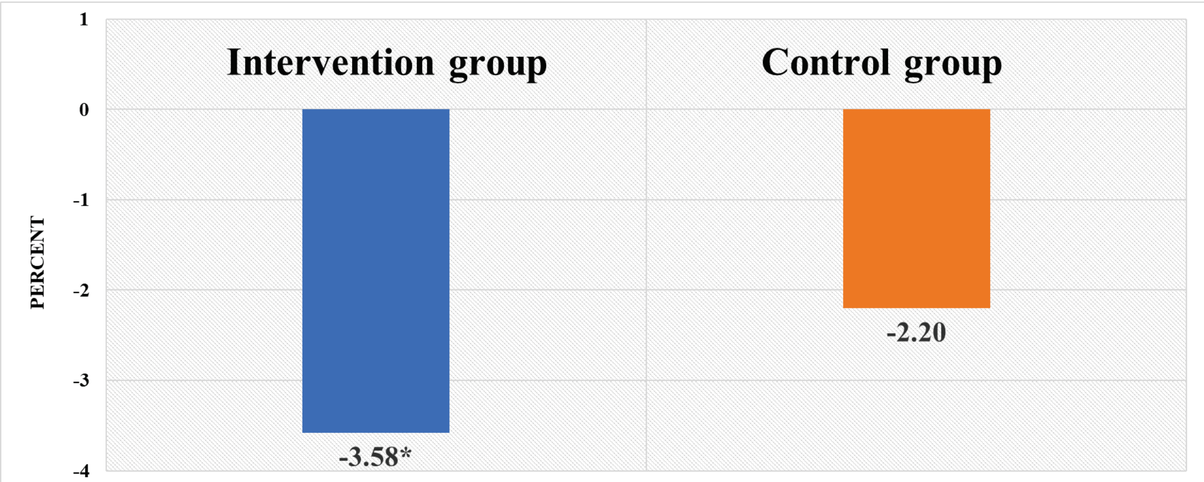

Fig. 10. Changes of mean blood pressure in the aorta after 2 months

Abbreviations and explanations: * – statistically significant difference (p<0.05).

After 2 months, no statistically significant reduction of CCA stiffness and carotid IMT was observed in either intervention or control group. However, there was a statistically significant difference between the magnitude of stiffness of CCA change between the groups (p=0.022).

Changes in the arterial wall functional and structural parameters after 2 months are presented in Tables 3 and 4.

Table 3. Changes in arterial wall functional and structural parameters after 2 months

Intervention group				**p value between the groups**	**Control group**			
At baseline	**After 2 months**	**Change**	**p value**		**p value**	**Change**	**At baseline**	**After 2 months**
M ± SD	**M ± SD**	**M ± SD**				**M ± SD**	**M ± SD**	**M ± SD**
Carotid-radial PWV (m/s)					**Carotid-radial PWV (m/s)**			
9.07 ±	8.81 ±	-0.26 ±	0.137	0.105	0.384	0.21 ±	9.18 ±	9.39 ±

1.18	1.20	1.40				1.69	1.22	1.59
Carotid-femoral PWV (m/s)						**Carotid-femoral PWV (m/s)**		
8.53 ± 1.36	7.99 ± 1.04	-0.54 ± 1.32	**<0.001**	**0.034**	0.533	-0.07 ± 1.17	8.11 ± 1.36	8.04 ± 1.19
AIxHR@75 (%)						**AIxHR@75 (%)**		
22.13 ± 12.59	20.84 ± 12.86	-1.30 ± 11.73	0.368	0.595	0.299	-1.18 ± 7.88	21.4 ± 10.72	20.22 ± 11.26
MBP in aorta (mm Hg)						**MBP in aorta (mm Hg)**		
104.17 ± 9.49	100.44 ± 9.99	-3.73 ± 10.11	**0.001**	0.439	0.146	-2.28 ± 11.35	103.54 ± 10.78	101.26 ± 12.75
IMT of CCA (µm)						**IMT of CCA (µm)**		
648.23 ± 104.70	648.88 ± 94.00	0.65 ± 60.69	0.923	0.088	**0.032**	21.90 ± 83.96	636.12 ± 95.42	658.02 ± 100.14
Stiffness of CCA						**Stiffness of CCA**		
4.39 ± 1.68	4.06 ± 1.35	-0.33 ± 1.33	0.079	**0.022**	0.121	0.26 ± 1.39	4.14 ± 1.36	4.40 ± 1.69

Abbreviations and explanations: M ± SD – mean ± standard deviation, PWV – pulse wave velocity, AIxHR@75 – augmentation index, normalized by 75 b/min heart rate, MBP – mean blood pressure, CCA – common carotid artery, IMT – intima-media thickness.

Table 4. Changes of carotid-femoral pulse wave velocity after 2 months depending on the baseline pulse wave velocity.

Parameter	**Intervention group**			**Control group**		
	At baseline	After 2 months	p value	At baseline	After 2 months	p value
Carotid-femoral PWV:						
- ≥ 10 m/s (%)	14.46	4.88		7.14	5.36	
- 9–9.9 m/s (%)	20.48	10.98		16.07	16.07	
- 8–8.9 m/s (%)	32.53	34.15	**0.001**	28.57	26.79	0.491
- 7–7.9 m/s (%)	20.48	34.15		32.14	32.14	
- < 7 m/s (%)	12.05	15.85		16.07	19.64	

Abbreviations and explanations: PWV – pulse wave velocity.

Anxiety-depression parameters. We did not observe the symptoms of anxiety in 84.6 % of the intervention group subjects. Light symptoms were observed in 10.3 % and symptoms of moderate severity in 5.1 % of subjects. In the control group, 75.5 % of the subjects had no symptoms of anxiety, 20.7 % had light, 1.9 % moderate and 1.9 % severe symptoms (Table 1). There were no symptoms of anxiety in 88.5 % of the intervention group subjects, in 10.2 % light and in 1.3 % moderate. In both groups there were no symptoms of severe depression. After 2 months, there were no statistically significant changes in the level of anxiety and only in the intervention group the reduction of depression was observed in 11 % of the subjects (p=0.021) (Table 5).

Table 5. Changes of anxiety and depression levels after 2 months

Sign	Intervention group	p value	Control group	p value
Anxiety				
Improved (%)	2.8	0.109	10.0	0.796
Not changed (%)	84.9		82.5	
Worsened (%)	12.3		7.5	
Depression				
Improved (%)	10.9	**0.021**	1.9	1.000
Not changed (%)	87.7		98.1	
Worsened (%)	1.4		0	

Physical activity. After 2 months, the analysis of physical activity, focusing on the domain characters and levels, revealed statistically significant differences between the intervention, and control group. In the former, we observed a significantly greater improvement in performing moderate and vigorous physical activity during leisure time: working in the garden and yard, recreation, sports and other leisure activities (Fig. 11).

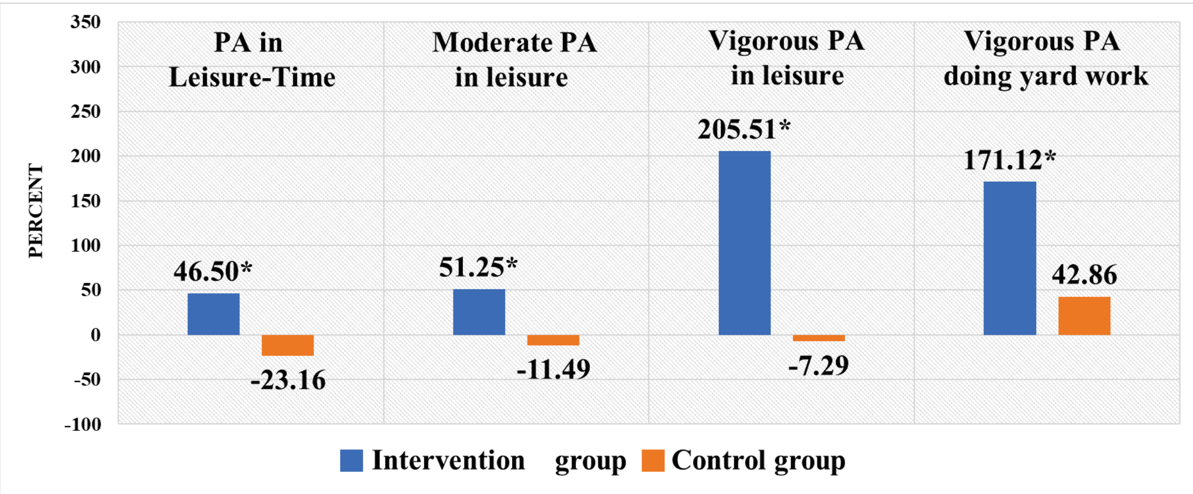

Fig. 11. Changes of physical activity according to the domains after 2 months

Abbreviations and explanations: PA – physical activity, * – statistically significant difference ($p<0.05$).

Likewise, we observed a statistically significant difference in the change of the sitting time between the intervention and control group (Fig. 12).

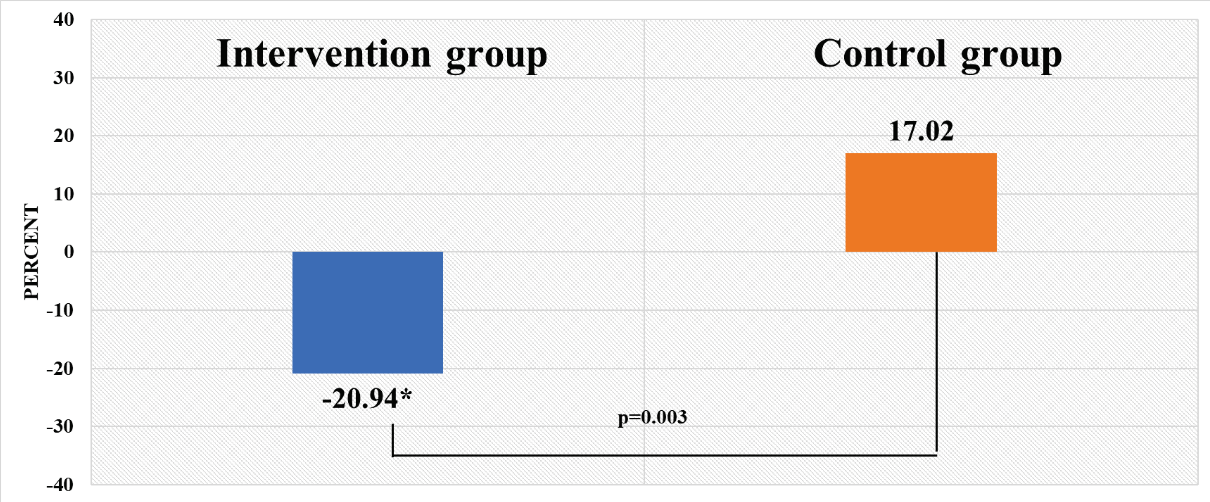

Fig. 12. Change of the sitting time after 2 months.

Abbreviations and explanations: * – statistically significant difference (p<0.05).

There were no significant changes of any intensity physical activity and the sitting time in the control group (Tab. 6).

Tab. 6. Changes of physical activity after 2 months according to the domain and character.

Intervention group				p value between the groups	Control group			
At baseline	After 2 months	Change	p value		p value	Change	At baseline	After 2 months
M ± SD	M ± SD	M ± SD				M ± SD	M ± SD	M ± SD
Physical activity at work (MET-minutes/week)					**Physical activity at work** (MET-minutes/week)			
1496.85 ± 3802.33	1750.71 ± 2907.98	253.86 ± 4366.86	0.242	0.648	0.164	195.48 ± 2000.52	1244.98 ± 2566.95	1440.46 ± 2116.50
Walking at work (MET-minutes/week)					Walking at work (MET-minutes/week)			
414.78 ± 1250.78	407.95 ± 853.22	-6.83 ± 1018.04	0.728	0.445	0.199	368.28 ± 1487.07	417.78 ± 1045.38	786.06 ± 1489.69
Vigorous physical activity at work (MET-minutes/week)					Vigorous physical activity at work (MET-minutes/week)			
699.31 ± 2191.94	717.93 ± 1702.68	18.62 ± 2857.20	0.602	0.710	0.813	-182.40 ± 1941.48	556.80 ± 1437.87	374.40 ± 1125.87
Moderate physical activity at work (MET-minutes/week)					Moderate physical activity at work (MET-minutes/week)			
382.76 ± 953.37	624.83 ± 1744.22	242.07 ± 1912.89	0.932	0.613	0.767	9.60 ± 534.45	270.40 ± 689.28	280.00 ± 581.03
Physical activity for transportation (MET-minutes/week)					**Physical activity for transportation** (MET-minutes/week)			
994.58 ± 1057.19	1059.41 ± 1851.12	64.84 ± 2025.68	0.866	0.396	0.168	205.32 ± 1258.98	665.58 ± 1154.72	870.90 ± 862.12
Walk (MET-minutes/week)					Walk (MET-minutes/week)			
929.41 ± 1028.44	695.28 ± 839.28	-234.13 ± 1174.05	0.523	0.309	0.224	120.12 ± 1230.83	622.38 ± 1147.88	742.50 ± 817.87
Cycle (MET-minutes/week)					Cycle (MET-minutes/week)			
65.17 ± 209.75	364.14 ± 1694.18	298.97 ± 1707.94	0.221	0.800	0.345	85.20 ± 324.69	43.20 ± 182.09	128.40 ± 338.69
Physical activity in a domestic setting and gardening (MET-minutes/week)					**Physical activity in a domestic setting and gardening** (MET-minutes/week)			

1912.67 ± 2652.40	2457.59 ± 4130.29	544.91 ± 4309.16	0.733	0.996	0.753	-163.80 ± 2063.91	1397.40 ± 2256.32	1233.60 ± 1402.46
Vigorous physical activity doing yard work (MET-minutes/week)					Vigorous physical activity doing yard work (MET-minutes/week)			
354.66 ± 1017.35	961.55 ± 2166.41	606.90 ± 2205.30	**0.037**	0.762	0.394	178.20 ± 1296.52	415.80 ± 945.60	594.00 ± 1056.52
Moderate physical activity doing yard work (MET-minutes/week)					Moderate physical activity doing yard work (MET-minutes/week)			
637.59 ± 978.25	749.66 ± 1575.65	112.07 ± 1646.30	0.701	0.789	0.723	-172.80 ± 847.96	456.00 ± 872.93	283.20 ± 321.23
Moderate physical activity doing inside chores (MET-minutes/week)					Moderate physical activity doing inside chores (MET-minutes/week)			
920.43 ± 1588.00	746.38 ± 1116.55	-174.05 ± 1594.97	0.700	0.620	0.313	-169.20 ± 628.46	525.60 ± 711.82	356.40 ± 525.74
Physical activity in leisure time (MET-minutes/week)					**Physical activity in leisure time** (MET-minutes/week)			
912.32 ± 1144.34	1336.51 ± 1508.95	424.19 ± 1544.89	**0.032**	0.166	0.578	-311.64 ± 1795.18	1345.32 ± 2645.06	1033.68 ± 1242.14
Walking physical activity in leisure (MET-minutes/week)					Walking physical activity in leisure (MET-minutes/week)			
572.66 ± 881.99	533.41 ± 749.06	-39.26 ± 812.10	0.825	0.666	0.560	-273.24 ± 1742.39	898.92 ± 2070.85	625.68 ± 833.62
Moderate physical activity in leisure (MET-minutes/week)					Moderate physical activity in leisure (MET-minutes/week)			
152.07 ± 389.04	230.00 ± 365.71	77.93 ± 481.29	**0.042**	0.463	0.161	-16.00 ± 414.25	139.20 ± 418.11	123.20 ± 233.79
Vigorous physical activity in leisure (MET-minutes/week)					Vigorous physical activity in leisure (MET-minutes/week)			
187.59 ± 439.85	573.10 ± 1032.07	385.52 ± 1027.47	**0.004**	0.246	0.722	-22.40 ± 524.35	307.20 ± 648.15	284.80 ± 661.34
Walking physical activity (MET-minutes/week)					Walking physical activity (MET-minutes/week)			
1916.85 ± 2124.19	1636.63 ± 1646.77	-280.22 ± 2122.50	0.708	0.688	0.587	215.16 ± 3034.06	1939.08 ± 2735.24	2154.24 ± 2198.61
Moderate physical activity (MET-minutes/week)					Moderate physical activity (MET-minutes/week)			
2512.67 ± 2616.01	3676.55 ± 4966.91	1163.88 ± 5292.23	0.430	0.751	0.841	-85.00 ± 2354.09	1850.20 ± 2263.90	1765.20 ± 1654.82
Vigorous physical activity (MET-minutes/week)					Vigorous physical activity (MET-minutes/week)			
886.90 ± 2186.70	1291.03 ± 2319.43	404.14 ± 3175.93	0.077	0.119	0.576	-204.80 ± 2031.50	864.00 ± 1492.38	659.20 ± 1296.00
Sitting (minutes/week)					**Sitting** (minutes/week)			
1927.30 ± 877.00	1523.72 ± 867.59	-403.58 ± 835.85	**0.000**	**0.003**	0.201	275.71 ± 1250.81	1620.29 ± 989.90	1896.00 ± 940.55
Total Physical Activity (MET-minutes/week)					**Total Physical Activity** (MET-minutes/week)			
5316.41 ± 4409.31	6604.22 ± 5384.76	1287.80 ± 7056.06	0.163	0.391	0.819	-74.64 ± 3668.28	4653.28 ± 4200.04	4578.64 ± 2655.55

Abbreviations and explanations: M ± SD – mean ± standard deviation, MET – metabolic equivalent of the task.

Cardiorespiratory fitness. The mean values of the VO2max parameter at baseline were as follows: 22.28 ml/kg/min in the intervention group and 22.51 ml/kg/min in the control group. AT in the intervention group was 76.2 % and in the control group 77.98 % (of the predicted value). In the intervention group, mean HR at rest interventionwas 63.57 b/min, whereasin control group 61.30 b/min. We assessed CRF according to the guidelines of the *Cooper* aerobic investigations' institute and determined that it was very poor almost in all the study subjects (in 97.6 % of the intervention group subjects and in 100 % of the control group subjects). After 2 months, statistically significant improvement in CRF was found in both groups, but in the intervention group these changes were pronounced more statistically significantly (Fig.16). VO2max increased, on average, by 2.22 ml/kg/min (9.96 %, p<0.001) in the intervention group and by 0.94 ml/kg/min (4.18 %, p=0.005) in the control group, with a statistically significant difference between the groups (p=0.005). AT assessed by the percentage of estimated VO2 in the intervention group increased, on average, by 9.05 (11.87 %, p<0.001), whereas in the control group it decreased, on average, by 3.64 (4.67 %, p=0.018), the change difference between the groups being statistically significant (p<0.01). HR at rest significantly decreased only in the intervention group: on average, by 2.78 b/min (4.37 %, p=0.018).

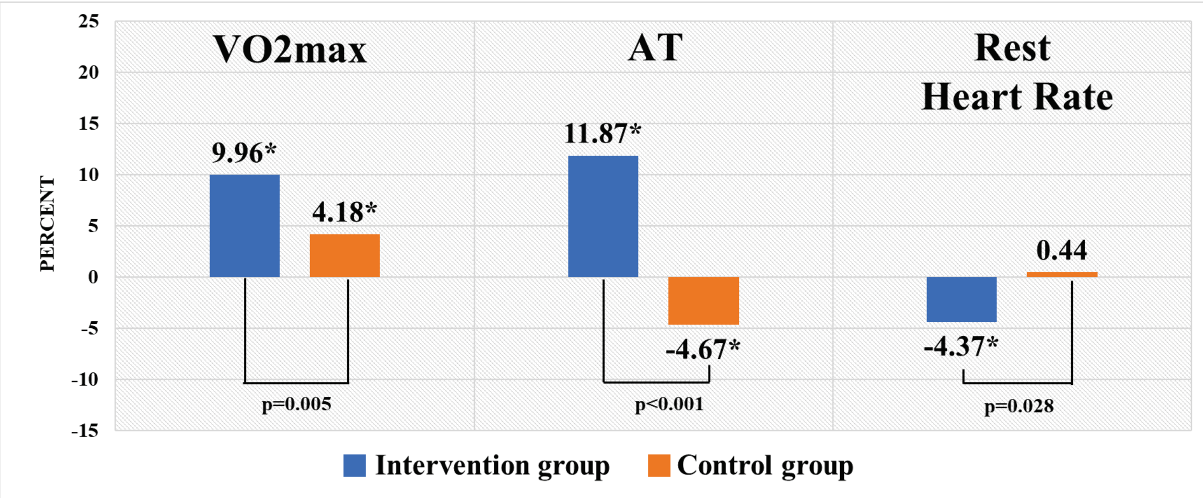

Fig. 13. The values of cardiorespiratory fitness parameters after 2 months

Abbreviations and explanations: VO2max – maximal consumption of oxygen, AT – anaerobic threshold, VO2 – consumption of oxygen, HR – heart rate; * – statistically significant difference (p<0.05).

