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The relationship between secondary school exam performance and lifestyle behaviors at the onset of university education

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There is a lack of evidence regarding the relationship between students' academic achievements in various secondary school (gymnasium) subjects and factors such as sports participation, physical activity, sedentary behavior, physical health indicators, mental health indicators, sleep quality, eating habits, smoking, alcohol consumption, and the frequency of consuming healthy and unhealthy foods. The aim of our study was to address this research gap by examining how final secondary school (gymnasium) exam scores in Mathematics, Native Languages, Foreign Languages, and Biology are associated with healthy lifestyle habits, mental health, and physical health. This cross-sectional and retrospective study included 397 undergraduate students, aged 19 to 24 years, from three universities in Lithuania. We evaluated various health and lifestyle factors among students, including body mass index (BMI), waist circumference, and systolic blood pressure. Additionally, we assessed their levels of physical activity and sedentary behavior, as well as sleep quality, perceived stress, and symptoms of depression. We also measured indicators of well-being, such as vigor and happiness, and examined their habits regarding alcohol consumption, smoking, breakfast consumption, and overeating. Finally, we looked at the frequency of their consumption of both healthy and unhealthy food products. We collected data on students' academic achievements in their final exams for Mathematics, Native Language, Foreign Languages, and Biology based on standardized national secondary school (gymnasium) graduation examinations. General linear modeling (GLM) indicated that moderate to vigorous physical activity, sedentary behavior, and sleep quality did not significantly associate with academic achievement in secondary school (gymnasium) graduation examinations. Mathematics exam performance from secondary school (gymnasium) was most significantly associated with lower sugar consumption in coffee or tea and non-smoking habits during the first two years of university education. In Native Language tests, females generally outperformed males, and their performance was linked to higher levels of happiness at the entrance to university studies. Conversely, in Foreign Language exams, males outperformed females, and their performance was also associated with abstaining from alcohol and consuming fewer boiled potatoes during the entrance years of university. For Biology exam performance, there was a positive correlation with the consumption of fresh and canned vegetables, lower sugar intake in coffee or tea, and more frequent breakfast consumption. Our findings indicated that factors such as physical activity, sedentary behavior, sleep quality, and most psychological aspects measured at the time of university entry—except for happiness—were not consistently linked to

academic performance as reflected in final secondary school (gymnasium) graduation examinations. Instead, the exam results showed modest but systematic relationships with specific health-related factors assessed during university entry. These factors include body composition, dietary habits, and lifestyle behaviors such as smoking, alcohol consumption, and breakfast patterns. Additionally, we observed significant gender differences in these associations. These findings do not imply causality, but suggest that lifestyle and psychological characteristics at the start of university may be linked to prior academic achievement patterns.

Keywords Physical activity, Healthy nutrition, Obesity, Mental health, Sleeping, Academic achievements

Abbreviations

BMI	Body mass index
MET	Metabolic equivalent of task
MVPA	Moderate-to-vigorous physical activity
PA	Physical activity
PSQI	Pittsburgh sleep quality index
PSS	Perceived stress scale
SB	Sedentary behavior
SBP	Systolic blood pressure

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There is no doubt that both physical and mental health and well-being is influenced by the complex of factors such as physical activity [1–11,12], balanced nutrition [1,13–15], adequate rest and especially sleep [1,16], avoidance of prolonged sitting [3,17,18], emotional and impulse control [4,19], as well as non-smoking, abstinence from alcohol consumption, engagement in cognitive leisure activities and meditation [20].

Physical activity has systemic effects that extend beyond improved cardiovascular and metabolic health. It also involves direct molecular signaling between muscles and the brain, a process known as muscle-brain crosstalk [2]. The factors released during exercise, now referred to as exerkines, play a vital role in brain plasticity, emotional regulation, and stress resilience [5]. Global health authorities, including the WHO, now emphasize that even light to moderate physical activity, when performed regularly, can significantly lower the risks associated with chronic diseases and improve cognitive and emotional outcomes in both children and adults [3]. A national-level study involving over 6,000 individuals in Lithuania indicated that increased physical activity levels were linked to reduced depression and stress, enhanced emotional intelligence, and improved logical reasoning, regardless of age or sex [4]. Furthermore, engaging in physical activity has been associated with improved long-term maintenance of executive functions and memory, suggesting it may help reduce age-related cognitive decline [6].