The parameters of cardiorespiratory fitness are presented in Table 7.

Table 7. The changes of cardiorespiratory fitness parameters.

Intervention group				p value between the groups	Control group			
At baseline	After 2 months	Change	p value		p value	Change	At baseline	After 2 months
M ± SD	M ± SD	M ± SD				M ± SD	M ± SD	M ± SD
VO_2max (ml/kg/min)					VO_2max (ml/kg/min)			
22.28 ± 5.47	24.50 ± 5.24	2.22 ± 2.76	**<0.001**	**0.005**	**0.005**	0.94 ± 2.39	22.51 ± 4.61	23.45 ± 5.03
AT (%)					AT (%)			

76.22 ± 17.63	85.27 ± 16.54	9.05 ± 13.27	**<0.001**	**<0.001**	**0.018**	-3.64 ± 11.15	77.98 ± 17.55	74.34 ± 19.33
HR at rest (b/min), M ± SD					**HR at rest (b/min), M ± SD**			
63.57 ± 7.96	60.79 ± 8.38	-2.78 ± 8.28	**0.003**	**0.028**	0.778	0.27 ± 7.06	61.30 ± 8.04	61.57 ± 7.81

Abbreviations and explanations: M ± SD – mean and standard deviation; VO2max – maximal consumption of oxygen, AT – anaerobic threshold, VO2 – consumption of oxygen, HR – heart rate.

Quality of life. Subjects of both groups rated the health changes during the last year, general health condition, energy and vitality status as the worst. Social functions, physical activity and limitations due to emotional disorders were rated with top scores. (Fig. 14).

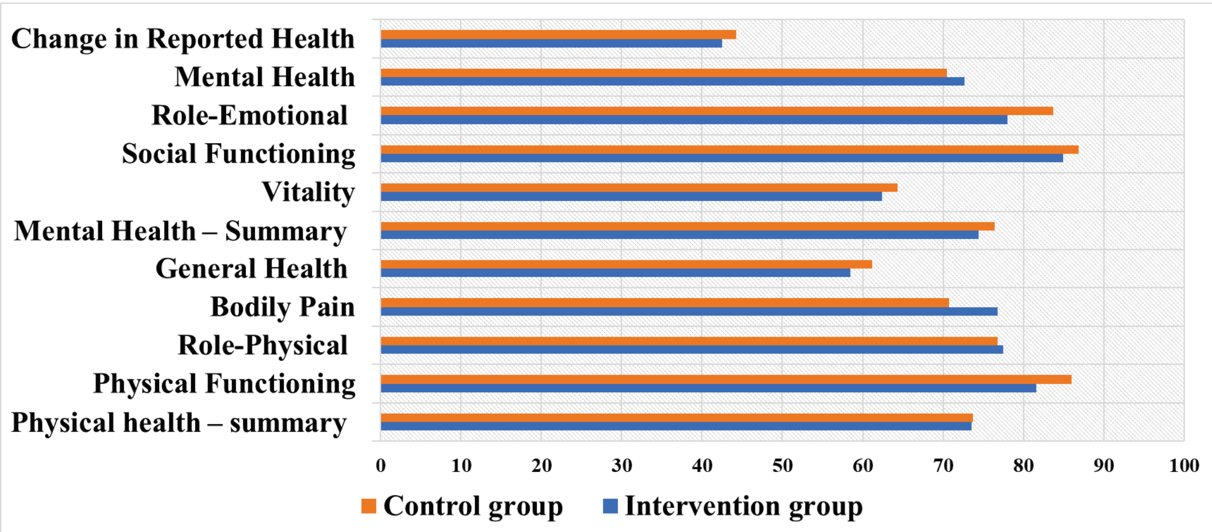

Fig. 14. Initial health-related evaluations of quality of life

Based on the analysis of how various aspects of QOL were evaluated by the subjects of different genders, age groups and obesity levels, we conclude that men rated their physical activity better than women, (p = 0.002 in the intervention group and p = 0.007 in the control group), and the younger subjects better than older (p = 0.009 in the intervention group and p = 0.012 in the control group). In the intervention group, pain more affected older subjects (p = 0.009), and the social functions were rated worse by women as well as by the older (p = 0.003 and 0.029, respectfully). By assessing the changes of QOL after 2 months it was estimated that, in the intervention group, physical activity increased. Limitation of activity decreased, most likely due to emotional disorders and changes in the generalized score of mental health. The overall score of physical activity, scores of basic health assessment, energy, vitality, emotional status and changes of health statistically significantly improved in both groups, and the score of pain increased (that means decreased bodily pain) only in the control group (Fig. 15).

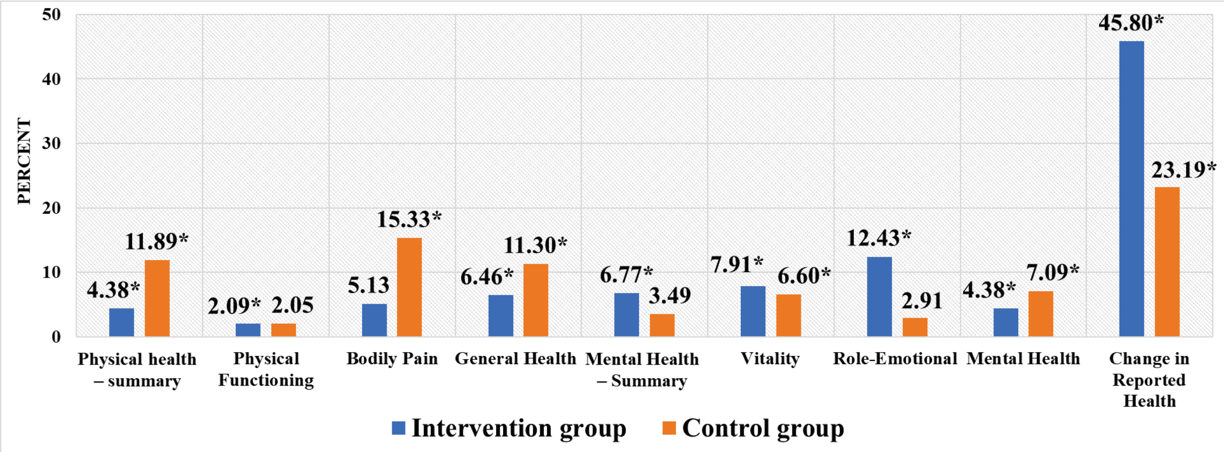

Fig. 15. Changes of quality of life scores after 2 months

Abbreviations and explanations: * – statistically significant difference (p<0.05).

Changes after 2 months of QOL are presented in Table 8.

Table 8. Changes of health-related quality of life after 2 months

Intervention group				**p value between groups**	**Control group**			
At baseline	**After 2 months**	**Change**	**p value**		**p value**	**Change**	**At baseline**	**After 2 months**
M ± SD	**M ± SD**	**M ± SD**				**M ± SD**	**M ± SD**	**M ± SD**
Physical health – summary					**Physical health – summary**			
73.57 ± 17.43	76.79 ± 17.43	3.22 ± 11.68	**0.020**	0.051	**<0.001**	8.76 ± 15.19	73.69 ± 15.29	82.45 ± 14.23
Physical Functioning					**Physical Functioning**			
81.58 ± 17.10	83.29 ± 17.10	1.71 ± 12.05	**0.010**	0.279	0.265	1.76 ± 8.12	85.99 ± 12.40	87.75 ± 9.40
Role-Physical					**Role-Physical**			
77.53 ± 33.87	80.91 ± 31.36	3.38 ± 28.54	0.373	0.364	0.051	15.24 ± 53.00	76.83 ± 34.64	92.07 ± 38.91
Bodily Pain					**Bodily Pain**			
76.79 ± 21.44	80.73 ± 27.08	3.94 ± 25.16	0.211	0.052	**0.004**	10.84 ± 21.01	70.73 ± 0.30	81.57 ± 18.36
General Health					**General Health**			
58.45 ± 15.07	62.23 ± 16.06	3.78 ± 12.13	**0.006**	0.934	**0.014**	6.92 ± 22.76	61.22 ± 14.00	68.14 ± 22.01
Mental Health – Summary					**Mental Health – Summary**			
74.43 ± 15.21	79.47 ± 13.73	5.03 ± 12.03	**<0.001**	0.295	0.108	2.67 ± 11.03	76.41 ± 16.12	79.08 ± 13.81
Vitality					**Vitality**			
62.37 ± 18.21	67.31 ± 14.43	4.94 ± 14.27	**0.002**	0.932	**0.036**	4.25 ± 12.38	64.38 ± 15.57	68.63 ± 15.02
Social Functioning					**Social Functioning**			
84.97 ± 17.26	86.23 ± 16.09	1.27 ± 16.94	0.496	0.719	0.779	0.00 ± 13.11	86.89 ± 15.80	86.89 ± 15.80
Role-Emotional					**Role-Emotional**			
78.06 ± 31.53	87.76 ± 23.37	9.70 ± 29.31	**0.009**	0.138	0.724	2.44 ± 28.27	83.74 ± 31.73	86.18 ± 26.85
Mental Health					**Mental Health**			
72.67 ± 14.51	75.85 ± 13.31	3.18 ± 11.66	**0.009**	0.365	**0.011**	5.00 ± 11.77	70.50 ± 14.57	75.50 ± 14.86

Change in Reported Health						Change in Reported Health		
42.53 ± 19.89	62.01 ± 21.69	19.48 ± 25.20	**0.0001**	0.101	**0.003**	10.26 ± 16.93	44.23 ± 1 7.64	54.49 ± 19.76

Abbreviations and explanations: M ± SD – mean ± standard deviation.

In sum, we conclude that, after 2 months, the scores of QOL have improved in both intervention and control groups. However, in the intervention group, physical activity, limitation of activity due to emotional disorders and the generalized assessment of mental health scores improved more.

Motivation for physical training. In both groups, the dominant motives for being physically active were health, appearance, fitness, whereas the least frequently mentioned motives were social engagement, recreative and emotional (Fig. 16).

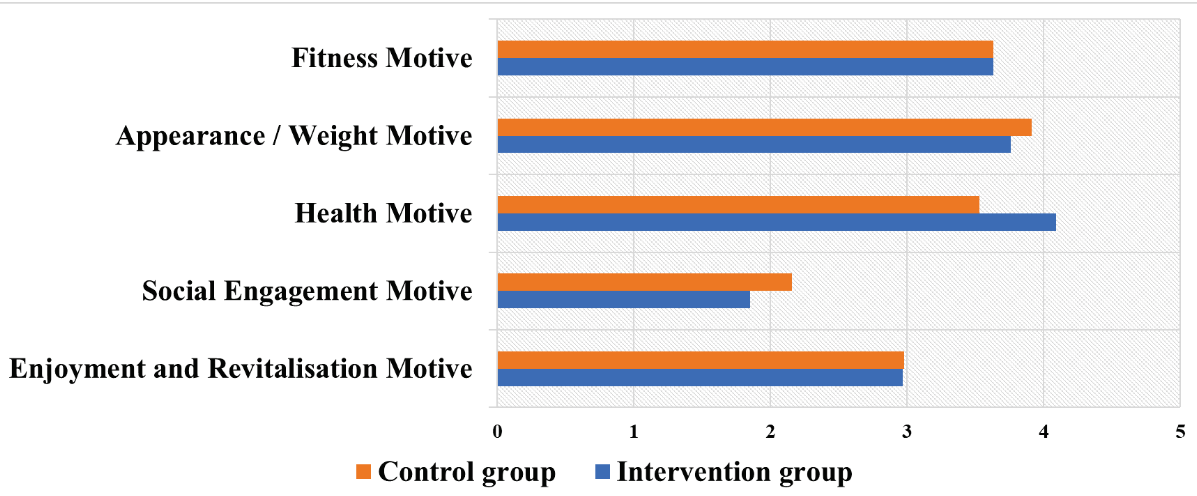

Fig. 16. Initial scores of motives for physical training

After 2 months, in both groups recreation and emotional motives increased and only in the intervention group social and physical fitness motives increased. Statistically significant improvement was also observed in the motive for stress management, recreation joy, challenge, social engagement, affiliation and competition scores, whereas social engagement and competition remained the weakest among the motivation for physical training factors. In the control group, appearance and weight management motives decreased the most. (Fig. 17 and Table 9).

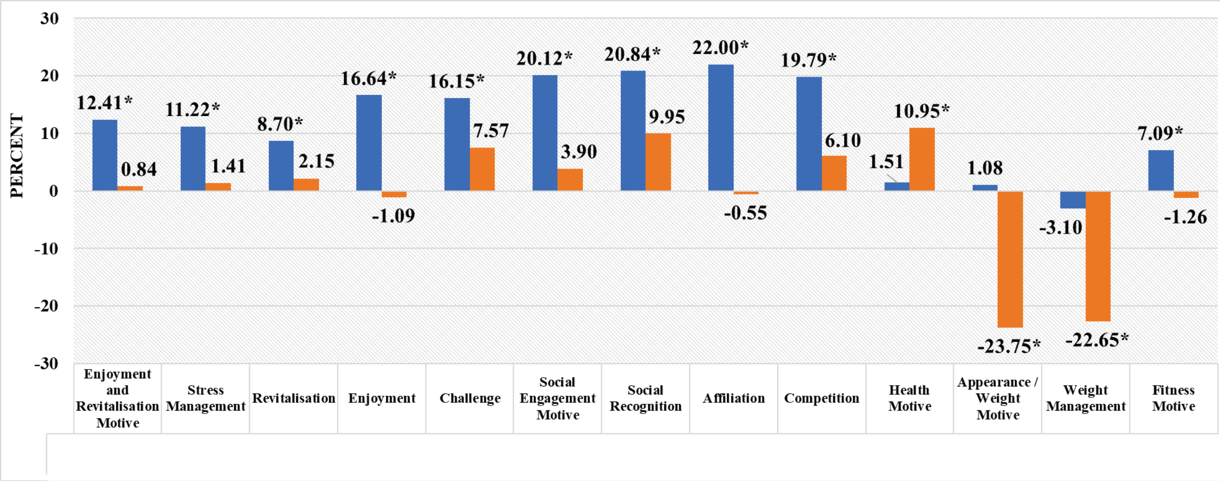

Fig. 17. Changes in scores of motives for physical training after 2 months

Abbreviations and explanations: * – statistically significant difference ($p<0.05$).

Table 9. Changes in scores of motives for physical training after 2 months

Intervention group				**p value between the groups**	**Control group**			
At baseline	**After 2 months**	**Change**	**p value**		**p value**	**Change**	**At baseline**	**After 2 months**
M ± SD	**M ± SD**	**M ± SD**				**M ± SD**	**M ± SD**	**M ± SD**
Enjoyment and Revitalisation Motive					**Enjoyment and Revitalisation Motive**			
2.97 ± 1.26	3.34 ± 1.12	0.37 ± 0.81	**<0.001**	**0.048**	0.848	0.03 ± 0.83	2.98 ± 1.13	3.01 ± 1.20
Stress Management					Stress Management			
2.83 ± 1.37	3.14 ± 1.22	0.32 ± 0.98	**0.002**	0.115	0.743	0.04 ± 0.82	3.01 ± 1.20	3.05 ± 1.25
Revitalisation					Revitalisation			
3.92 ± 1.11	4.26 ± 0.89	0.34 ± 0.85	**0.001**	0.215	0.254	0.08 ± 0.86	3.78 ± 0.94	3.86 ± 1.03
Enjoyment					Enjoyment			
2.85 ± 1.47	3.32 ± 1.25	0.47 ± 1.11	**0.001**	0.069	0.864	-0.03 ± 1.13	2.80 ± 1.35	2.77 ± 1.33
Challenge					Challenge			
2.36 ± 1.49	2.75 ± 1.43	0.38 ± 0.93	**0.001**	0.328	0.177	0.19 ± 0.87	2.49 ± 1.41	2.68 ± 1.46
Social Engagement Motive					**Social Engagement Motive**			
1.85 ± 1.47	2.22 ± 1.41	0.37 ± 0.94	**0.003**	0.146	0.568	0.08 ± 0.94	2.16 ± 1.33	2.24 ± 1.46
Social Recognition					Social Recognition			
1.80 ± 1.56	2.17 ± 1.50	0.37 ± 1.06	**0.004**	0.548	0.300	0.19 ± 0.87	2.18 ± 1.49	2.39 ± 1.41
Affiliation					Affiliation			
1.88 ± 1.56	2.30 ± 1.45	0.41 ± 1.19	**0.006**	0.060	0.756	-0.01 ± 1.03	2.26 ± 1.37	2.25 ± 1.51
Competition					Competition			
1.75 ± 1.48	2.09 ± 1.44	0.35 ± 1.01	**0.004**	0.228	0.359	0.12 ± 0.82	2.00 ± 1.50	2.12 ± 1.61
Health Motive					**Health Motive**			
4.09 ± 0.78	4.15 ± 0.81	0.06 ± 0.73	0.177	0.870	0.421	0.39 ± 1.53	3.53 ± 1.53	3.92 ± 0.91
Health Pressures					Health Pressures			
3.39 ±	3.43 ±	0.04 ±	0.566	0.537	0.806	-0.05 ±	3.40 ±	3.35 ±

1.31	1.30	1.20				1.09	1.39	1.29
Ill-Health Avoidance					Ill-Health Avoidance			
4.46 ± 0.78	4.47 ± 0.83	0.01 ± 0.95	0.581	0.928	0.443	0.40 ± 1.61	3.75 ± 1.57	4.15 ± 0.86
Positive Health					Positive Health			
4.41 ± 0.72	4.46 ± 0.76	0.05 ± 0.81	0.470	0.468	0.667	-0.05 ± 0.78	4.26 ± 0.84	4.21 ± 0.80
Appearance / Weight Motive					**Appearance / Weight Motive**			
3.76 ± 1.00	3.80 ± 1.15	0.04 ± 0.82	0.222	**0.001**	**0.002**	-0.93 ± 1.78	3.91 ± 1.05	2.98 ± 1.65
Weight Management					Weight Management			
4.27 ± 1.01	4.14 ± 1.15	-0.13 ± 0.88	0.564	0.088	**0.010**	-0.96 ± 1.92	4.23 ± 0.95	3.27 ± 1.76
Appearance					Appearance			
3.22 ± 1.30	3.39 ± 1.34	0.17 ± 1.05	0.251	0.077	0.185	-0.15 ± 0.93	3.43 ± 1.36	3.28 ± 1.20
Fitness Motive					**Fitness Motive**			
3.63 ± 1.13	3.89 ± 1.01	0.26 ± 0.94	**0.023**	0.162	0.986	-0.05 ± 0.84	3.63 ± 1.01	3.59 ± 1.07
Strength & Endurance					Strength & Endurance			
3.71 ± 1.22	4.05 ± 0.93	0.35 ± 0.99	0.006	**0.049**	0.558	-0.13 ± 0.98	3.75 ± 0.93	3.62 ± 1.06
Nimbleness					Nimbleness			
3.57 ± 1.24	3.65 ± 1.26	0.08 ± 1.10	0.435	0.540	0.539	0.07 ± 0.91	3.48 ± 1.29	3.55 ± 1.22

Abbreviations and explanations: M ± SD – mean ± standard deviation.

Optimal changes of cardiovascular risk factors in the intervention and control groups in 2 months. In order to assess the effect of the 2-month individually HR controlled supervised aPT programme, the ROC (*Receiver Operating Characteristic*) curve analysis was performed and the threshold values were estimated. Using the ROC curves we estimated the optimal threshold values of changes in waist circumference, HDL-Chol, c-f PWV, rest HR, VO2max, AT (in percent of VO2) and HR during AT. These threshold values separated the groups with the highest prognostic accuracy (the highest sensitivity and specificity). Then the odds ratio for the groups to achieve the optimal effect of the change of a risk factor were determined. *Waist circumference*. The optimal threshold value for the change of the waist circumference is 0 cm, (sensitivity 0.657 and specificity 0.541) (Fig. 18). The odds ratio for the intervention group to lower waist circumference more than 0 cm or equal after 2 months was 1.5 [1.02–2.20] (p=0.039) as compared to the control group.

HDL-Chol. The optimal threshold value for the change of the HDL-Chol was 0 cm, (sensitivity 0.772 and specificity 0.529) (Fig. 19). The odds ratio for the intervention group to increase HDL-Chol more than 0 cm or equal after 2 months was 1.71 [1.2–2.43] (p=0.003) as compared to the control group.

Carotid-femoral PWV. The optimal threshold value for the decreasing of c-f PWV was ≥ 1.4 m/s (sensitivity 0.786 and specificity 0.459) (Fig. 20). The odds ratio for the intervention group to lower c-f PWV for more than 1.4 m/s or equal after 2 months was 1.76 [1.08–2.87] (p = 0.023) as compared to the control group.

*HR at rest***.** The optimal threshold value of the decreasing of the HR value at rest was ≥ 3 b/min (sensitivity 0.672 and specificity 0.5) (Fig. 21). The odds ratio for the intervention group to lower HR at rest more than 3 b/min or equal after 2 months was 1.43 [1.0–2.05] (p = 0.048) as compared to the control group.

VO2max. The optimal threshold value of the increasing of VO2max was ≥ 0.3 ml/min/kg (sensitivity at this point was 0.691 and specificity – 0.619) (Fig. 22). The odds ratio for the intervention group to increase VO2max more than 0.3 ml/min/kg or equal after 2 months was 1.91 [1.3–2.78] (p=0.001) as compared to the control group.

Anaerobic threshold (percent of VO2). The optimal threshold value of the increasing AT of predicted VO2 was ≥ 8 % (sensitivity 0.86 and specificity – 0.585) (Fig. 23). The odds ratio for the intervention group to increase AT more than or equal 8 % of predicted VO2 after 2 months was 2.94 [1.91–4.54] (p<0.001) as compared to the control group.

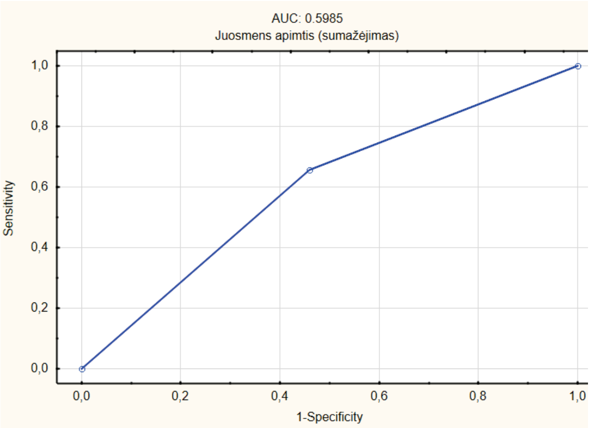

Fig. 18. ROC curve for the optimal threshold value 0 cm for the change of the waist circumference.

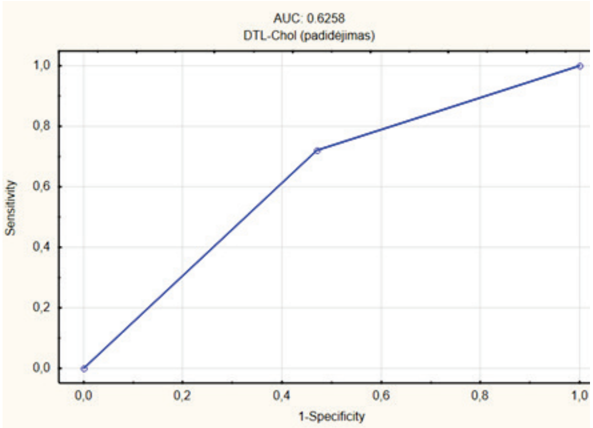

Fig. 19. ROC curve for the optimal threshold value 0 mmol/l for the change of the high density lipoprotein cholesterol

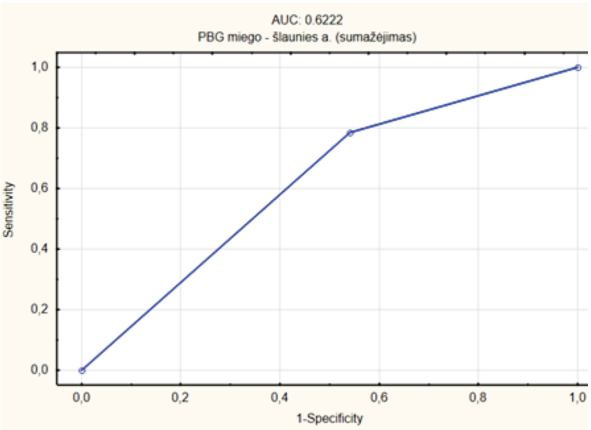

Fig. 20. ROC curve for the optimal threshold value 1.4 m/s for the decreasing of the carotid femoral pulse wave velocity

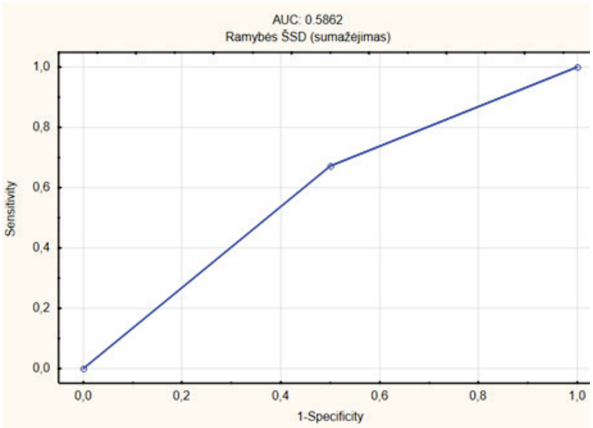

Fig. 21. ROC curve for the optimal threshold value 3 b/min for the decreasing of the heart rate at rest

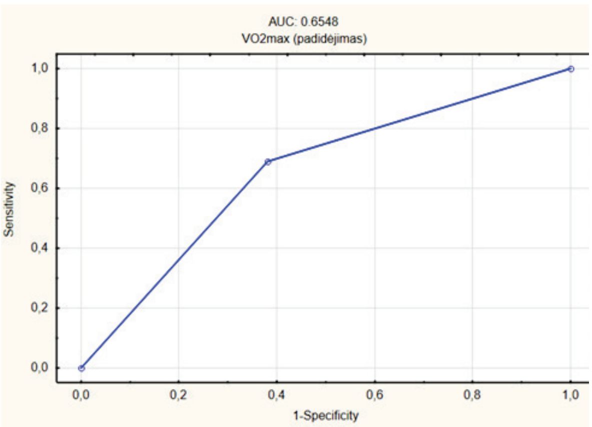

Fig. 22. ROC curve for the optimal threshold value 0.3 ml/min/kg for the increasing of the maximal consumption of oxygen

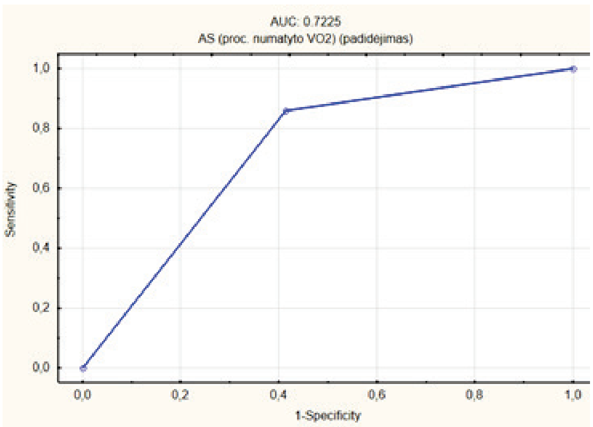

Fig. 23. ROC curve for the optimal threshold value 8 % for the increasing of the of anaerobic threshold (the percent of predicted oxygen consumption)

Abbreviations and explanations: AUC – area under the curve.

Interdependence analysis of the observed changes in the intervention and control groups. After the estimation of the statistically significant changes in the CV risk factors, MetS components, scores of QOL and motivation for physical training after 2 months of physical training in the intervention group, we estimated their interdependence.(Fig 24 and 25).

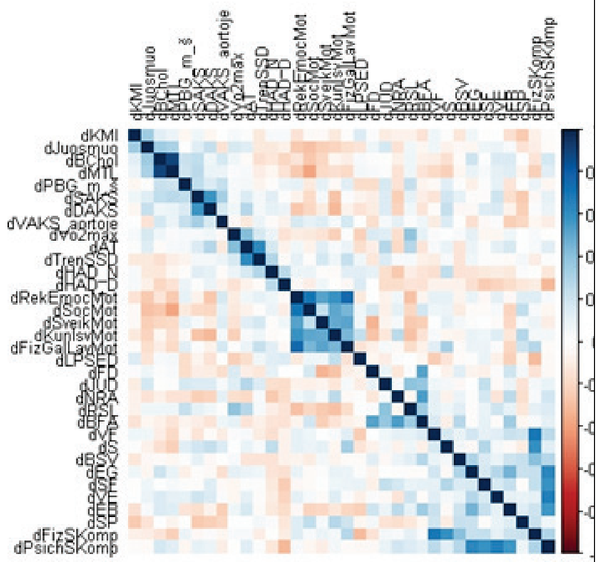

Fig. 24. Correlation between cardiovascular risk factors, components of metabolic syndrome, arterial wall functional and structural parameters, cardiorespiratory fitness, quality of life and motivation for physical training in the intervention group.

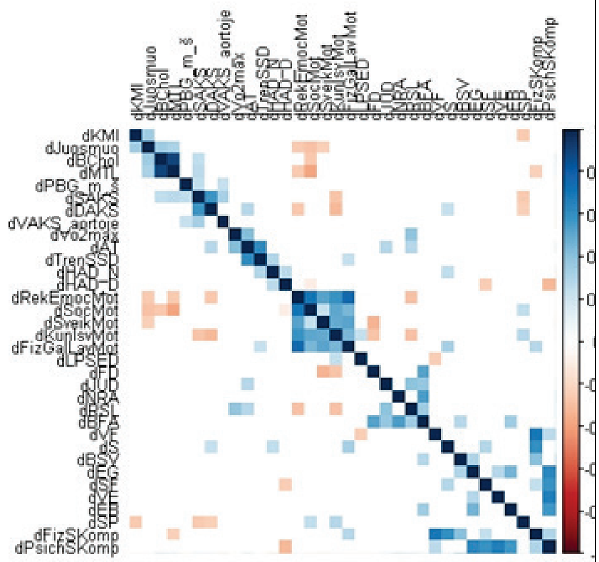

Fig. 25. Statistically significant correlation of cardiovascular risk factors, components of metabolic syndrome, arterial wall functional and structural parameters, cardiorespiratory fitness, quality of life and motivation for physical training in the intervention group.

Abbreviations and explanations: Correlation coefficient is presented in colours.

Statistically significant correlation between the CV risk factors, components of MetS, cardiorespiratory fitness and signs of physical activity after 2 months was estimated in the intervention group (Table 10).

Table 10. Statistically significant correlations between cardiovascular risk factors, components of MetS, cardiorespiratory fitness and signs of physical activity after 2 months in the intervention group

Parameters	**r**	**p**
Δ Waist circumference and Δ T-Chol	0.35	**0.001**
Δ Waist circumference and Δ LDL-Chol	0.31	**0.005**
Δ Body mass and Δ Waist circumference	0.27	**0.014**
Δ sBP and Δ T-Chol	0.24	**0.031**

Δ SBP and Δ LDL-Chol	0.26	**0.020**
Δ sBP ir Δ MBP in aorta	0.32	**0.005**
Δ Carotid-femoral PWV and Δ sBP	0.24	**0.033**
Δ Carotid-femoral PWV and Δ MBP in aorta	0.23	**0.042**
Δ VO2max and Δ Physical activity in leisure-time	0.39	**0.003**

Abbreviations and explanations: Δ – change, T-Chol – total cholesterol, LDL-Chol – low density lipoprotein cholesterol, sBP – systolic blood pressure, MBP – mean blood pressure, PWV – pulse wave velocity, VO2max – maximal oxygen consumption.

In the intervention group, the decrease of c-f PWV positively correlated with the decrease in BP parameters: sBP and MBP in the aorta. The correlation between the decrease of WC and the reduction of T-Chol and LDL-Chol was also observed. We also observed a significant correlation between the decrease of sBP and the reduction of T-Chol, LDL-Chol, MBP in the aorta, elevation of VO2 max and increased recreation, sports and leisure activity. In order to further investigate the dependence of the significant c–f PWV change on other parameters in the intervention group, we performed a univariate linear regression analysis of the change of c-f PWV. Regression models were constructed to investigate whether the reduction in c-f PWV in the intervention group is dependent on the change in sBP, MBP in the aorta, WC, T-Chol and LDL-Chol, increase of VOmax and increased recreation, sports and leisure activity. The univariate linear regression analysis demonstrated that the change of c-f PWV in the intervention group was significantly associated only with the decrease in sBP and MBP in the aorta (Table 11). However, the analysis of multiple linear regression that included sBP and MBP in the aorta was not dependent on the influence of any of these parameters on c-f PWV after 2 months of aPT (Table 12).

Table 11. Univariate linear regression models for the change in carotid-femoral pulse wave velocity (as a dependent variable) in the intervention group

Independent variables	**Unstandardized coefficients**		**95 % CI for B**		**Standardized coefficients**		**95 % CI for Beta**		**p**	**R^2**	**Adj. R^2**
	B	**SE**	**Lower limit**	**Upper limit**	**Beta**	**SE**	**Lower limit**	**Upper limit**			
Δ sBP	0.024	0.011	0.002	0.047	0.242	0.111	0.020	0.463	**0.033**	0.058	0.046
Δ MBP in aorta	0.030	0.014	0.001	0.058	0.230	0.111	0.009	0.451	**0.042**	0.053	0.041
Δ Waist circumference	-0.020	0.041	-0.101	0.060	-0.056	0.113	-0.281	0.169	0.619	0.003	-0.010
Δ T-Chol	0.173	0.104	-0.033	0.379	0.184	0.111	-0.036	0.404	0.099	0.034	0.022

Δ LDL-Chol	0.257	0.130	-0.003	0.517	0.218	0.111	-0.002	0.438	0.052	0.047	0.035
Δ Vo2max	0.020	0.051	-0.082	0.122	0.044	0.113	-0.181	0.269	0.698	0.002	-0.011
Δ PALT	0.000	0.000	0.000	0.000	0.209	0.133	-0.058	0.476	0.122	0.044	0.026

Abbreviations and explanations: Δ – change, CI – confidence interval, sBP – systolic blood pressure, MBP – mean blood pressure, T-Chol – total cholesterol, LDL-Chol – low density lipoprotein cholesterol, PALT – physical activity in leisure time, R^2 – coefficient of determination, Adj. R^2 – adjusted coefficient of determination; B – unstandardized regression coefficient, Beta – standardized regression coefficient, SE – standard error.

Table 12. Multiple regression model for change of carotid-femoral PWV (as a dependent variable) in the intervention group.

Model	**Unstandardized coefficients**		**95 % CI for B**		**Standardized coefficients**		**95 % CI for Beta**		**p**	**R^2**	**Adj. R^2**
	B	**SE**	**Lower limit**	**Upper limit**	**Beta**	**SE**	**Lower limit**	**Upper limit**			
Intercept	-0.400	0.161	-0.720	-0.080					**0.015**	0.090	0.065
Δ sBP	0.022	0.012	-0.002	0.046	0.216	0.118	-0.019	0.451	0.071		
Δ MBP in aorta	0.019	0.015	-0.011	0.049	0.150	0.118	-0.085	0.385	0.207		

Abbreviations and explanations: Δ – change, CI – confidence interval, sBP – systolic blood pressure, MBP – mean blood pressure, R^2 - coefficient of determination, Adj. R^2 – adjusted coefficient of determination; B – unstandardized regression coefficient, Beta – standardized regression coefficient, SE – standard error.

We performed the linear regression analysis of the c-f PWV change as a dependent variable and the study group as an independent variable adjusted for age and gender and determined the association between the reduction of c-f PWV and the intervention group (Table 13).

Table 13. Linear regression analysis for change of carotid-femoral PWV as a dependent variable and the study group as an independent variable adjusted for age and gender

Model	**Unstandardized coefficients**		**95 % CI for B**		**Standardized coefficients**		**95 % CI for Beta**		**p**	**R^2**	**Adj. R^2**
	B	**SE**	**Lower limit**	**Upper limit**	**Beta**	**SE**	**Lower limit**	**Upper limit**			
Intercept	0.744	1.393	-2.012	3.499					0.594	0.038	0.016
Intervention group	-0.223	0.111	-0.443	-0.004	-0.173	0.086	-0.343	-0.003	**0.046**		
Male gender	-0.065	0.179	-0.420	0.290	-0.051	0.140	-0.328	0.226	0.717		
Age	-0.020	0.026	-0.072	0.032	-0.106	0.141	-0.384	0.172	0.453		

Abbreviations and explanations: CI – confidence interval, R^2 – coefficient of determination, Adj. R^2 – adjusted coefficient of determination; B – unstandardized regression coefficient, Beta – standardized regression coefficient, SE – standard error.

Interrelationships of the change of carotid-femoral pulse wave velocity with baseline carotid femoral pulse wave velocity. Comparing the dynamics of arterial stiffness among the study subjects divided into groups according to the quartiles of the baseline c-f PWV, we found that, in the intervention group, c-f PWV change after 2 months of aPT was dependant on the initial magnitude of c-f PWV: the stiffer aorta was at the inclusion, the greater reduction of c-f PWV was achieved.. These differences remained statistically significant even after the correction for the sBP change . The reduction of c-f PWV after 2 months of aPT occurred when c-f PWV at baseline was in the third quartile (≥ 8.2 m/s) (Table 14).

Table 14. The dependence of change in carotid-femoral pulse wave velocity on the magnitude of the baseline values.

Quartiles	**Baseline carotid-femoral PWV (m/s)**	**Change of carotid-femoral PWV (m/s) M ± SD**	**p value**	**p value (adjusted for the change in sBP)**
I	<7.4	0.73 ± 0.95	<0.001	<0.001
II	7.4–8.19	0.005 ± 0.98		
III	8.2–9.09	-0.61 ± 0.92		
IV	>=9.1	-1.75 ± 1.03		

Abbreviations and explanations: M ± SD – mean ± standard deviation, PWV – pulse wave velocity, sBP – systolic blood pressure

The same dynamic was found in correlation analysis: we observed a statistically significant negative correlation between c-f PWV after 2 months of aPT and baseline c-f PWV (Fig. 26): the higher was the baseline c-f PWV, the lower c-f PWV after the intervention– correlation coefficient (r) equals 0.656 (a medium strength relationship, *p<0.001*).

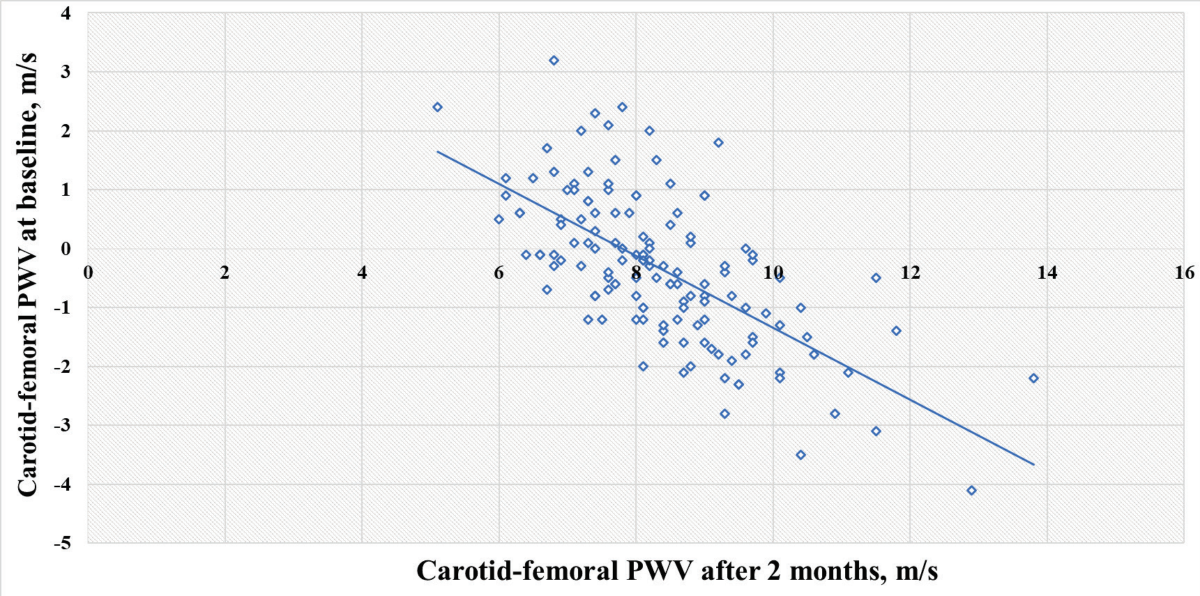

Fig. 26. Scatter plot for the interdependence between carotid-femoral pulse wave velocity at baseline and after 2 months..