Research indicates that not all types of exercise offer the same benefits for psychological and cognitive enhancement. Activities that involve coordination and social interaction—like dance, martial arts, or team sports—seem to enhance emotional intelligence and cognitive flexibility more effectively than repetitive or solitary forms of exercise [8]. Minimal adherence to generic physical activity guidelines may not lead to significant short-term changes, particularly in individuals with obesity or metabolic dysfunction [8]. Furthermore, recent findings show that leisure-time physical activity, as opposed to occupational effort, is consistently associated with better mood and emotional well-being across all age groups [10], reinforcing the importance of voluntary, intrinsically motivated movement in promoting sustained mental health.

It has been clearly demonstrated that total physical activity is favourably associated with physical, psychological/social, and cognitive health indicators in school-aged children and youth [21]. Despite clear evidence of a positive relationship between physical activity and mental and brain health [2,3,5,6,11,21], there is no clear evidence that physical activity has a significant direct impact on students' academic achievements [18]. For example, one study might find improvements in Math and reading, and another study might find improvements in reading and spelling but not Math and reading. Similar inconsistencies were found when comparing girls and boys [18]. Recent studies indicate that physical activity and aerobic fitness can moderately predict proficiency in Mathematics and the Italian language [22].

According to research, the consumption of less healthy food groups is associated with poorer academic achievement in elementary schoolchildren [23]. For example, as found by Bleiweiss-Sande et al., greater intake of less healthy food groups (such as sweet snacks, salty snacks, and sweetened beverages) was associated with lower standardized Foreign Language test scores [23]. However, a recent comprehensive analysis by the EAT-Lancet Commission showed that there is little high-quality, strong causal evidence regarding the effects of an individual food on cognitive function across the life course [24].

Despite the previous studies, there is still insufficient evidence regarding the relationship between students' academic achievements in various subjects of secondary school (gymnasium) graduation examinations and factors such as sports participation, physical activity, sedentary behavior, and indicators of physical health

(including body mass index. BMI). Additionally, the connection between academic success and mental health indicators (such as depression, vigor, perceived stress, and happiness), as well as sleep quality, eating habits, smoking, alcohol consumption, and the frequency of consuming healthy versus unhealthy foods, remains unclear. Moreover, there is a notable gap in research focusing on older students (aged 19–24 years) and the connection between the academic performance of secondary school (gymnasium) graduation examinations and factors such as physical activity, physical health, healthy nutrition, and mental well-being at the entrance to university studies. The purpose of our study was to investigate the relationship between graduation exam scores—in Mathematics, Native Language, Foreign Languages, and Biology—taken at the end of secondary school (gymnasium) education, and healthy lifestyle habits, as well as mental and physical health, and overall well-being during the early years of higher education.

Materials and methods

Sample

A total of 397 healthy first- and second-year bachelor's students participated in this cross-sectional study, and none of them were taking any medication. None of the participants reported a diagnosis of autism, Asperger's syndrome, or ADHD. The group consisted of 308 females and 89 males, whose mean ages were 23.4 and 21.8 years, respectively. Statistical comparison showed a non-significant trend toward an age difference ($p = 0.066$). Students were randomly selected from three universities in Lithuania, specifically from first- and second-year bachelor's programs in Health Sciences, Law, and Sports Science. Our objective was to recruit an approximately equal number of students from each university. In practice, the distribution was fairly balanced, with about 30–35% of the total sample representing each university. Participants were selected using a convenience sampling method, with random selection applied at the course level. Entire classes or student groups from the chosen study programs were invited to participate. The selection of courses was based on their accessibility and the willingness of instructors to permit data collection during class sessions. The inclusion criteria for participants in the study were as follows: they had to be first-year bachelor's students enrolled in Health Sciences, Law, or Sports Science programs; self-report good health; not be taking any medications; and have no self-reported diagnosis of autism, Asperger's syndrome, or ADHD. The exclusion criteria included individuals taking medication, any self-reported diagnosis of autism, Asperger's syndrome, or ADHD, being older than 25 years, and refusal to provide informed consent.