Abbreviations and explanations: PWV – pulse wave velocity.

Estimation of the threshold carotid-femoral pulse wave velocity value at baseline.

ROC curve analysis. In order to estimate the value of c-f PWV at baseline with the highest prognostic accuracy (the highest sensitivity and specificity) that enables to predicted the improvement of c-f PWV after 2 months of aPT, we conducted the ROC curve analysis. The threshold value of baseline c-f PWV was found to be 8.1 m/s, with the prediction sensitivity 0.778 and specificity 0.704, and the area under the curve 0.8175 (see Fig. 27).

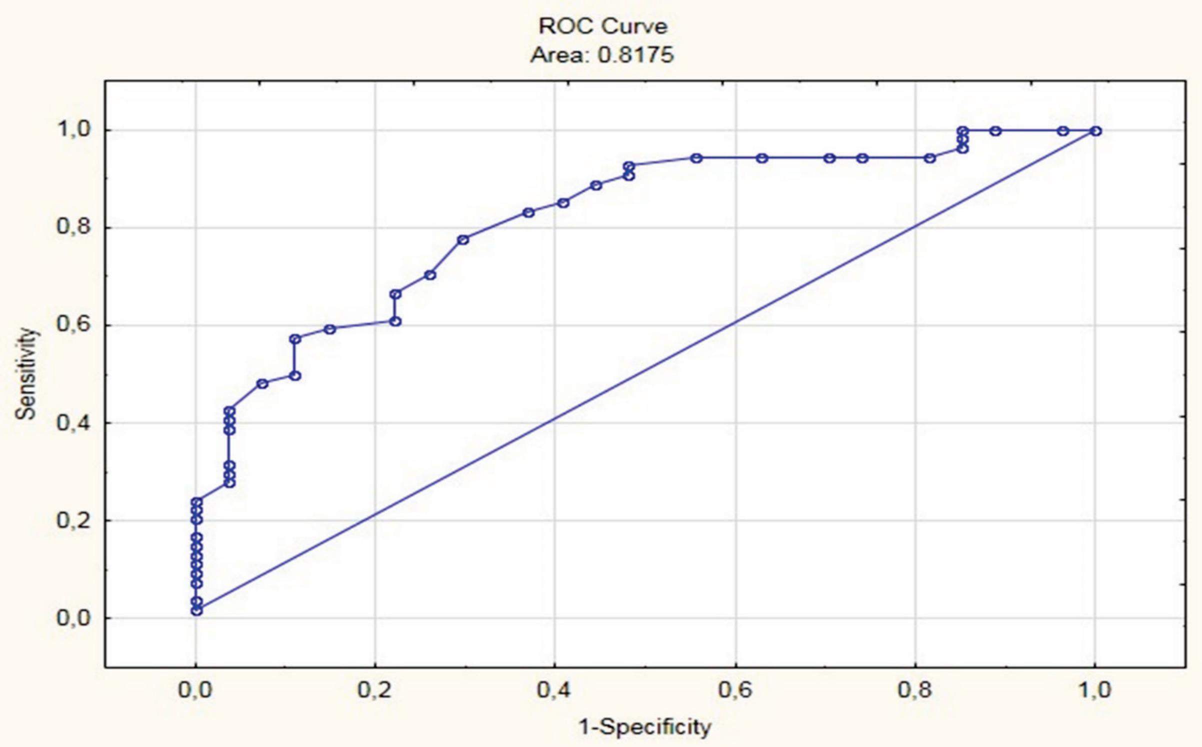

Fig. 27. ROC curve for estimating the threshold value of baseline carotid-femoral pulse wave velocity predictive of the interventation-related arterial stiffness reduction.

Regression Tree method. For a more accurate estimation of the relationship between c-f PWV at baseline and its change after 2-month of aPT, we used Regression Tree method. The application of it allowed to construct the decision tree that enabled to assess which threshold values of baseline c-f PWV might be used to predict lowering or further growing of c-f PWV after 2 month of aPT (Fig. 28). We found that the highest improvement after training was achieved when c-f PWV was > 10.1 m/s (-2.31 ± 1.15 m/s, M ± SD), moderate – in the interval 8.7–10.1 m/s (-1.22 ± 0.86 m/s). No changes were observed in the interval 7.4–8.6 m/s (-0.10 ± 0.94 m/s), and a minor worsening in the interval ≤ 7.3 m/s (0.73 ± 0.95 m/s).

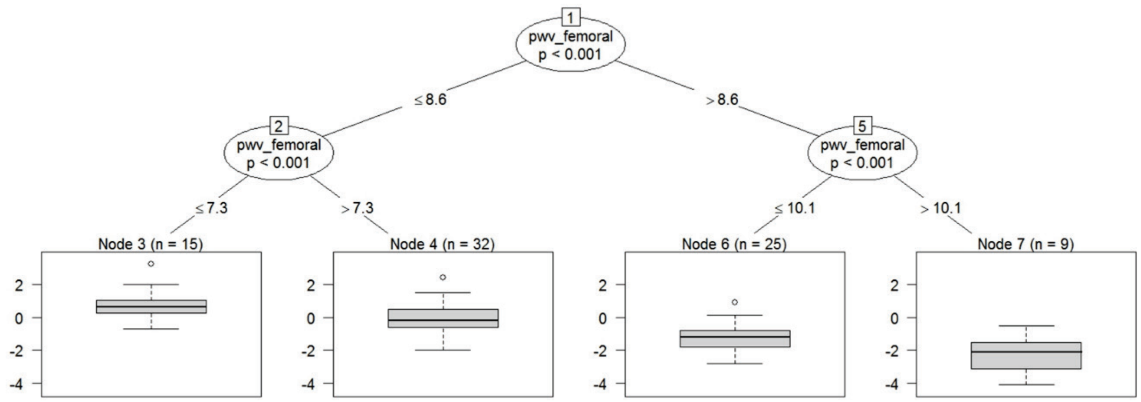

Fig. 28. Regression tree of the change of carotid-femoral pulse wave velocity

Abbreviations and explanations: c-f PWV – carotid-femoral pulse wave velocity.

<u>*Long-term assessment of the 2-month duration aerobic training programme after 8 months*</u>.

In order to assess what had happened with the CV risk factors, cardiorespiratory fitness, anxiety and depression, QOL in the long-term period, after 8 months, all subjects who arrived for a control visit were reassessed. Out of 140 subjects who participated in the investigation after 2 months, this third visit was missed by 35 (25 %) subjects: 11 (13.1 %) in the intervention group and 24 (42.9 %) in the control group. The data of these subjects were not included into the 8-month analysis. During the third visit, 105 subjects were investigated,:73 (68 %) in the intervention group and 32 (22 %) in the control group.

Cardiovascular risk factors, metabolic syndrome components after 8 months. After 8 months, the changes in BP from baseline were assessed in both groups, and the results were compared with those obtained at baseline. The analysis of the results in the intervention group after 8 months as well as after 2 months revealed the same tendencies of the BP change: sBP decreased in average by 4.46 mm Hg (3.35 %, p=0.003) (after 2 months the decrease was 4.09 mm Hg, 3.08 %), dBP decreased in average by 4.46 mm Hg (3.35 %, p=0.003) (after 2 months it decreased by 4.09 mm Hg, 3.08 %). In the control group, neither BP change after 2 months nor after 8 months was statistically significant (Fig. 29).

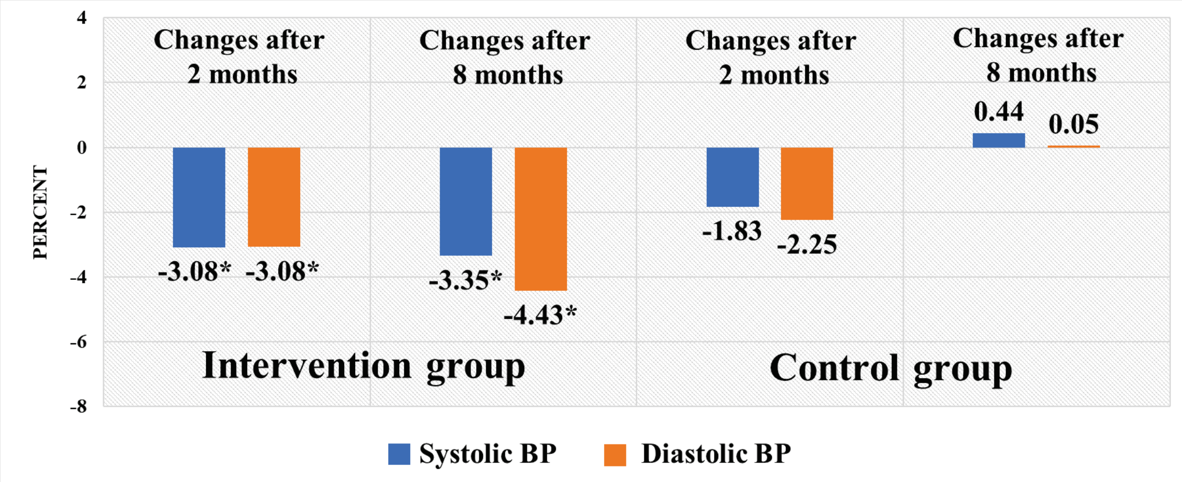

Fig. 29. Blood pressure changes after 2 and 8 months

Abbreviations and explanations: BP – blood pressure; * – statistically significant difference (p<0.05).

In the intervention group, the overall incidence of AH after 8 months statistically significantly decreased (10.47 %, p=0.021), and the severity of hypertension has improved.intervention:Namely, the number of subjects with grade I and II hypertension has decreased, whereas the number of subjects with pre-hypertension and normal BP increased. Likewise, after 8 months there were less subjects with isolated systolic AH. The incidence of AH and the distribution of the subjects according to the hypertension grade did not change in the control group after 8 months (Table 15).

Table 15. Changes of the degree of BP and the incidence of AH after 8 months

Parameter	Intervention group				Control group			
	First visit	Third visit	Difference	p	First visit	Third visit	Difference	p
Systolic BP (mm Hg), M ± SD	132.98 ± 13.26	128.52 ± 11.03	-4.46 ± 11.58	**0.003**	135.23 ± 14.28	135.82 ± 16.33	0.59 ± 11.65	0.814
Diastolic BP (mm Hg), M ± SD	81.94 ± 9.55	78.31 ± 7.81	-3.63 ± 7.67	**<0.001**	84.14 ± 10.04	84.18 ± 11.25	0.05 ± 7.67	0.978
Arterial hypertension (%)	94.05	83.58	-10.47	**0.021**	87.50	95.45	7.95	1.000
Degrees of BP:				**0.014**				0.558
- optimal BP (%)	13.25	19.70	6.44		19.64	13.64	-6.01	
- normal BP (%)	21.69	27.27	5.59		17.86	18.18	0.32	
- high-normal BP (%)	30.12	36.36	6.24		17.86	22.73	4.87	
- I° elevation of BP (%)	19.28	7.58	-11.70		14.29	27.27	12.99	
- II° elevation BP (%)	4.82	1.52	-3.30		8.93	9.09	0.16	
- Isolated systolic hypertension (%)	10.84	7.58	-3.27		21.43	9.09	-12.34	

Abbreviations and explanations: BP – blood pressure, M ± SD – mean ± standard deviation.

After 8 months, as well as after 2 months, T-Chol (p<0.001) and LDL-Chol statistically significantly decreased in the intervention group. T-Chol decreased in average by 0.82 mmol/l (13 %) while after 2 months it decreased by 0.52 mmol/l (8 %). LDL-Chol after 8 months decreased in average by 0.66 mmol/l (15 %), while after 2 months by 0.39 mmol/l (15 %). Statistically significant decrease in TG – in average by 0.42 mmol/l (17 %, p=0.027) – was found in the intervention group after 8 months. In the intervention group, this parameter did not reach statistical significance after 2 monthsintervention. In the control group there was no significant change in TG both after 8 and 2 months. There were no statistically significant changes in HDL-Chol both in the intervention and control groups after 8 months as well as after 2 months (Fig. 30).

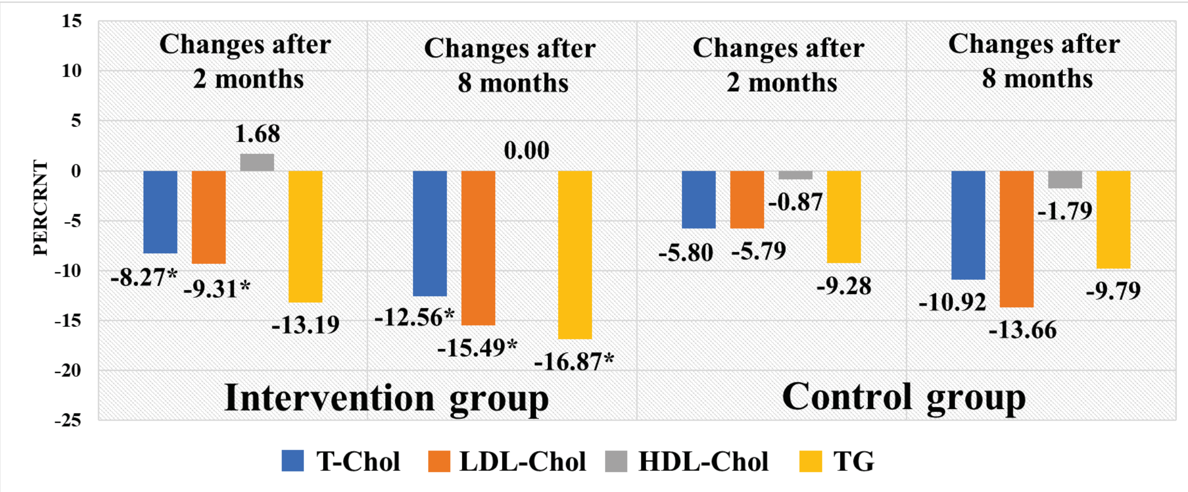

Fig. 30. Changes in the lipid parameters after 2 and 8 months

Abbreviations and explanations: T-Chol – total cholesterol, MTL-Chol – low density lipoprotein cholesterol, HDL-Chol – high density lipoprotein cholesterol, TG — triglycerides, * – statistically significant difference (p<0.05).

Although the values of lipid parameters changed in the intervention group, the incidence of dyslipidaemia did not change neither after 8 months nor 2 months (Table 16).

Table 16. Changes of the lipid parameters after 8 months

Parameter	Intervention group				Control group			
	First visit	Third visit	Difference	p	First visit	Third visit	Difference	p
T-Chol (mmol/l), M ± SD	6.53 ± 1.43	5.71 ± 1.25	-0.82 ± 1.45	**<0.001**	5.68 ± 1.33	5.06 ± 1.11	-0.62 ± 1.76	0.123
LDL-Chol (mmol/l), M ± SD	4.26 ± 1.17	3.60 ± 1.18	-0.66 ± 1.09	**<0.001**	3.66 ± 1.12	3.16 ± 0.99	-0.50 ± 1.54	0.140

HDL-Chol (mmol/l), M ± SD	1.19 ± 0.31	1.19 ± 0.31	0.01 ± 0.15	0.939	1.12 ± 0.29	1.10 ± 0.23	-0.03 ± 0.17	0.441
TG (mmol/l), V ± SN	2.49 ± 3.10	2.07 ± 1.59	-0.42 ± 3.08	**0.027**	1.94 ± 0.63	1.75 ± 0.84	-0.19 ± 0.84	0.140
Dyslipidaemia (%)	100.0	93.2	-6.8	-	94.6	100.0	5.4	-

Abbreviations and explanations: M ± SD – mean ± standard deviation, T-Chol – total cholesterol, MTL-Chol – low density lipoprotein cholesterol, HDL-Chol – high density lipoprotein cholesterol, TG – triglycerides.

Both after 8 and 2 months, the decrease of BMI in the intervention group remained statistically significant – on average, by 0.53 kg/m^2 (1.69 %, p<0.001). After 2 months it was 0.37 kg/m^2 (1.2 %). In the control group, the reduction in BMI did not reach statistical significance after 8 months, and was only 0.14 kg/m^2 (0.41 %), although after 2 months it was 0.34 kg/m^2 (1.1 %, p=0.011). After 8 months, WC remained statistically significantly reduced, on average, by 1.07 cm (1.06 %, p=0.038), whereas after 2 months by 1.34 cm (1.31 %). In the control group, after 8 months this parameter even increased, on average, by 3.05 cm, p=0.002). After 2 months, it has also increased, on average, by 0.2 cm, however the increase wasnot statistically significant (Fig. 31).

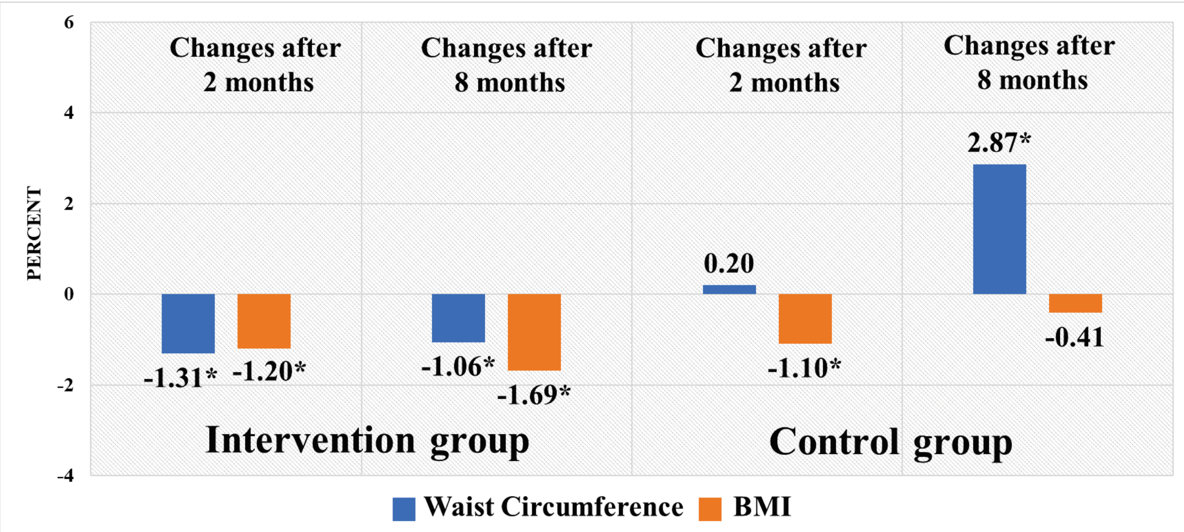

Fig. 31. Changes of waist circumference and body mass index after 2 and 8 months

Abbreviations and explanations: BMI – body mass index, * – statistically significant difference (p<0.05).

The distribution of subjects according to the degree of obesity improved statistically significantly in the intervention group – the number of the subjects with BMI < 25 kg/m^2 increased up to 6.94 %, thus the number of overweight and obesity containing subjects decreased (p=0.029). There was no such change in the control group neither after 2 nor 8 months. The changes of waist circumference, BMI, the incidence of abdominal obesity and obesity degree after 8 months are presented in Table 17.