Measures

Final exam results were self-reported and referred to standardized national secondary school (gymnasium) graduation examinations, typically taken at the age of 18 or 19. All other data—including electronic questionnaire responses and physiological measurements—were collected later, during the participants' first and second year of university studies in 2024, when participants were typically between 19 and 24 years old. Thus, the study design combines retrospective academic data with cross-sectional health-related data collected at a single time point. This approach allowed us to explore whether academic performance during secondary school (gymnasium) was associated with current health-related behaviors, mental well-being, and physical characteristics in early university students.

Data collection took place during scheduled seminar sessions in university classrooms from 10:00 a.m. to 2:00 p.m. During these sessions, students completed an electronic questionnaire on-site that covered various topics, including physical activity, sports participation, sedentary behaviors, diet, sleeping habits, mood and well-being, academic achievements, and perceived stress. Standardized equipment was used to measure body weight and height (height was measured using a stadiometer), enabling the calculation of Body Mass Index (BMI) by dividing body weight in kilograms by the square of height in meters. Body weight was measured using a Tanita BC-420MA foot-to-foot bioelectrical impedance analyzer (Tanita Corporation, Tokyo, Japan). Additionally, blood pressure and waist circumference were measured using a tape measure. Blood pressure was measured three times using an automated digital monitor (model: Omron M6 Comfort, Omron Healthcare Co., Kyoto, Japan). This approach ensured efficient and consistent data collection in a controlled academic setting.

Academic achievements

Participants provided their final scores from the state graduation exams, which they had completed at the end of secondary school (gymnasium) education, typically at the age of 18 or 19. These exams covered subjects including Mathematics, the Native Language (Lithuanian), a Foreign Language, and Biology. In Lithuania, these nationally standardized exams are administered by the National Examination Center and are graded on a 100-point scale, with the minimum passing score set at 16 points.

Physical activity (PA) and sedentary behavior (SB)

Physical activity (PA) and sedentary behavior (SB) of the participants were determined by the Danish Physical Activity Questionnaire (DPAQ). The DPAQ was adapted from the International Physical Activity Questionnaire (IPAQ) and differs from it by referring to PA in the past 24 h (for 7 consecutive days) instead of the past 7 days. The selected activities were listed on the PA scale at nine levels of physical exertion in metabolic equivalents (METs), ranging from sleep or inactivity (0.9 MET) to highly strenuous activities (> 6 METs). Each level (A = 0.9 MET, B = 1.0 MET, C = 1.5 METs, D = 2.0 METs, E = 3.0 METs, F = 4.0 METs, G = 5.0 METs, H = 6.0 METs, and I > 6 METs) was described using examples of specific activities of that particular MET level and a small drawing. The PA scale was constructed so that the number of minutes (15, 30, or 45) and hours (1–10) spent at each MET activity level on an average 24-h weekday could be filled out. This allowed for a calculation of the total MET time, representing 24 h of sleep, work, and leisure time on an average weekday [25,26].