Table 17. Changes of waist circumference, body mass index, the incidence of abdominal obesity and obesity degree after 8 months

Parameter	Intervention group				Control group			
	First visit	Third visit	Difference	p	First visit	Third visit	Difference	p
Waist circumference (cm), M ± SD	102.09 ± 9.51	101.01 ± 9.22	-1.07 ± 4.16	**0.038**	106.38 ± 10.26	109.43 ± 12.13	3.05 ± 3.83	**0.002**
Abdominal obesity (%)	81.9	79.1	-2.8	0.289	80.4	90.5	10.1	1.000
Body mass index (kg/m^2), M ± SD	30.81 ± 4.06	30.29 ± 4.03	-0.53 ± 1.10	**<0.001**	31.41 ± 3.75	31.28 ± 3.79	-0.14 ± 0.89	0.469
Obesity:				**0.029**				0.317
no (%)	4.82	11.76	6.94		1.79	4.55	2.76	
overweight (%)	38.55	35.29	-3.26		35.71	27.27	-8.44	
I degree (%)	40.96	39.71	-1.25		48.21	45.45	-2.76	
II degree (%)	14.46	13.24	-1.22		14.29	22.73	8.44	
III degree (%)	1.20	0.00	-1.2		0.00	0.00	0	

Abbreviations and explanations: M ± SD – mean ± standard deviation

Changes of the MetS components were assessed 8 months after the evaluation at baseline. It was ascertained that in the intervention group after 8 months 3 of 5 MetS components improved statistically significantly. After 2 months, the improvement of only 2 components was observed in the intervention group. The decrease of WC, BP and TG was estimated after 8 months. WC statistically significantly decreased after 8 months as well as 2 months, respectively by1.07 cm (1.06 %, p=0.038) and 1.34 cm (1.31 %). In the control group, WC even increased by 3.05 cm (2.87 %, p=0.002) after 8 months, whereas its increase by 0.2 cm after 2 months was not significant. Systolic BP in the intervention group after 8 months decreased, on average, by 4.46 mm Hg (3.35 %, p=0.003), after 2 months it also decreased, on average, by 4.09 mm Hg (3.08 %). Diastolic BP in the intervention group after 8 months decreased, on average, by 3.63 mm Hg (4.43 %, p<0,001). After 2 months it was also significantly decreased, on average, by 2.51 mm Hg (3.08 %). TG in the intervention group after 8 months statistically significantly decreased, on average, by 0.42 mmol/l (16.87 %, p=0.027), while after 2 months the decrease was not significant. There were no statistically significant changes in the MetS components in the control group, with the exception of the increased waist circumference (Fig. 32 and 33).

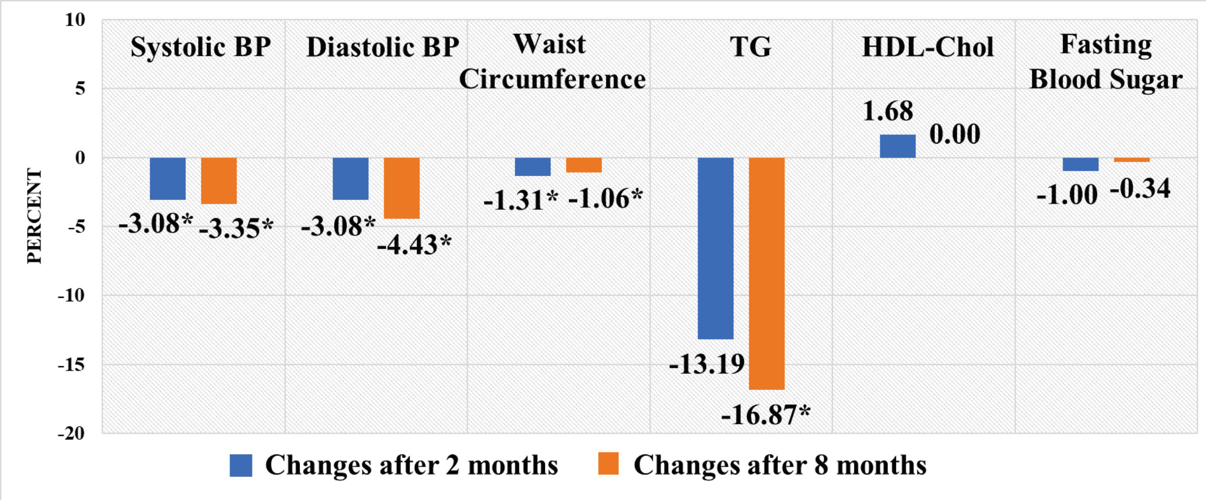

Fig. 32. Changes in the metabolic syndrome components after 2 and 8 months in the intervention group

Abbreviations and explanations: BP – blood pressure, TG – triglycerides, HDL-Chol – high density lipoprotein cholesterol, * – statistically significant difference ($p<0.05$).

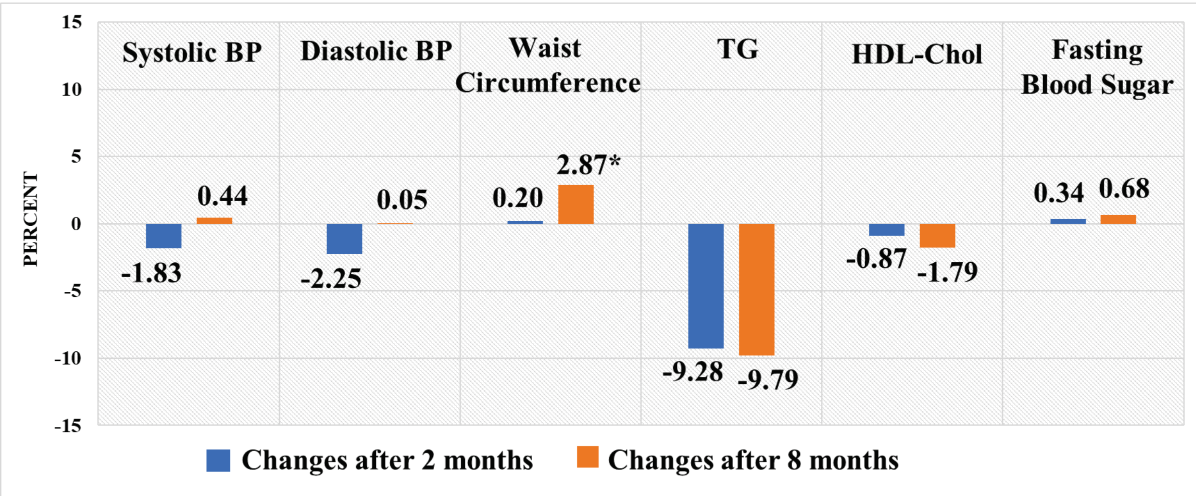

Fig. 33. Changes in the metabolic syndrome components after 2 and 8 months in the control group

Abbreviations and explanations: BP – blood pressure, TG – triglycerides, HDL-Chol – high density lipoprotein cholesterol, * – statistically significant difference ($p<0.05$).

After 8 months, the number of MetS components in the intervention group statistically significantly decreased:– from 3.75 components at baseline to 3.29 (decrease by 0.46, $p<0.001$). There were no significant changes in the number of MetS components in the control group after 8 months, while after 2 months the decrease was observed in both groups (Fig. 34). After 8 months, 25.3 % of the subjects in the intervention group and 14.3 % of subjects in the control group had less than 3 out of 5 MetS components.

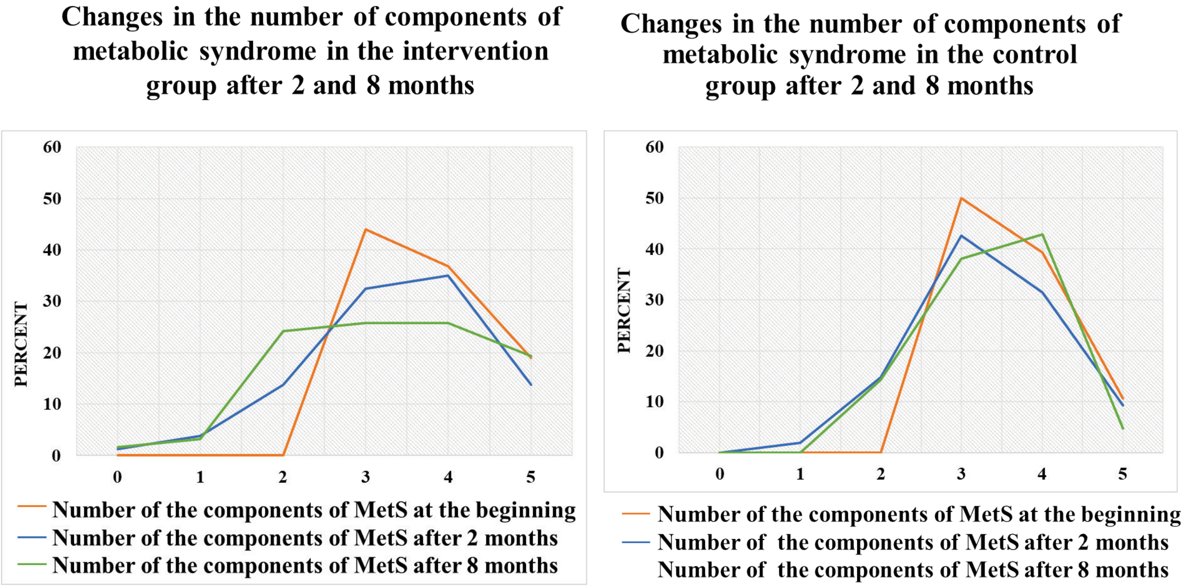

Fig. 34. Changes in the number of metabolic syndrome components after 2 and 8 months

After 2 months, p=0.001 After 2 months, p=0.016

After 8 months, p<0.001 After 8 months, p=0.109

Abbreviations and explanations: MetS – metabolic syndrome.

Changes in the MetS components after 8 months are presented in Table 18.

Table 18. Changes in theMetS components after 8 months

Parameter	**Intervention group**				**Control group**			
	First visit	Third visit	Difference	p	First visit	Third visit	Difference	p
sBP (mm Hg), M ± SD	132.98 ± 13.26	128.52 ± 11.03	-4.46 ± 11.58	**0.003**	135.23 ± 14.28	135.82 ± 16.33	0.59 ± 11.65	0.814
dBP (mm Hg), m ± SD	81.94 ± 9.55	78.31 ± 7.81	-3.63 ± 7.67	**<0.001**	84.14 ± 10.04	84.18 ± 11.25	0.05 ± 7.67	0.978
Waist circumference (cm), M ± SD	102.09 ± 9.51	101.01 ± 9.22	-1.07 ± 4.16	**0.038**	106.38 ± 10.26	109.43 ± 12.13	3.05 ± 3.83	**0.002**
TG (mmol/l), M ± SD	2.49 ± 3.10	2.07 ± 1.59	-0.42 ± 3.08	**0.027**	1.94 ± 0.63	1.75 ± 0.84	-0.19 ± 0.84	0.140
HDL-Chol (mmol/l), M ± SD	1.19 ± 0.31	1.19 ± 0.31	0.01 ± 0.15	0.939	1.12 ± 0.29	1.10 ± 0.23	-0.03 ± 0.17	0.441
Fasting glucose in plasma (mmol/l), M ± SD	5.97 ± 0.86	5.95 ± 0.97	-0.02 ± 0.55	0.736	5.86 ± 0.60	5.90 ± 0.54	0.04 ± 0.44	0.654
Number of MetS components:				**<0.001**				0.109
0 (%)	0.0	1.6	1.6		0.0	0.0	0	
1 (%)	0.0	3.2	3.2		0.0	0.0	0	

2 (%)	0.0	24.2	24.2	0.0	14.3	14.3
3 (%)	44.0	25.8	-18.2	50.0	38.1	-11.9
4 (%)	36.9	25.8	-11.1	39.3	42.9	3.6
5 (%)	19.0	19.4	0.4	10.7	4.8	-5.9

Abbreviations and explanations: M ± SD – mean ± standard deviation, sBP – systolic blood pressure, dBP – diastolic blood pressure, TG – triglycerides, HDL-Chol – high density lipoprotein cholesterol, MetS – metabolic syndrome.

Functional and structural parameters of the arterial wall after 8 months. After 8 months, as well as after 2 months, the decrease of c-f PWV, on average, by 0.74 m/s (8.6 %, p<0.001) remained statistically significant in the intervention group. After 2 months, the reduction was 0.54 m/s (6.33 %) (Fig. 35).

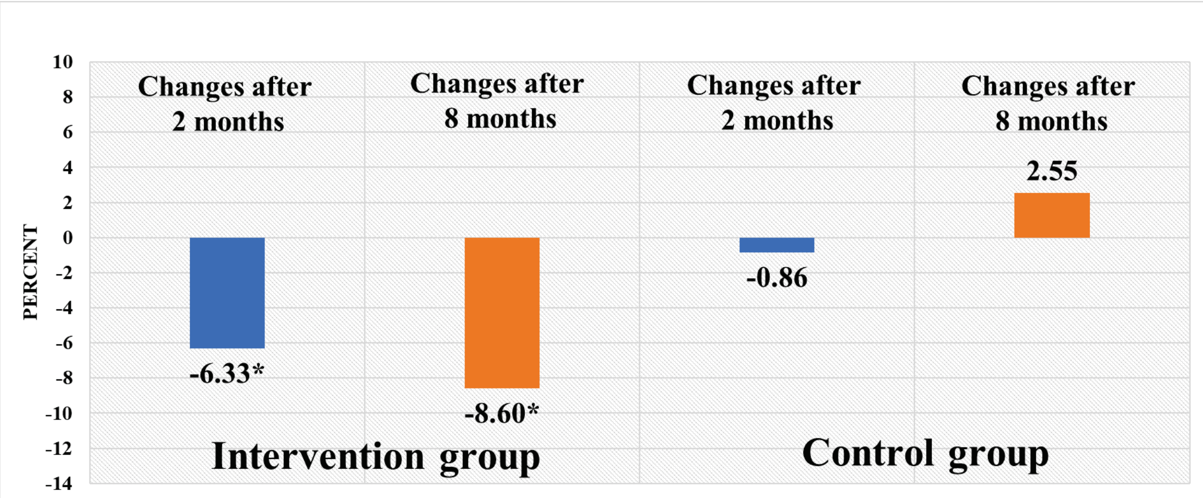

Fig. 35. Change of carotid-femoral pulse wave velocity after 2 and 8 months

Abbreviations and explanations: * – statistically significant difference (p<0.05).

After 8 months, MBP in the aorta was decreased, on average, by 8.44 mm Hg (7.99 %, p=0.001) (after 2 months the decrease was by 3.73 mm Hg, 3.58 %) in the intervention group. We did not observe such changes in the control group neither after 2 nor after 8 months (Fig. 36).

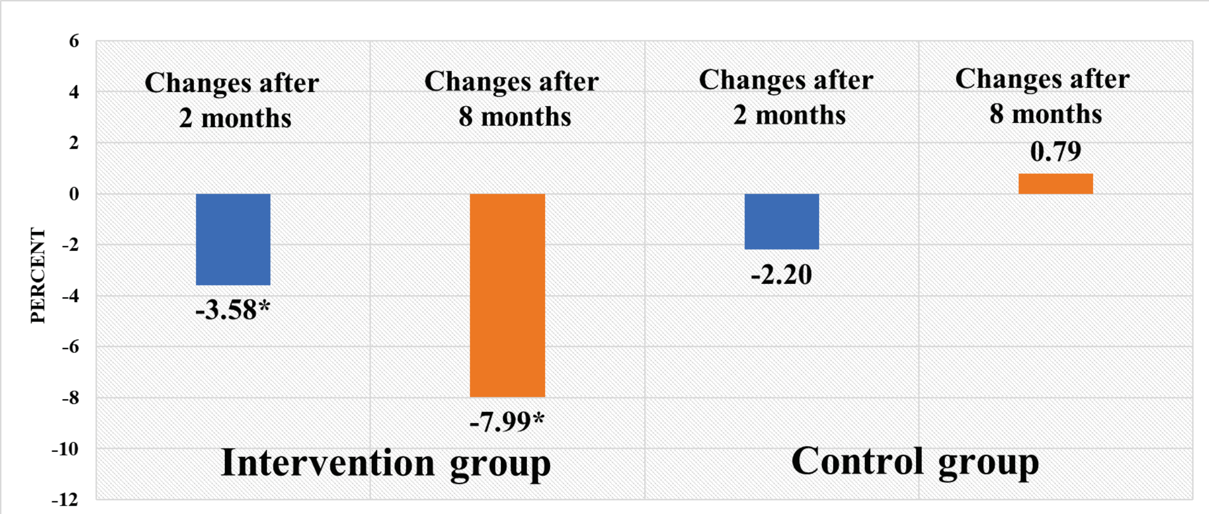

Fig. 36. Change of mean blood pressure in the aorta after 2 and 8 months

Abbreviations and explanations: * – statistically significant difference (p<0.05).

The analysis according to the categories of c-f PWV in the intervention group demonstrated that, from the first to the third visit, the number of subjects with higher c-f PVW values (>8 m/s) statistically significantly decreased on the account of the number of subjects with lower c-f PVW values increasing. We did not observe the changes of c-f PWV in the control group. The changes in the functional and structural parameters of the arterial wall after 8 months are presented in Table 19.

Table 19. Changes in the functional and structural parameters of the arterial wall after 8 months

Parameters	Intervention group				Control group			
	First visit	Third visit	Difference	p	First visit	Third visit	Difference	p
c-r PWV (m/s), M ± SD	9.13 ± 1.20	10.67 ± 13.67	1.55 ± 13.74	0.220	8.96 ± 0.85	13.57 ± 17.68	4.61 ± 17.75	0.062
c-f PWV (m/s), M ± SD	8.60 ± 1.30	7.86 ± 1.42	-0.74 ± 1.42	**<0.001**	8.25 ± 0.83	8.46 ± 1.65	0.20 ± 1.37	0.490
c-f PWV:				**<0.001**				0.67
- ≥10 m/s (%)	14.46	6.15	-8.30		7.14	13.64	6.49	
- 9-9.9 m/s (%)	20.48	12.31	-8.17		16.07	18.18	2.11	
- 8-8.9 m/s (%)	32.53	24.62	-7.91		28.57	27.27	-1.30	
- 7-7.9 m/s (%)	20.48	27.69	7.21		32.14	31.82	-0.32	
- <7 m/s (%)	12.05	29.23	17.18		16.07	9.09	-6.98	

MBP in aorta (mm Hg), M ± SD	105.67 ± 8.93	97.23 ± 15.62	-8.44 ± 15.06	**<0.001**	104.32 ± 11.67	105.14 ± 18.21	0.82 ± 19.30	0.844
CCA IMT (μm), M ± SD	653.65 ± 109.24	658.38 ± 99.20	4.73 ± 75.72	0.614	646.84 ± 97.23	628.55 ± 87.47	-18.30 ± 74.28	0.261
CCA stiffness, M ± SD	4.41 ± 1.73	4.42 ± 1.38	0.01 ± 1.30	0.835	4.23 ± 1.66	4.47 ± 1.97	0.24 ± 1.45	0.385

Abbreviations and explanations: M ± SD – mean ± standard deviation, c-r PWV – carotid–radial pulse wave velocity, c-f PWV – carotid–femoral pulse wave velocity, MBP – mean blood pressure, CCA – common carotid artery, IMT – intima-media thickness.

Anxiety and depression. There were no statistically significant changes in the scores of anxiety and depression after 8 months, as well as after 2 months.

Physical activity. Positive changes of recreation, activity in sports and leisure, particularly performing moderate and vigorous physical activity during leisure time remained statistically significant in the intervention group after 8 months, as well as it was after 2 months. Moderate physical activity during leisure time increased, on average, by 217.24 METmin/week (p=0.046), while after 2 months the increase was by 77.93 METmin/week. Vigorous physical activity during leisure time increased, on average, by 696.55 METmin/week (p=0.001), while after 2 months it was 385.52 METmin/week. In the control group, we observed the increased walking activity, on average, by 1298.79 METmin/week (p=0.048) (Fig. 37 and Table 20).

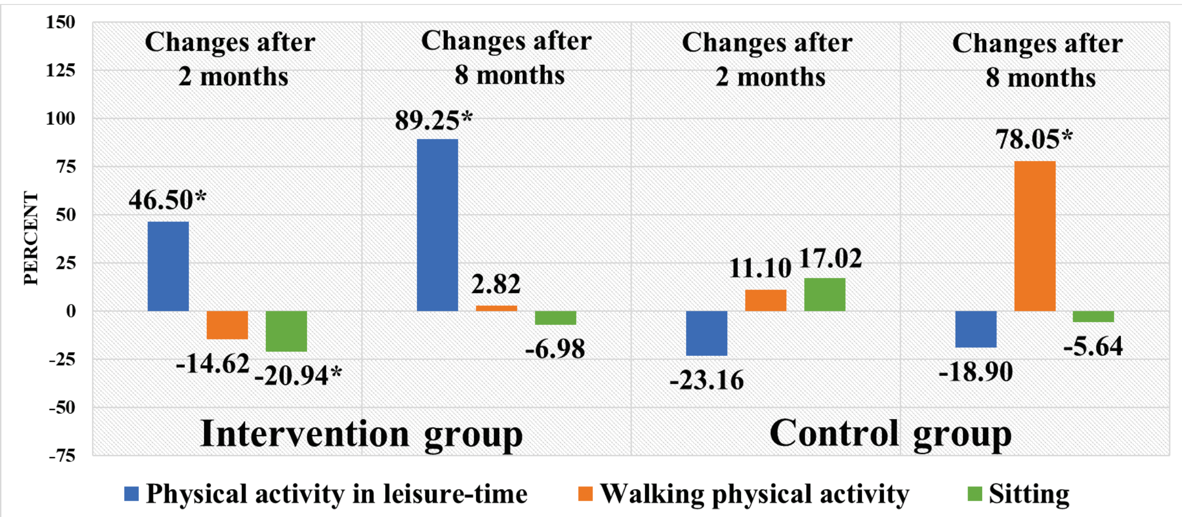

Fig. 37. Changes in physical activity according to the domains after 2 and 8 months

Abbreviations and explanations: * – statistically significant difference (p<0.05).

Table 20. Changes in physical activity according to the domains and the character after 8 months

Intervention group: At baseline M ± SD	Intervention group: After 8 months M ± SD	Intervention group: Change M ± SD	Intervention group: p value	p value between groups	Control group: p value	Control group: Change M ± SD	Control group: At baseline M ± SD	Control group: After 8 months M ± SD
Walking at work (MET-minutes/week)					Walking at work (MET-minutes/week)			
457.45 ± 1358.50	862.55 ± 1537.49	405.10 ± 1867.59	0.102	0.174	**0.021**	1072.50 ± 1803.53	218.04 ± 531.33	1290.54 ± 1698.21
Walk (MET-minutes/week)					Walk (MET-minutes/week)			
984.31 ± 1066.15	718.03 ± 909.26	-266.28 ± 1411.01	0.611	0.066	**0.041**	221.57 ± 967.85	894.54 ± 1462.55	1116.11 ± 809.87
Physical activity in leisure time (MET-minutes/week)					**Physical activity in leisure time** (MET-minutes/week)			
932.71 ± 1281.64	1765.14 ± 1790.25	832.43 ± 1821.85	**0.005**	**0.045**	0.594	-318.14 ± 1105.28	1683.00 ± 2152.58	1364.86 ± 2003.34
Moderate physical activity in leisure (MET-minutes/week)					Moderate physical activity in leisure (MET-minutes/week)			
195.17 ± 480.88	412.41 ± 557.76	217.24 ± 779.48	**0.046**	0.105	0.834	-111.43 ± 561.79	205.71 ± 522.92	94.29 ± 164.26
Vigorous physical activity in leisure (MET-minutes/week)					Vigorous physical activity in leisure (MET-minutes/week)			
140.69 ± 358.83	837.24 ± 1172.83	696.55 ± 978.02	**0.001**	**0.007**	0.225	-211.43 ± 574.84	925.71 ± 1933.47	714.29 ± 1915.50
Walking physical activity (MET-minutes/week)					Walking physical activity (MET-minutes/week)			
2038.60 ± 1934.70	2096.07 ± 2286.47	57.47 ± 2561.25	0.991	0.144	**0.048**	1298.79 ± 2564.39	1664.14 ± 2206.43	2962.93 ± 2012.70
Sitting (minutes/week)					**Sitting** (minutes/week)			
1713.08 ± 821.42	1593.46 ± 914.02	-119.62 ± 734.33	0.315	0.873	0.445	-102.35 ± 539.07	1814.12 ± 754.05	1711.77 ± 662.08

Abbreviations and explanations: M ± SD – mean ± standard deviation, MET – metabolic equivalent of task.

Cardiorespiratory fitness parameters after 8 months. Statistically significant improvement in VO2max (ml/kg/min) and the rest HR parameters persisted after 8 months in the intervention group. VO2max in the intervention group increased, on average, by 1.62 ml/kg/min (7.38 %, p<0.001), while after 2 months it increased by 2.22 ml/kg/min, 9.96 %. After 8 months, HR at rest decreased, on average, by 3.10 b/min (4.85 %, p<0.001), while after 2 months the decrease was 2.78 b/min (4.37 %). In the control group, there was no such improvements after 8 months, although after 2 months there was an improvement of VO2max (Fig. 38).

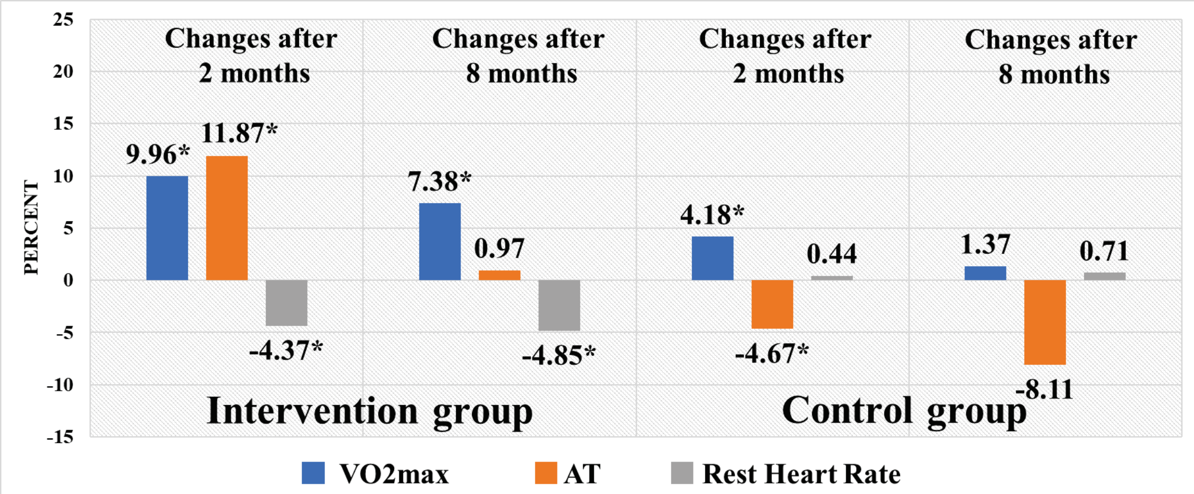

Fig. 38. Changes of the cardiorespiratory fitness parameters after 2 and 8 months

Abbreviations and explanations: * – statistically significant difference (p<0.05).

Changes of the CRF parameters after 8 months are presented in Table 21.

Table 21. Changes of the cardiorespiratory fitness parameters after 8 months

Parameter	Intervention group				Control group			
	First visit	Third visit	Difference	p	First visit	Third visit	Difference	p
VO2max (ml/kg/min), M ± SD	21.95 ± 5.20	23.57 ± 4.85	1.62 ± 3.57	**<0.001**	21.91 ± 5.13	22.21 ± 5.64	0.31 ± 2.62	0.628
AT (in % from predicted VO2), M ± SD	76.24 ± 17.81	76.98 ± 18.02	0.74 ± 16.48	0.539	80.89 ± 20.08	74.33 ± 26.27	-6.56 ± 13.66	0.058
Rest HR (b/min), M ± SD	63.94 ± 7.88	60.84 ± 7.55	-3.10 ± 7.42	**<0.001**	63.14 ± 7.68	63.59 ± 8.88	0.45 ± 7.79	0.732

Abbreviations and explanations: M ± SD – mean ± standard deviation, VO2max – maximal consumption of oxygen, AT – anaerobic threshold, HR – heart rate.

Quality of life after 8 months. The analysis of various aspects of QOL changes after 8 months, as well as after 2 months, revealed that in the intervention group the scores of general health, vitality, role-emotional and the change in reported health remained statistically significantly improved. Bodily pain, vitality, mental health scores improved in the control group also (Fig. 39, Table 22).

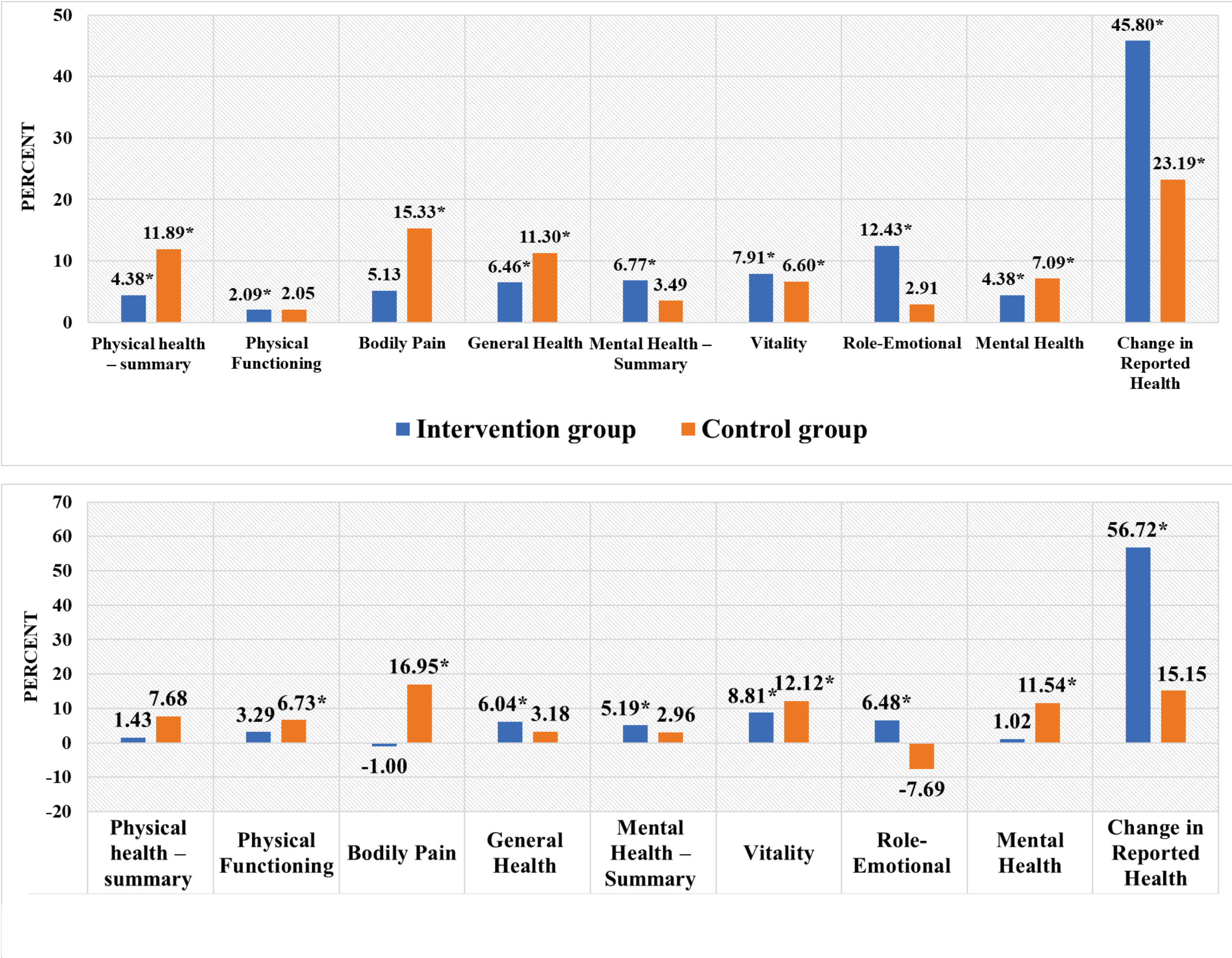

Fig. 39. Changes of the quality of life scores after 2 months (upper figure) and after 8 months (lower figure)

Abbreviations and explanations: * – statistically significant difference (p<0.05).

Table 22. Changes of quality of life after 8 months

Intervention group				p value between the groups	Control group			
At baseline	After 2 months	Change	p value		p value	Change	At baseline	After 2 months
M ± SD	M ± SD	M ± SD				M ± SD	M ± SD	M ± SD
Physical Functioning					**Physical Functioning**			
82.89 ± 19.07	85.61 ± 14.88	2.72 ± 13.96	0.155	0.365	**0.045**	5.83 ± 11.15	86.67 ± 14.55	92.50 ± 8.27
Bodily Pain					**Bodily Pain**			
77.52 ± 21.89	76.74 ± 25.29	-0.78 ± 21.60	0.943	0.114	**0.033**	12.35 ± 23.15	72.84 ± 22.94	85.19 ± 17.46
General Health					**General Health**			
57.73 ± 13.13	61.22 ± 15.83	3.49 ± 11.24	**0.048**	0.660	0.456	2.08 ± 11.58	65.56 ± 14.44	67.64 ± 11.83
Mental Health – Summary					**Mental Health – Summary**			
73.49 ± 14.63	77.31 ± 15.72	3.81 ± 10.37	**0.019**	0.621	0.372	2.41 ± 9.98	81.62 ± 10.34	84.03 ± 11.23
Vitality					**Vitality**			
59.32 ± 14.89	64.55 ± 16.38	5.23 ± 12.20	**0.012**	0.377	**0.006**	8.24 ± 10.74	67.94 ± 13.93	76.18 ± 7.81
Role-Emotional					**Role-Emotional**			
83.72 ± 25.59	89.15 ± 25.94	5.43 ± 22.92	**0.038**	0.233	0.201	-7.41 ± 24.40	96.30 ± 10.78	88.89 ± 28.01
Mental Health					**Mental Health**			
70.79 ± 13.45	71.51 ± 14.43	0.72 ± 13.50	0.604	**0.049**	**0.028**	8.21 ± 13.56	71.16 ± 13.24	79.37 ± 9.26
Changes in Reported Health					**Changes in Reported Health**			
41.88 ± 19.10	65.63 ± 22.42	23.75 ± 24.64	**<0.001**	**0.030**	0.161	6.94 ± 18.80	45.83 ± 17.68	52.78 ± 11.79

Abbreviations and explanations: M ± SD – mean ± standard deviation.

5. Discussion

The influence of physical training on cardiovascular risk factors and metabolic syndrome components

Regular physical activity decreases CV mortality by 20 % [51]. We have demonstrated that regular 2-month duration aerobic HR targeted PT has a positive effect on cardiovascular risk factors: AH, dyslipidaemia, and the components of metabolic syndrome. Most of these effects persisted even after 8 months. We did not find such changes in the control group where only recommendations for PA and PT were provided to the subjects.

After 2 months of aPT, statistically significant decrease in sBP and dBP was found and these changes persisted even after 8 months. It is well known that even a small decrease in BP by 2–

3 mm Hg due to PT lowers the risk of coronary heart disease by 5–9 %, the risk of stroke by 8–14 % and general mortality by 4 % [52].

Good physical fitness at baseline and its long-term maintenance protects against the development of dyslipidaemia [53-56]. In meta-analysis performed the lack of physical training programmes that improve lipid profile in subjects with MetS is stated [57]. The European Society of Cardiology concluded that it has not yet been established how much exercise is required in order to improve the lipid profile and reduce cardiovascular risk [58]. High fitness at baseline and its maintenance over time protects against the development of atherogenic dyslipidaemia [53]. The lack of evidence for PT programs that optimally improve lipid profile in MetS subjects was indicated in the meta-analysis [57]. It was shown that moderate aerobic exercise increases HDL-Chol and reduces TG level without prominent effect on LDL-Chol [56]. In our study, after 2 months of aPT, we observed a statistically significant decrease in LDL-Chol (from 4.19 mmol/l up to 3.8 mmol/l) without a significant decrease in TG or change in HDL-Chol. After 8 months, the lowering of LDL-Chol persisted and a statistically significant decrease in TG was observed in the interventiona group. These changes were not present in the control group. Other authors had pointed out, that in subjects with elevated LDL-Chol at baseline, intensive PT lowered LDL-Chol [59, 60]. In our study, baseline levels of LDL-Chol were elevated:4.19 in the intervention group and 3.8 mmol/l in the control group. Thus, our MetS subjects, additionally to the MetS components, had an elevated LDL-Chol at baseline, which decreased significantly after aPT. Similar results were found in the study by Dunn et al. [61], in which 24 week-long training (20–60 minutes of aPT, 3 times a week) was accompanied by a significantly decreased LDL-Chol without the increase in HDL. Significant decrease of LDL-Chol, non-significant decrease of TG and the increase of HDL-Chol has been reportedin premenopausal women after intensive walking intervention program [62]. Scholars agree that over months, not weeks, endurance exercise involving minimum expenditure of about 1200 kcal per week results in the increase of HDL-Chol [56].

Overweight and obesity incidence is growing dramatically all over the world. It is related to CV, metabolic, gastroenterological and oncological diseases. In the early stages of overweight, the prevention of obesity becomes very important, and physical activity is a major means to achieve it [63]. Measurement of BMI and WC are the recognised methods to assess this disorder and are related to the risk of CVD and DM [64]. In our study, we estimated that in the intervention aPT group statistically significant decrease of WC took place and persisted for 8 months, while in control group it even increased after 8 months in average by 3.05 cm. BMI decreased after 2 months in both groups, the intervention group and control group. After

8 months, statistically significant decrease of BMI was observed only in the intervention aPT group. So, according to our results, measurement of WC was a more specific parameter than BMI for the assessment of the effect of aPT.

The growing rates of abdominal obesity and MetS in Europe and the USA are increasingly recognized as the predictors of CVD[2] and T2DM [65-69]. The incidence of MetS in the middle-aged subjects in Lithuania is 28.7 %, in women 31.5 %, in men 25.1 % [6]. In our study, MetS was diagnosed according to NCEP/APT III criteria[34, 70]. In our MetS cohort,AH was present in 92.1 %, fasting glucose ≥5.6 mmol/l in 63.3% , elevated TG in 59.3% and decreased HDL-Chol in 47.9% of subjects. An important characteristic of our MetS subjects was the high frequency of an elevated LDL-Chol,which additionally rises the CV risk of these subjects. At baseline, 3 out of 5 MetS components were present in 46.4 %, 4 out of 5 in 37.9 %, and all 5 in 15.7 % of the study subjects. In all individuals low level physical activity was observed at baseline.

Heretofore, there is no consensus on the optimal type and intensity of PT for CV risk lowering [58] in MetS subjects. Various types of PT are applied – aerobic, interval and endurance [71-73]. In our study, we used individually HR targeted aerobic physical training. We demonstrated a statistically significant decrease in BP and WC following aPT intervention, both after 2 intervention and 8 months. Statistically significant decrease in TG in the aPT group was observed only after 8 months; after 2 months, it did not reach statistical significance. All these changes were absent in the control group. According to other studies, an individually adapted PT programme also improved most of the cardiometabolic parameters: BMI, WC, TG, and HDL-Chol. Only fasting glucose did not change statistically significantly [57, 72, 74, 75]. Similarly, we also did not observe a statistically significant change in plasma glucose either in the intervention or control group. After 2 months of aPT intervention, 18.8 % of our subjects had less that 3 components of MetS, and this percentage was even higher after 8 months (25.3 %). interventionOne other study has reported the decrease of MetS components after PT from 22.3 % to 13.5 % [74]. Another study has demonstrated that, due to PT intervention, 30.5 % of subjects were no longer classified as having MetS [75].

The effect of aerobic physical training on the functional and structural parameters of the arterial wall.