Exercise and sports habits

To determine sports habits, we asked a question, 'Are you currently exercising?'. The respondents had to indicate their sport habits on a scale from 1 to 4, where 1 is "I don't exercise"; 2 is "I exercise by myself"; 3 is "I exercise in a gym/health center"; 4 is "I am in professional sports". To evaluate exercise and sports habits, participants were asked the question: "Are you currently exercising?" They could choose from one of four options regarding their physical activity: 1. Participants who selected "I don't exercise" reported no regular physical activity. 2. Those who chose "I exercise by myself" engaged in self-directed activities such as walking, running, cycling, or home workouts without formal supervision. In this study, regular exercise was defined as participating in physical activity at least 2 to 3 times per week, in accordance with standard physical activity guidelines (at least 150 min per week). 3. Participants who selected "I exercise in a gym or health center" reported exercising in structured environments, such as fitness clubs or gyms, either independently or under supervision, with a minimum frequency of 2 to 3 sessions per week. 4. Those opting for "I participate in professional sports" were involved in competitive or professional-level sports, training under coaches, and participating in organized competitions, typically with high-frequency training schedules.

Sleep quality

The sleep quality of participants was assessed by the Pittsburgh Sleep Quality Index (PSQI). The PSQI was developed by Buysse et al. [27] and is a self-report assessment tool that evaluates sleep quality over a one-month period. A global score and seven component scores can be derived from the scale. The component scores are the following: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medications and daytime dysfunction. Each component is scored on a scale from 0–3, with the total score ranging from 0–21, where a higher score describes poorer sleep quality. A total PSQI score greater than 5 has been validated as being highly sensitive and specific in distinguishing good from poor sleepers across a number of populations [28].

Perceived stress

The 10-item Perceived Stress Scale (PSS-10) was used to measure the participants' perceived stress levels [29]. The PSS-10 asks the participants to answer 10 questions about their feelings and thoughts in the past month on a five-point scale ranging from 0–4. Total scores ranged from 0 to 40. Higher scores indicate higher levels of perceived stress.

Mood

Vigour and depression of the participants were assessed by using the Lithuanian-language version of the Brunel Mood Scale (BRUMS-LTU), which consists of 24 items designed to assess tension, depression, anger, vigour, fatigue and confusion. In this case, we used only the Vigour subscale, whose items were energetic, active, lively and alert. Participants responded on a five-point Likert scale, where 0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit and 4 = extremely, with total possible subscale scores ranging from 0–16 [30,31].

Happiness

The Happiness index was assessed by using the question 'Are you happy in life?' with response options on a 10-point scale from 1 ("very unhappy") to 10 ("very happy"). We did not provide a specific definition of "happiness" in the questionnaire; instead, participants were asked to rate their overall happiness according to their own subjective understanding. This approach to assessing happiness has also been used in our previous research [32].

Harmful habits

To identify harmful habits, the respondents had to indicate their smoking habits on a scale from 1 to 4, where 1 is "I have never smoked"; 2 is "I smoke occasionally"; 3 is "I smoke every day"; 4 is "I used to smoke, but quit". Alcohol consumption was assessed using a 7-point self-report frequency scale. Participants were asked: "How often do you consume alcoholic beverages?" The response options ranged from 1 to 7, where 1 indicated "never", 2 indicated "rarely (less than once a month)", 3 indicated "once a month", 4 indicated "2–3 times a month", 5 indicated "once a week", 6 indicated "several times a week", and 7 indicated "daily." This scale allowed us to capture a wide range of alcohol use frequencies, from abstinence to daily consumption.

Eating habits

The frequency of consuming healthy and unhealthy food products were determined by questions prepared by using the nutrition section of the Finbalt Health Monitor questionnaire from an international adult study conducted in Lithuania in 1994 [33]. To understand eating habits, respondents were asked about the frequency of consumption of certain products (fish, red meat, processed meat, fresh vegetables, canned vegetables, fresh fruits, sweets, chocolate, sweetened drinks, sugar in coffee or tea, pasta, rice, porridge, poultry, fast food, boiled potatoes, fried potatoes, eggs, biscuits, cakes, other dairy products, yogurt) over the past week. Possible responses were "Never," "1–2 days," "3–5 days," and "6–7 days."

Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics, version 22 (IBM Corp., Armonk, NY, USA). The normality of the data distribution was assessed using the Shapiro–Wilk test, which is appropriate for evaluating normality in small to moderate sample sizes. To investigate gender differences, independent samples t-tests were employed for continuous variables (where variances were equal), while chi-square (χ^2) tests were used for categorical variables. A significance level of $p < 0.05$ was established for all analyses. To investigate

the relationships between lifestyle, behavioral, psychological, and dietary factors and academic performance in secondary school (gymnasium) graduation examinations in four subjects—Mathematics, Native Language, Foreign Language, and Biology—a structured, multi-step general linear modeling (GLM) approach was utilized. The dependent variables were the self-reported academic grades for each subject. Independent variables included demographic indicators (e.g., gender, body mass index), systolic blood pressures, waist circumference, measures of physical activity and sedentary behavior (MVPA, SB), health-related behaviors (e.g., smoking status, alcohol consumption, breakfast habits, overeating), psychological indicators (Pittsburgh Sleep Quality Index, perceived stress, depression, vigor, happiness), and the frequency of consumption of various food groups. In the first step, univariate linear regressions were performed to assess the individual relationships between each predictor and academic outcomes. For each regression, unstandardized coefficients (B), standardized coefficients (Beta), p-values, and the Akaike Information Criterion (AIC) were calculated. Predictors with a p-value below 0.10 were retained for further model building. In the second step, the selected variables were examined for multicollinearity using the variance inflation factor (VIF), with a conservative cutoff of VIF < 2, along with a Pearson correlation matrix to ensure that no pairwise correlations exceeded 0.80. No multicollinearity was observed, and all candidate predictors were retained. In the third step, a multivariable linear regression model was constructed for each academic subject using the eligible predictors. Each final model included unstandardized and standardized coefficients, corresponding p-values, and overall model fit statistics, including AIC, R^2, and adjusted R^2. Finally, to enhance model parsimony and protect against overfitting, variables with $p \geq 0.05$ were sequentially excluded, and the models were re-estimated at each step. Only statistically significant ($p < 0.05$) and conceptually meaningful predictors were retained in the final models.

Results

The percentages of women with a normal BMI (18.5–25 kg/m^2) were 70.8% and 69.7%, respectively ($p > 0.05$), and 15.9% and 20.2%, respectively, had overweight (>25–29.9 kg/m^2) ($p > 0.05$). Additionally, 3.9% and 7.9% of the participants had a BMI of 30 kg/m^2 and above, respectively ($p > 0.05$). Underweight individuals (BMI < 18.5 kg/m^2) accounted for 9.4% of women and 2.2% of men ($p < 0.05$). Hence, BMI showed no gender dependency ($\chi^2 = 7.5$, $p = 0.55$).

The descriptive data of students are shown in Table 1. Men exhibited significantly higher BMI, SBP, and waist circumference, yet they were more physically active than women. Additionally, men demonstrated the lower stress level and better sleep quality than women. Interestingly, men consumed red and processed meat, poultry, and fried potatoes statistically significantly more often per week than women. Moreover, men were more prone than women to drink sugary beverages and consume fast food (Table 1).

In secondary school (gymnasium) graduation examinations, men predominantly performed better in the Foreign Language exam, whereas women excelled in the Native Language exam; no significant differences were observed between men and women in the Biology and Mathematics exams (Table 2).

Multivariable general linear models (GLMs) were used to identify lifestyle, psychological, and dietary predictors of academic achievement across four subjects: Mathematics, Native Language, Foreign Language, and Biology. Initially, a multivariable model (Step 3) was constructed for each subject using all relevant predictors selected through univariate screening and multicollinearity diagnostics (Table 3). Non-significant predictors were removed to enhance model simplicity, leading to a final model that included only statistically significant predictors ($p < 0.05$).

Mathematics: In the Step 3 model, five predictors were included. A higher sugar intake from coffee or tea during the early years of university was significantly associated with lower Mathematics grades ($p = 0.0065$) obtained in secondary school (gymnasium), while non-smoking status among university students was associated with higher past academic performance in secondary school (gymnasium) ($p = 0.0128$). Associations with canned vegetables, fresh vegetables, and fresh fruits were positive but not statistically significant. The model demonstrated a moderate fit (AIC = 3094.45; $R^2 = 0.100$; Adjusted $R^2 = 0.087$). The final model retained two predictors: sugar intake from coffee or tea (showing a negative association, $p = 0.0008$) and non-smoking status (showing a positive association, $p = 0.0085$). This final model had a slightly reduced fit (AIC = 3103.79; $R^2 = 0.059$; Adjusted $R^2 = 0.053$).

Native language: The Step 3 model included eight predictors. Female gender was significantly associated with higher grades in secondary school (gymnasium) graduation examinations ($p = 0.0003$), along with biscuit consumption (positive association, $p = 0.0124$), happiness (positive association, $p = 0.0479$), and egg intake (negative association, $p = 0.0274$) at the entrance to university studies. Depression, overeating, red meat intake, and BMI were not found to be significant. The model demonstrated reasonable explanatory power (AIC = 3461.04; $R^2 = 0.112$; Adjusted $R^2 = 0.093$). In the final model, only gender (positive association, $p < 0.0001$) and happiness (positive association, $p = 0.0033$) remained significant. Model fit decreased slightly (AIC = 3468.62; $R^2 = 0.065$; Adjusted $R^2 = 0.060$).

Foreign language: The Step 3 model included four predictors. Female gender was negatively associated with achievement in secondary school (gymnasium) graduation examinations ($p = 0.0013$), while non-drinking alcohol had a positive association ($p = 0.006$) at the entrance to university studies. Boiled potato consumption also showed a negative association ($p = 0.0397$). Pasta and rice intake exhibited a positive but non-significant trend ($p = 0.067$). The model demonstrated modest fit (AIC = 3151.45; $R^2 = 0.070$; Adjusted $R^2 = 0.059$). In the final model, three predictors remained significant: gender (negative association, $p = 0.0005$), non-drinking alcohol (positive, $p = 0.0106$), and boiled potatoes (negative, $p = 0.0398$). Model fit remained comparable (AIC = 3152.86; $R^2 = 0.061$; Adjusted $R^2 = 0.053$).

Biology: The Step 3 model included eight predictors. Fresh vegetable intake (positive association, $p = 0.0003$), canned vegetable intake (positive, $p = 0.0051$), breakfast consumption (positive, $p = 0.0231$), non-smoking (positive, $p = 0.0293$), and sugar in coffee or tea (negative, $p = 0.0334$) at the entrance to university