Early vascular aging is a relatively new definition of biological and vascular age mismatch, which increases the cardiovascular risk [8]. Vascular age can be assessed by obtaining arterial wall parameters. It was estimated, that 1 m/s increase in aortic pulse wave velocity corresponds to an age-, sex-, and risk factor-adjusted risk increase of 15 % in CVD and all-cause mortality [76]. Oxidative stress and inflammation are the main mechanisms causing stiffening of the arteries [77, 78]. Furthermore, a 0.1 mm increase in CCA IMT is associated with an 18 % and 15 % increased risk for a stroke and myocardial infarction [79]. In spite of the relatively rich cross-sectional data on vascular aging in the MetS subjects without overt CVD, the data on dynamics of the arterial wall parameters after the supervised HR targeted aPT is very limited. Our study is one of the first to assess the influence of such modality of training not only on CV risk factors and the components of MetS, but also on the arterial wall parameters reflecting the aging of the arteries. Improvement of the arterial wall parameters after PT has been shown in several previously reported studies. After training performed 3 times a week for 4 weeks, resting arterial compliance was elevated by ~30 % [80]. In the group of 21 middle-aged overweight and obese men, the 12-week walking or jogging for 40–60 minutes 3 days a week significantly increased carotid arterial compliance and reduced the stiffness index, assessed by post-study image analysis software, which was a relatively inaccurate method of the direct clipper measurements from ultrasound images [32]. In another study, arterial pulse wave velocities and augmentation index were measured immediately before and within 5–10 min after an incremental shuttle walk test [81]. Reduction of augmentation index after acute exercise but not decrease in aortic stiffness (c-f PWV) was observed. We did not measure the acute effect of training on augmentation index. According to the systematic review and meta-analysis of the large number of randomized controlled trials performed in various subjects, which did not specify the method used for dosing the exercise load, the reduction of brachial-ankle PWV was more significant than c-f PWV [82]. The authors also stated that higher intensity aerobic PT was associated with larger reductions in augmentation index, and aPT had more effect on brachial-ankle PWV rather than on central c-f PWV. The latter observation was not confirmed in our study, which analysed arterial wall parameters in a uniform group of the middle-aged MetS subjects under supervised HR targeted aPT. In our study, after 2 months of aPT in the intervention group there was statistically significant decrease in c-f PWV indicating the improvement of aortic compliance (decrease of aortic stiffness) and decrease of mean BP in the aorta. These changes persisted in the intervention group even after 8 months. In the control group, where only recommendations for PA and PT were provided, we did not observe such changes. We think that this result is of major importance and shows that HR targeted aPT can contribute not only to physical status of the MetS subject, but also to the reduction of early preclinical arterial damage.

It has been shown that cardiorespiratory exercise testing prior to exercise training is very important for the choice of the optimal exercise load [40]. In this respect, the assessment of VO2max during the exercise testing and the oxygen consumption at the AT are of great significance for the adjustment of the exercise load during training [40]. In our study, the training at the AT was chosen as the most effective way to enhance the exercise effectiveness for CVD risk reduction. Hence, our study demonstrates that by decreasing the c-f PWV by HR targeted aPT, we can, firstly, positively influence the mean BP in the aorta and, secondarily, affect the indices of the early "vascular aging" in the middle-aged subjects with MetS, and, possibly, delay the development of type 2 DM or CVD.

Previously conducted studies revealed that arterial stiffness independently of BP can predict an elevated risk of stroke and CHD [83-86]. A single study on the effect of aerobic training on arterial stiffness, comparable to ours, was published by Donley DA et al. in 2014 [31]. The study assessed arterial stiffness parameters before and after 8 weeks of supervised aerobic exercise training by deploying a ramp exercise protocol in a relatively small group of 22 individuals with metabolic syndrome. The findings revealed the improvement of the aortic and peripheral arteries stiffness parameters after exercising without the positive effect on lipid parameters. The publication concludes that the study needs to be continued in the bigger cohort of subjects. In our study we raised the hypothesis that HR targeted dosed supervised APT can reduce arterial and aortic stiffness as well as CCA stiffness and IMT and this will reduce the CV risk of our subjects.

We have analysed much more numerous cohort of the middle-aged subjects than Donley et al.: 170 subjects were divided into the intervention aPT group (85 subjects) and the control group (85 subjects). Arterial and aortic stiffness in our study was measured using the golden standard method, applanation tonometry (*Sphygmocor, AtCor Medical*) [87, 88]. After the analysis of the arterial wall functional parameters by the categories was carried out, we observed the statistically significantly increased number of subjects in whom c-f PWV was < 9 m/s. There was no such result achieved in the control group. intervention We estimated that, after 2 months, the intervention group showed the improvement of aortic stiffness: a statistically significant reduction in c-f PWV. The same result was obtained while measuring another parameter, MBP in the aorta. These effects persisted even after 8 months. There were no statistically significant changes in these parameters in the control group. The ROC curve analysis in the intervention group showed that the cutoff point, when the effect of aPT is optimal, occurred when the baseline c-f PWV value was > 8.1 m/s. According to the regression tree method, the improvement started when it was >8.6 m/s, and the maximal effect was reached at c-f PWV >10.1 m/s. In the multiple regression analysis, we also demonstrated that intervention was an independent predictor of the improvement in arterial compliance.intervention.

One of the gratest methodological assets of our study was that, as compared to other studies, we analysed a relatively larger group of MetS subjects. The other methodologocal advantage was that we applied a HR targeted and thus individually adjusted aPT. Likewise, we used the most accurate assessment of carotid stiffness and IMT currently available:CCA measurement by a highly accurate echotracking system (*Art. Lab, Esaote Europe B.V.*) [35]. The CCA measurements were based on the analysis of the radiofrequency signals and were obtained by high-resolution echo-tracking technology [35]. Hence, the fact that we did not observe any improvement in carotid distensibility or reduction of IMT after training is the more credible.. We are confident that the findings of our more numerous and accurate study are highly reliable. It is possible that longer intervention is needed to impact these parameters. The results of our study showed that HR targeted aPT reduces some of the arterial parameters which are which are surrogate markers of early atherosclerosis. The aerobic training-induced changes of anthropometric, metabolic and arterial markers can contribute to the reduction of the CV risk in subjects with metabolic syndrome and increase patient's motivation for further physical training, as the residual effect of aPT takes place even after 8 months.

The effect of aerobic physical training on anxiety and depression, physical activity, cardiorespiratory fitness, quality of life and motivation for physical training.

The data on how MetS is associated with depression and anxiety is limited. Some studies have observed that MetS is associated with depression, but not anxiety [11-13]. Other researchers emphasise that some of the MetS components, including obesity, impaired glucose tolerance or insulin resistance, and subclinical signs of atherosclerosis are linked with symptoms of depression or anxiety [9, 10, 14]. There are very few studies analysing the effect of the PT programme on subjects with MetS and their levels of anxiety and depression. There are some studies which demonstrated a positive or even compromising effect of PT on depression symptoms in patients suffering from chronic diseases, including type 2 DM or CHD, and those with decreased PA [22-25]. Our study have also evaluated the levels of anxiety and depression in subjects with MetS before and after HR targeted 2-month duration aPT in the intervention group and compared their results with the results of the subjects who were just provided with the recommendations for PA and PT in the control group. The results were reassessed after 8 months. There were no statistically significant differences between the subjects in different age, BMI and physical capacity according to depression and anxiety estimates.

The lack of PA has an adverse effect on the prevalence of CVD and type 2 DM (3, 61]. According to the national LitHiR programme, sedentary living was estimated in 49.9 % (54.4 % of women and in 43.1 % of men) of middle-aged subjects in Lithuania (89). Sedentary living is a prevalent risk factor in subjects with MetS [90-93]. The total PA duration and intensity inversly correlate with the risk of MetS and the freqency of its components. Conversely, the time spent in a sitting position directly correlates with the presence of MetS [94]. Sitting time is a very important living style factor affecting total mortality and is related to MetS [95], arterial stiffness [96-100] and risk of atherosclerosis [101]. That is why diminishing of sitting time is a very important means of MetS prevention [92]. In our study, sitting time at baseline in average was 1927.3 min/week (4.5 h/d) in the intervention group and 1620.29 min/week (almost 4 h/d) in the control group. After 2 months, sitting time statistically significantly diminished in both groups: in the intervention group by 403.58 min/week ($p<0.0001$) and in the control group by 275.71 ($p<0.003$) min/week. After 8 months, such changes were no longer observed . After 2 and 8 months, in the intervention group statistically significant improvement in leisure time, moderate and vigorous physical activity was observed. There were no such changes in the control group subjects. However, after 8 months, walking PA significantly improved.

The low level of cardiorespiratory fitness is a well-known factor of CV mortality [102, 103]. Better CRF means the lower risk of CVD, MetS, AH and dyslipidaemia. There is a positive relation between CRF and PA, and negative between PA and body fat amount [104]. In MetS subjects, there is an obvious relation between CRF and CVD mortality [105]. High CRF in subjects with elevated CV, MetS, glycemic disorders, type 2 DM means better prognosis in these subjects [106]. More precisely, CRF can be assessed by performing a cardiorespiratory stress test and assessing VO2max, AT, ventilation threshold and other parameters [107]. This is how we assessed CRF in our study subjects when comparing the intervention and control groups after 2 and 8 months. After 2 months, we found statistically significant improvement in VO2max and AT both in the intervention and the control groups, while HR at rest significantly decreased only in the intervention group. Similar results were presented in two other studies where the improvement of VO2max was found after PT in MetS subjects [20, 57]. When assessing CRF after 8 months we were able to find the improvement of VO2max and HR at rest only in the intervention group. That means a higher motivation of the subjects after 2-month duration aPT for further PT during next months.

It is known that patients with MetS syndrome are at increased risk to develop diabetes and cardiovascular diseases [15] which are associated with worse QOL [16, 17]. The evaluation of life quality disorders is especially relevant for this type of population, in which the adverse results of treatment, such as poor response to treatment, rapid disease progression and high mortality, are seen more often [17-19]. Some of the MetS components, including obesity, insulin resistance and arterial hypertension, are related to worse QOL [108-111]. This suggests that MetS itself may be the cause of life quality disorders. Several studies have confirmed this conclusion [112-116]. Our study revealed how quality of life in terms of QOL domains, measured with the SF-36 questionnaire is affected in MetS subjects. At the baseline, during the initial examination, both study groups had highest scores in the categories of social and physical functioning, and activity limitation due to emotional problems, and the worst in the change of reported health, general health assessment and vitality. After 2 months, in the intervention aPT group statistically significant improvement was achieved in those life quality domains that had been previously evaluated by the worst scores: changes in the reported health and emotional state, and activity limitation due to emotional problems. Changes in reported health, general health and physical health improved in the control group of PA and PT recommendations after 2 months. In the intervention group, the scores of general health, vitality, role-emotional, and the change in reported health, improved statistically significantly both after 2 and 8 months.intervention. Bodily pain, vitality, and mental health scores improved in the control group. Recently, Jahangiry L *et al.* have investigated HR QOL of MS subjects in comparison with subjects without overt MetS [117]. Similarly to the results of our study, it was observed that the most impaired domains of QOL in subjects having MetS were physical condition, energy and psycho-emotional condition [117]. In addition, some studies have also demonstrated that aerobic exercises can significantly improve QOL in subjects with obesity, or patients suffering from type 2 diabetes [21, 22, 118]. In contrast to previous studies, Vetter ML *et al.* reported that MetS was not associated with decreased QOL [119]. It was suggested that not MetS itself, but the components of MetS, such as obesity, depression and greater disease burden may significantly affect QOL in this population [119].

The role of motives for physical activity have been analysed in various studies [120-127], but most of them were based on self-determination theory perspective and examined general population. Since we used a standardized questionnaire (Exercise Motivations

Inventory v. 2) to investigate MetS subjects and their motives for physical activity, our study provides a more accurate estimate. We obtained that the most dominant motives to be physically active were health motives, especially ill-health avoidance and positive health. The participants of our study were the least motivated by social engagement and enjoyment, and revitalization motives, and the most motivated by health, fitness and appearance/weight motives measured at baseline. Self-reported evaluation of motives for physical activity did not differ between the patients of different genders, age groups, BMI and physical capacity categories. After 2 months, in both groups the health related motive improved most.In the intervention group, the best improvement was observed in recreation and emotional, social and physical fitness motives. After 2 months, in the control group appearance and weight management reasoning decreased the most. To our best knowledge, there are no previous studies that assessing MetS subjects' motivation for physical exercise. Only a few studies analysed motivation for exercise in patients with type 2 diabetes [128, 129]. Korkiakangas E *et al*. highlighted gender differences and demonstrated that women were more likely to indicate the importance of the positive body image for engaging in physical activity, whereas men more often indicated the importance of health-promoting behaviours [129]. Ferrand C *et al*. showed that motivation to physical activity in subjects with type 2 diabetes were mostly related to weight management, social relationships, physical and mental well-being [106]. According to Murer M *et al*., subjects having MetS are usually motivated to improve their physical activity and are familiar with its positive effect [130]. However, patients have to be better supported and advised how to get physically active [130].

Lastly**,** we investigated how individually tailored aerobic physical training by the heart rate targeting had affected MetS patients' quality of life, motives for physical activity and psycho-emotional state. Although BMI and oxygen uptake at peak load after the physical training programme statistically significantly improved, there was no statistically significant relation between the changes of these parameters and the changes of QOL domains, motives for physical activity, estimates of anxiety and depression.

Conclusions

1. Our complex assessment of cardiovascular risk factors, components of metabolic syndrome, arterial wall functional and structural parameters, cardiorespiratory fitness, motivation for physical training, and quality of life before and after the training

programme in metabolic syndrome subjects has demonstrated the efficacy of two-month long heart rate targeted supervised aerobic physical training: :

1.1. Only in the intervention group statistically significant positive effect on blood pressure indices, total cholesterol, low density lipoprotein cholesterol and waist circumference was obtained.
1.2. Both in the intervention and control groups the reduction of components of metabolic syndrome was observed.
1.3. Only in the intervention group there was an improvement of arterial wall parameters: a decrease of carotid-femoral pulse wave velocity and mean blood pressure in the aorta. At the baseline measured carotid-femoral pulse wave velocity > 8.6 m/s was associated with greater improvement.
1.4. Only in the intervention group sitting time decreased.
1.5. Both in the intervention and control groups cardiorespiratory fitness improved after 2 months. That suggests that even in the control group some subjects followed the recommendations for physical activity and training.

2. In the intervention group statistically significant improvement in motivation for physical training was found. Both in the intervention and control groups quality of life has improved.
3. The evaluation of the residual effect after 8 months of the 2-month duration aerobic physical training programme in the intervention group and in the control subjects who only followed standard recommendations for physical activity and training, demonstrated statistically significant residual positive effect of training only in the intervention group. Supervised PT had a positive impact on blood pressure indices, total cholesterol, low density lipoprotein cholesterol and triglycerides, waist circumference, components of metabolic syndrome, aortic stiffness, and cardiorespiratory fitness.

6. Practical recommendations

1. In subjects with metabolic syndrome, supervised aerobic physical training not only improves the quality of life, appearance and physical fitness but also reduces the risk of development of cardiovascular disease and/or diabetes mellitus by reducing cardiovascular and metabolic risk and development of atherosclerosis.
2. Heart rate controlled aerobic physical training can be reccomened as an integral part of primary prevention programmes in metabolic syndrome subjects. Such training is the

means for improving health quality, physical activity, cardiorespiratory fitness, vascular health and motivation for further physical training, and reduces cardiovascular risk and number of metabolic syndrome components..

3. Based on this study, a proposal to the government could be prepared for funding aerobic physical training activity once a year as a part of the ongoing Lithuanian High Cardiovascular Risk Programme.

4. From among the many parameters that might be considered for the monitoring of aerobic physical training effect, which we analyzed in this study, aortic stiffness and mean blood pressure in the aorta, measured by applanation tonometry, could be recommended for clinical practice.

7. List of publications and presentations

Publications

1. Ieva Slivovskaja, Ligita Ryliskyte, Pranas Serpytis, Rokas Navickas, Jolita Badarienė, Jelena Celutkiene, Roma Puronaite, Kristina Ryliskiene, Alma Cypiene, Egidija Rinkuniene, Vaida Sileikiene, Birute Petrauskiene, Alvydas Juocevicius, Aleksandras Laucevicius. Aerobic Training Effect on Arterial Stiffness in Metabolic Syndrome. American Journal of Medicine. Publication stage: In Press Accepted Manuscript. Published online: August 29, 2017: <http://www.amjmed.com/article/S0002-9343(17)30839-2/abstract>.
2. Ieva Slivovskaja, Jurgita Buzinskaitė, Ligita Ryliškytė, Jūratė Balsytė, Rokas Navickas, Roma Puronaitė, Agnė Jucevičienė, Alvydas Juocevičius, Aleksandras Laucevičius. Positive impact of a 4-week duration supervised aerobic training on anthropometric, metabolic, hemodynamic and arterial wall parameters in metabolic syndrome subjects. Seminars in Cardiovascular Medicine. 2017; 23: 11-16.
3. Ieva Slivovskaja, Alvydas Juocevičius, Galina Kargina, Aurelija Meškaitė. Fizinio aktyvumo vaidmuo mažinant metabolinio sindromo sukeltą širdies ir kraujagyslių ligų bei diabeto riziką. Sveikatos mokslai. 2012; 22(6):5-10.

Presentations:

1. Slivovskaja Ieva, Ryliskyte Ligita, Badariene Jolita, Cypiene Alma, Rinkuniene Egidija, Juocevicius Alvydas, Laucevicius Aleksandras. Immediate effect of aerobic training on arterial stiffness – novel marker for monitoring of cardiovascular fitness. 20th European Congress of Physical and Rehabilitation Medicine, 2016.04.23–28, Estoril–Lisbon, Portugal.

2. Slivovskaja, L. Ryliskyte, J. Badariene, A. Cypiene, E. Rinkuniene, J. Buzinskaite, J. Balsyte, A. Juocevicius and A. Laucevicius. Aerobic training improves arterial stiffness in metabolic syndrome subjects. EuroPRevent 2016 The leading international congress from the European Association for Cardiovascular Prevention & Rehabilitation, 2016.05.05–07, Sophia Antipolis, France.

3. Ieva Slivovskaja, Jurgita Buzinskaite. Effectiveness of different physiotherapy methods in patients with increased cardiometabolic risk. 4th Baltic and North Sea Conference on Physical and Rehabilitation Medicine, 2015.09.16–18, Riga, Latvia.

4. Ieva Slivovskaja, Jolita Badarienė, Rokas Navickas, Alvydas Juocevičius. Estimation of cardiorespiratory fitness in middle-age adults with metabolic syndrome and correction of physical activity: evidence, rationale and organization. 7th Baltic Rehabilitation Association Conference on Physical and Rehabilitation Medicine, November 30–December 1, 2012, Vilnius, Lithuania.

8. Brief information about the author

Name and Surname: Ieva Slivovskaja

Date and place of birth: 26th of October 1970, Vilnius, Lithuania

Office: Vilnius University Hospital Santaros Klinikos,
Santariskiu st. 2, LT-08661 Vilnius
Phone No.: +370 5 236 51 70

E-mail: ieva.slivovskaja@santa.lt

Education:

1987 – 1993 Tartu University Faculty of Medicine, graduated as Medical Doctor

2004 – Licence of physical medicine and rehabilitation physician issued the ministry of Health of the Republic of Lithuania

2013 – 2017 Doctoral student at Department of Rehabilitation, Physical and Sports Medicine of the Institute of Health Sciences of the Faculty of Medicine of Vilnius University.

Professional experience:

Since 1999 – head of the Outpatient Rehabilitation unit at Rehabilitation, Physical and Sports Medicine and Centre of Vilnius University Hospital Santaros Klinikos
Since 1996 – assistant at Department of Rehabilitation, Physical and Sports Medicine of the Institute of Health Sciences of the Faculty of Medicine of Vilnius University
1996 –1999 staff physician in Outpatients Rehabilitation unit at Rehabilitation, Physical and Sports Medicine and Centre of Vilnius University Hospital Santaros Klinikos.

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SUMMARY IN LITHUANIAN

ĮVADAS

Širdies ir kraujagyslių ligos (ŠKL) Lietuvoje, kaip ir visame pasaulyje buvo ir tebėra pagrindinė mirtingumo priežastis. Lietuvoje nuo ŠKL miršta beveik dvigubai daugiau gyventojų negu vidutiniškai Europos Sąjungos (ES) šalyse senbuvėse – Lietuvos vyrų ir moterų standartizuoti mirtingumo nuo kraujotakos sistemos ligų rodikliai yra vieni didžiausių ES.. Rūkymas, dislipidemija, cukrinis diabetas (CD), arterinė hipertenzija (AH), nepakankamas fizinis aktyvumas, netaisyklinga mityba, nutukimas, ypač pilvinis, psichosocialiniai veiksniai ir nesaikingas alkoholio vartojimas visame pasaulyje sudaro didžiąją dalį rizikos susirgti koronarine širdies liga (KŠL) ir miokardo infarktu (MI). Europos 2016 metų širdies ir kraujagyslių ligų prevencijos gairėse nurodoma bendrinė fizinio aktyvumo rekomendacija: bent 150 minučių aerobinio vidutinio intensyvumo fizinio aktyvumo (FA) per savaitę (po 30 minučių 5 dienas per savaitę) arba 75 minutės aerobinio didelio intensyvumo fizinio aktyvumo per savaitę (po 15 minučių 5 dienas per savaitę) arba jų derinys. Tam gali pagelbėti ir fizinės treniruotės pagal iš anksto sudarytą programą. Aerobinės fizinės treniruotės (aFT) labiausiai ištirtos, žinomas šių pratimų dozės ir atsako efektas.

DARBO TIKSLAS IR UŽDAVINIAI

Darbo tikslas - nustatyti individualiai pagal širdies susitraukimų dažnį (ŠSD) dozuojamų prižiūrimų dviejų mėnesių trukmės aFT programos veiksmingumą asmenims, kuriems nustatytas metabolinis sindromas (MetS), vertinant jų ŠKL rizikos veiksnių, MetS komponentų, arterijų sienelės funkcinių ir struktūrinių parametrų, kardiorespiracinio fizinio pajėgumo (KRFP), fizinių treniruočių motyvacijos bei gyvenimo kokybės pokyčius.

Darbo uždaviniai:

1. Nustatyti, įvertinti ir palyginti fizinių treniruočių programos ir savarankiško fizinio aktyvumo rekomendacijų laikymosi poveikį širdies ir kraujagyslių ligų rizikos veiksniams, MetS komponentams, arterijų sienelės funkciniams ir struktūriniams parametrams bei KRFP.
2. Nustatyti, įvertinti ir palyginti aFT programos ir savarankiško fizinio aktyvumo rekomendacijų laikymosi poveikį fizinių treniruočių motyvacijai ir gyvenimo kokybei.
3. Nustatyti, įvertinti ir palyginti liekamąjį 2 mėnesių trukmės aFT ir savarankiško fizinio aktyvumo rekomendacijų laikymosi poveikį po 8 mėnesių ŠKLrizikos veiksniams, MetS komponentams, arterijų sienelės funkciniams ir struktūriniams parametrams, KRFP, taip pat fizinių treniruočių motyvacijai ir gyvenimo kokybei.

TIRIAMŲJŲ KONTINGENTAS

Į tyrimą įtraukta 45–64 metų amžiaus 170 asmenų. Tiriamiesiems buvo nustatytas MetS, jie nesirgo CD, gavo optimalų AH gydymą vaistais bei sutiko dalyvauti tyrime. MetS buvo diagnozuotas pagal 2005 metais NCEP/ATP III modifikuotus kriterijus. Atrinkti asmenys, taikant 1:1 atsitiktinės atrankos metodą, suskirstyti į intervencinę (n=85) ir kontrolinę (n=85) grupes. Intervencinės grupės tiriamiesiems, be įprastinių aktyvios ŠKL rizikos veiksnių mažinimo – dietos, atsisakymo rūkyti, FA rekomendacijų, buvo taikomos individualiai pagal spiroergometrijos (SEM) metu nustatytą tikslinį ŠSD dažnį dozuotos prižiūrimos aFT 8 savaites 5 kartus per savaitę. Kontrolinės grupės tiriamiesiems buvo suteiktos dietos, atsisakymo rūkyti ir FA rekomendacijos. Abiejų grupių tiriamieji ištirti 3 kartus – tyrimo pradžioje, po 2 mėnesių bei vėlyvuoju laikotarpiu, praėjus 8 mėnesiams, siekiant įvertinti ilgalaikį taikytų treniruočių efektyvumą.

TYRIMO METODAI

Atlikti antropometriniai matavimai – matuotas tiriamųjų svoris, ūgis, juosmens apimtis (JA), apskaičiuotas kūno masės indeksas (KMI), matuotas arterinis kraujo spaudimas (AKS), atlikta lipidograma, gliukozė nevalgius.

Atliktas arterijų sienelės parametrų vertinimas: pulsinės bangos greičio (PBG) ir vidutinio arterinio kraujo spaudimo (VAKS) aortoje matavimas aplanacinės tonometrijos metodu, miego arterijų intimos ir medijos sluoksnio storio ir miego arterijų dilatacijos bei aterosklerozinių plokštelių miego arterijose nustatymas ultragarsiniu metodu.

HAD skale vertinti nerimas ir depresija, atliktas kasdienio fizinio aktyvumo vertinimas naudojant tarptautinį fizinio aktyvumo klausimyną IPAQ, atliekant spiroergometriją vertintas kardiorespiracinis fizinis pajėgumas (KRFP), MOS SF-36 klausimynu vertinta su sveikata susijusi gyvenimo kokybė (SSGK), EMI-2 fizinių treniruočių aprašu vertinta fizinių treniruočių motyvacija.

REZULTATAI IR JŲ APTARIMAS

Vertindami AKS pokyčius mūsų atliktame tyrime praėjus 2 mėnesiams po pirminio ištyrimo, radome, kad intervencinėje aFT grupėje statistiškai reikšmingai sumažėjo sistolinis ir diastolinis AKS. Tirdami po 8 mėnesių tik intervencinėje aFT grupėje nustatėme sistolinio ir diastolinio AKS sumažėjimą. Net nedidelis AKS sumažėjimas (2–3 mmHg) po fizinių treniruočių sumažina KŠL riziką nuo 5 iki 9 proc., insulto riziką – nuo 8 iki 14 proc., o bendrąjį mirtingumą – 4 proc.. Kontrolinėje FA grupėje statistiškai reikšmingų skirtumų tarp AKS rodiklių tyrimo pradžioje ir praėjus 2 mėnesiams nebuvo rasta.

Mūsų atliktame tyrime nustatytas statistiškai reikšmingas mažo tankio lipoproteinų cholesterolio (MTL-Chol) lygio sumažėjimas intervencinėje grupėje ir tokio sumažėjimo nekonstatavome kontrolinėje grupėje. Buvo matoma trigliceridų (TG) mažėjimo tendencija abiejose grupėse bei didelio tankio lipoproteinų (DTL-Chol) didėjimo tendencija intervencinėje grupėje, tačiau šie pokyčiai nebuvo statistiškai reikšmingi. Tirdami po 8 mėnesių tik intervencinėje grupėje nustatėme teigiamą aFT poveikį mažinantį bendrą cholesterolį ir MTL-Chol. Taip pat tik intervencinėje grupėje po 8 mėnesių atsirado prieš 2 mėnesius dar neišryškėjęs TG mažėjimo statistinis reikšmingumas.

Nutukimui vertinti atlikome KMI ir JA matavimus. KMI ir JA apimtis yra panašiai svarbūs ir stipriai susiję su ŠKL ir antro tipo CD rizika. Mūsų atliktame tyrime po 2 mėnesių JA statistiškai reikšmingai sumažėjo tik intervencinėje aFT grupėje, o kontrolinėje grupėje ji net padidėjo. Nustatėme, kad KMI po 2 mėnesių statistiškai reikšmingai sumažėjo abiejose grupėse. Po 8 mėnesių, kaip ir po 2 mėnesių, nustatytas statistiškai reikšmingas KMI sumažėjimas intervencinėje grupėje, kontrolinėje grupėje po 8 mėnesių KMI sumažėjimas nesiekė statistinio reikšmingumo. Intervencinėje grupėje po 8 mėnesių, kaip ir po 2 mėnesių, nustatyta statistiškai reikšmingai sumažėjusi JA, kontrolinėje grupėje šis rodiklis po 8 mėnesių net padidėjo. Taigi, mūsų duomenimis, JA mažėjimas buvo labiau specifinis aFT charakterizuojantis parametras negu KMI. Nustatėme, kad intervencinėje grupėje po 2 mėnesių aFT iš penkių MetS komponentų statistiškai reikšmingai pagerėjo dviejų – JA ir AKS, o po 8 mėnesių pagerėjo trijų – JA, AKS bei TG rodikliai. Kontrolinėje grupėje statistiškai reikšmingų MetS komponentų rodiklių skirtumų, išskyrus net padidėjusią JA po 8 mėnesių, nekonstatuota.

Savo darbe kėlėme hipotezę, kad pagal ŠSD dozuojamos aFT gali padėti sumažinti arterijų standumą ir vidutinį AKS aortoje, kas yra siejama su mažesne ŠKL rizika. Kadangi ŠKL baigtys pasireiškia tik laikui bėgant, arterijų standumo parametrų matavimas gali suteikti galimybę dinaminiam ŠKL rizikos vertinimui, o po aFT sumažėjusi rizika gali labai padidinti pacientų motyvaciją būti fiziškai aktyviems. Atlikta analizė parodė, kad pagal ŠSD dozuojamos aFT statistiškai reikšmingai sumažina aortos standumą (miego-šlaunies a. PBG) ir VAKS aortoje pacientams, turintiems MetS. Šio poveikio nerasta kontrolinėje grupėje, kuriai nebuvo taikomos individualios aFT, o tik suteiktos rekomendacijos dėl FA ir treniruočių. Periferinių arterijų standumas (miego-stipininės a. PBG) sumažėjimas intervencinėje nepasiekė statistinio reikšmingumo. Mūsų atliktame darbe, siekiant nustatyti pradinio miego-šlaunies a. PBG slenkstinę reikšmę, leidžiančią su didžiausiu prognoziniu tikslumu numatyti PBG pagerėjimą po individualiai pagal ŠSD dozuojamo fizinio krūvio 2 mėnesių trukmės aFT programos, buvo atlikta ROC kreivės analizė ir nustatyta pradinio miego-šlaunies a. PBG slenkstinė reikšmė – 8,1 m/s. Regresijos medžio metodu ši reikšmė buvo patikslinta - 8,6 m/s. Šie mūsų gauti duomenys yra visiškai originalūs. Svarbu ir tai, kad po 8 mėnesių intervencinėje, bet ne kontrolinėje grupėje, išliko ir aortos standumo (miego-stipininės a. PBG) nei VAKS sumažėjimo statistinis reikšmingumas. Tai rodo liekamąjį 2 mėnesių pagal ŠSD dozuojamų prižiūrimų aFT poveikį ŠKL rizikos mažėjimui. Mūsų atlikto tyrimo radiniai tiriant arterijų funkciją ir struktūrą leidžia manyti, kad aortos standumo parametrų ir VAKS aortoje pagerėjimas po mūsų taikytos aFT programos prisideda prie galimų subklinikinių arterijų pokyčių prevencijos ir aterosklerozės vystymosi MetS turintiems pacientams perspėjimo.

Pritaikius HAD skalę, statistiškai reikšmingų nerimo įvertinimo pokyčio skirtumų nerasta abiejose grupėse, o intervencinėje grupėje statistiškai reikšmingai pagerėjo depresijos įvertinimas. Įvertinus fizinį aktyvumą Tarptautiniu fizinio aktyvumo klausimynu, po 2 mėnesių tik intervencinėje grupėje rastas statistiškai reikšmingas pokytis atliekant labai intensyvią fizinę veiklą sode arba kieme, vidutiniškai ir labai intensyvią fizinę veiklą laisvalaikiu bei sėdėjimo laiko sumažėjimas.

Konstatuotas statistiškai reikšmingas visų KRFP rodiklių pagerėjimas tiek intervencinėje, tiek ir kontrolinėje grupėje. Pažymėtina, kad intervencinėje grupėje pagerėjimas buvo statistiškai reikšmingai didesnis ir tai liudija apie geresnį dozuojamų prižiūrimų aFT poveikį ŠKL rizikai mažinti. Tirdami KRFP po 8 mėnesių, tik intervencinėje grupėje konstatavome statistiškai reikšmingą VO_2max (ml/kg/min) ir ramybės ŠSD rodiklių pagerėjimą. Tai rodo, jog šie asmenys buvo pakankamai motyvuoti ir tęsė fizines treniruotes savarankiškai, pasibaigus 2 mėnesių pagal ŠSD dozuojamų aFT laikotarpiui.

Mūsų tyrimas parodė, kaip MetS veikia pacientų SSGK, vertinant ją SF-36 klausimynu. Šio tyrimo pradžioje abiejų grupių tiriamieji blogiausiai vertino sveikatos pasikeitimą per metus, bendrą sveikatos būklę bei energingumą ir gyvybingumą, o geriausiai – socialinę funkciją, fizinį aktyvumą ir veiklos apribojimą dėl emocinių sutrikimų. Po 2 mėnesių aFT intervencinėje grupėje statistiškai reikšmingai padidėjo fizinio aktyvumo, veiklos apribojimo dėl emocinių sutrikimų sričių įverčiai ir apibendrintas psichikos sveikatos įvertis. Apibendrintas fizinės sveikatos, bendrojo sveikatos vertinimo, energingumo ir gyvybingumo, emocinės būklės bei sveikatos pasikeitimo sričių įverčiai ir apibendrintas fizinės sveikatos įvertis statistiškai reikšmingai padidėjo abiejose grupėse. Tai rodo labai subjektyvų tokių vertinimų pobūdį, nesutampantį su objektyviu aFT sukeliamų pamatuojamų rodiklių dinamika.

Mūsų duomenimis, vertinant aFT motyvacijos vaidmenį labiausiai dominuojantys motyvai buvo sveikatos, kūno išvaizdos ir fizinių galių lavinimo, o mažiausiai tiriamuosius motyvuoja socialiniai bei rekreacijos ir emociniai motyvai. Po 2 mėnesių tik intervencinėje aFT grupėje statistiškai reikšmingai pagerėjo vidinės motyvacijos: patiriamo malonumo, iššūkio, fizinių galių lavinimo ir afiliacijos aspektai. Taigi, 2 mėnesių individualiai pagal tikslinį ŠSD dozuota prižiūrima aFT programa neabejotinai pagerina ilgalaikio fizinių treniruočių atlikimo motyvaciją. Originali mūsų atlikto tyrimo idėja – įvertinti 2 mėnesių aFT programos liekamąjį poveikį praėjus 8 mėnesiams. Svarbu pažymėti, kad iš 140 asmenų, dalyvavusių antrajame ištyrime, į trečią etapą po 6 mėnesių atvyko 86,9 proc. intervencinės ir tik 57,1 proc. kontrolinės grupės asmenų, o tai rodo pakankamą intervencinės grupės dalyvių motyvaciją tęsti pradėtą FT programą ir motyvacijos stoką kontrolinėje grupėje.

IŠVADOS

1. Dviejų mėnesių trukmės pagal širdies susitraukimų dažnį dozuojamų prižiūrimų aerobinių fizinių treniruočių programos taikymas asmenims, kuriems nustatytas metabolinis sindromas, yra veiksmingas. Tai rodo teigiami palyginamieji rezultatai, gauti prieš treniruotes ir po jų kompleksiškai vertinant širdies ir kraujagyslių ligų rizikos veiksnių ir metabolinio sindromo komponentų, arterijų funkcijos parametrų, fizinio pajėgumo, fizinių treniruočių motyvacijos ir gyvenimo kokybės įverčius:

1.1. Tik intervencinėje grupėje matomas statistiškai reikšmingas teigiamas poveikis širdies ir kraujagyslių ligų rizikos veiksniams – sistoliniam ir diastoliniam arteriniam kraujo spaudimui, bendro cholesterolio, mažo tankio lipoproteinų cholesterolio koncentracijai, juosmens apimčiai.

1.2. Intervencinėje ir kontrolinėje grupėse buvo rastas statistiškai reikšmingas metabolinio sindromo komponentų skaičiaus sumažėjimas.

1.3. Tik intervencinėje grupėje arterijų sienelės parametrų dinamika buvo teigiama: sumažėjo miego-šlaunies arterijų pulsinės bangos greitis ir vidutinis arterinis kraujo spaudimas aortoje. Nustatytas statistiškai reikšmingas skirtumas tarp pokyčių grupėse. Kai miego-šlaunies arterijų pulsinės bangos greitis viršija 8,6 m/s, šio parametro informatyvumas ima didėti.

1.4. Tik intervencinėje grupėje statistiškai reikšmingai sumažėjo laikas, praleidžiamas sėdint. Nustatytas statistiškai reikšmingas skirtumas tarp pokyčių grupėse.

1.5. Intervencinėje ir kontrolinėje grupėse buvo konstatuotas statistiškai reikšmingas kardiorespiracinio fizinio pajėgumo pagerėjimas, rodantis, kad dalis kontrolinės grupės asmenų vykdė fizinio aktyvumo rekomendacijas. Nustatytas statistiškai reikšmingas skirtumas tarp pokyčių grupėse, pokyčiai intervencinėje grupėje buvo didesni.

2. Intervencinėje grupėje nustatytas statistiškai reikšmingas fizinių treniruočių motyvacijos pagerėjimas, vertinant įverčių, priskiriamų vidinei motyvacijai, kuri skatina ilgalaikį fizinių treniruočių atlikimą, pokyčius – pagerėjo rekreacijos ir emocinių, socialinių ir fizinių galių lavinimo motyvų grupių įverčiai ir atskirų motyvų skalių įverčiai: streso įveikos / valdymo, rekreacijos, džiaugsmo, iššūkio, socialinio pripažinimo, afiliacijos bei varžymosi. Gyvenimo kokybė pagerėjo ir intervencinėje, ir kontrolinėje grupėse. Intervencinėje grupėje statistiškai reikšmingai pagerėjo abu apibendrinti (fizinės ir psichikos sveikatos) bei penkių iš aštuonių sričių įverčiai, kontrolinėje grupėje – apibendrintas fizinės sveikatos bei keturių iš aštuonių sričių įverčiai.
3. Įvertinus dviejų mėnesių trukmės aerobinių fizinių treniruočių programos ir savarankiško fizinio aktyvumo rekomendacijų laikymosi liekamąjį poveikį po aštuonių mėnesių, tik intervencinėje grupėje konstatuotas statistiškai reikšmingas poveikis arteriniam kraujo spaudimui, bendro cholesterolio, mažo tankio lipoproteinų cholesterolio ir trigliceridų koncentracijai, juosmens apimčiai, metabolinio sindromo komponentų skaičiui, arterijų standumui bei kardiorespiraciniam fiziniam pajėgumui.

PRAKTINĖS REKOMENDACIJOS

1. Skiriant fizines treniruotes asmenims, turintiems metabolinį sindromą, siekiama ne tik pagerinti jų gyvenimo kokybę, išvaizdą ir fizinį pajėgumą, bet ir sumažinti riziką susirgti širdies ir kraujagyslių ligomis ir (ar) diabetu, kuriam savo ruožtu būdingos kardiovaskulinės komplikacijos.

2. Kaip vieną efektyviausių priemonių vykdant pirminę širdies ir kraujagyslių ligų prevenciją metabolinį sindromą turintiems asmenims rekomenduojame individualiai pagal širdies susitraukimų dažnį dozuojamas prižiūrimas fizines treniruotes, kurios reikšmingai gerina kardiorespiracinį fizinį pajėgumą, turi teigiamą poveikį mažinant širdies ir kraujagyslių ligų rizikos veiksnius, mažina metabolinio sindromo išreikštumą, pagerina psichinę ir emocinę būklę, gyvenimo kokybę bei fizinių treniruočių motyvaciją, taip pat turi liekamąjį poveikį ir geriau motyvuoja asmenis būti fiziškai aktyvius.

3. Remiantis šiuo darbu būtų galima plėsti Lietuvoje vykstančios „Aukštos kardiovaskulinės rizikos pirminės prevencijos programos“ rėmus ir rekomenduoti Lietuvos Respublikos sveikatos apsaugos ministerijai pradėti bent kartą per metus kompensuoti šią prevencijos priemonę metabolinį sindromą turintiems asmenims, siekiant ne tik pagerinti tokių asmenų fizinį pajėgumą ir treniruotumą, bet ir sumažinti jų kardiovaskulinę riziką bei užkirsti kelią aterosklerozės progresavimui. Siekiant tolesnių „Aukštos kardiovaskulinės rizikos prevencijos programos“ rezultatų, reikia ne tik vykdyti arterinės hipertenzijos ir lipidų kontrolę, bet ir ieškoti būdų modifikuoti metabolinį sindromą turinčių vidutinio amžiaus asmenų gyvensenai. Šis darbas vienas pirmų, kuriuo remiantis galėtų būti kuriama valstybės remiama parama fiziniam aktyvumui skatinti. Dviejų mėnesių aktyvių fizinių treniruočių programą, skiriamą bent kartą per metus, galėtų paremti valstybė ir darbdaviai.

4. Iš daugelio parametrų, kuriais šiame darbe buvo vertintas fizinio aktyvumo poveikis kraujagyslėms, tinkamiausi ir jautriausi yra aortos standumas ir vidutinis arterinis kraujo spaudimas aortoje, todėl juos rekomenduojama plačiai naudoti klinikinėje praktikoje.