Indicators	Gender, mean		Standard deviation		Women vs men, *p*-value*
	Women	Men	Women	Men	
Number	308	89			
Age, years	23.4	21.8	6.2	4.7	**0.066**
BMI, kg/m^2	22.4	24	4.3	3.8	**0.002**
SBP, mm/Hg	116.1	124.5	12.9	13.1	**0.001**
Waist circumference, cm	75	84.4	11.2	12.7	**< 0.0001**
MVPA, min/week	147.5	195.2	137.2	153.8	**0.005**
SB, min/day	603.4	552.7	296.2	272.1	0.148
Sleeping time, h	9.1	8.8	1.6	1.6	0.161
Time to go to bed, h	23.2	23.6	1.3	1.3	**0.02**
Pittsburgh Sleep Quality Index	5.03	4.02	2.7	2.3	**0.005**
Perceived stress	20.9	17.3	6.9	7.2	**< 0.0001**
Depression	5.41	4.7	4.1	3.97	0.234
Vigour	7.35	9.35	3.2	3.3	**< 0.0001**
Happiness	7.18	7.57	1.7	1.7	0.08
Non-smoking, %	47.7	48.3			> 0.05#
Non-drinking alcohol	14.3	21.3			> 0.05#
Breakfast eating, %	61	52.8			> 0.05#
Overeating, %	20.1	23.6			> 0.05#
Non-exercise, %	48.7	16.9			**< 0.05#**
I exercise independently, %	35.1	47.2			**< 0.05#**
I exercise at the sports and fitness center, %	11	10.1			> 0.05#
I exercise professionally, %	5.2	25.8			**< 0.05#**
Fish, times per week	0.57	0.58	0.65	0.7	0.88
Red meat, times per week	1.05	1.51	0.77	0.88	**< 0.0001**
Processed meat, times per week	1.13	1.43	0.85	0.87	**0.006**
Fresh vegetables, times per week	1.8	1.76	0.85	0.89	0.71
Canned vegetables, times per week	0.93	1	0.75	0.78	0.52
Fresh fruits, times per week	1.49	1.49	0.87	0.84	0.98
Sweets, chocolate, times per week	1.31	1.13	0.8	0.78	0.057
Sweetened drinks, times per week	0.76	1.1	0.71	0.84	**0.001**
Sugar in coffee or tea, times per week	0.43	0.62	0.98	0.97	0.098
Pasta, rice, times per week	1.06	1.3	0.67	0.84	**0.006**
Porridge, times per week	0.9	1.04	0.86	0.92	0.18
Poultry, times per week	1.27	1.49	0.75	0.81	**0.017**
Fast food, times per week	0.71	1	0.54	0.61	**< 0.0001**
Boiled potatoes, times per week	0.71	0.73	0.61	0.67	0.76
Fried potatoes, times per week	0.42	0.58	0.51	0.52	**0.017**
Eggs, times per week	1.01	1.11	0.85	0.98	0.38
Biscuits, cakes, times per week	1.26	1.17	0.81	0.86	0.37
Other dairy products, yogurt, times per week	1.24	1.31	0.81	0.88	0.49

Table 1. Averages and standard deviations of indicators of healthy living for women and men. * Independent samples of T test; # p values of chi-square.

studies were all statistically associated with earlier secondary school (gymnasium) achievements. Additionally, egg consumption (negative, $p = 0.0097$) and higher BMI (negative, $p = 0.0215$) were significant as well. Pasta and rice intake showed a positive but non-significant trend ($p = 0.0919$). This model exhibited the strongest performance overall (AIC = 2300.44; $R^2 = 0.185$; Adjusted $R^2 = 0.159$). The final model retained four significant predictors: canned vegetables (positive association, $p = 0.0072$), fresh vegetables (positive, $p = 0.0124$), sugar in coffee or tea (negative, $p = 0.0173$), and breakfast consumption (positive, $p = 0.0385$). Model fit decreased slightly (AIC = 2311.4; $R^2 = 0.124$; Adjusted $R^2 = 0.110$).

Discussion

The key findings of the research are summarized as follows: 1. Moderate to vigorous physical activity (MVPA), sedentary behavior, and sleep quality assessed among university students significantly reflected overall academic achievement in earlier stages of education (gymnasium). However, a higher body mass index (BMI) was

Subject	Gender		Mean		Standard deviation		Women vs men p value*
	Women	Men	Women	Men	Women	Men	
Mathematics	260	77	36.9	41.1	24.8	24.5	0.197
Native Language	294	88	65.4	53.9	22.2	24.9	**0.0001**
Foreign Language	262	85	66.8	76.1	23.6	20.7	**0.001**
Biology	213	50	62.9	61.6	20.2	22.3	0.68

Table 2. The exam results of secondary school (gymnasium) graduation examinations (averages and standard deviations) in Mathematics, Native Language, Foreign Language, and Biology for women and men. * Independent samples of T test.

Subject	Model	Predictor	Direction	*p*-value	AIC	R^2	Adj. R^2
Mathematics	Step 3	Sugar in coffee or tea	Negative	0.0065	3094.4	0.100	0.087
		Non-smoking	Positive	0.0128			
		Canned vegetables	Positive	0.0556			
		Fresh vegetables	Positive	0.1283			
		Fresh fruits	Positive	0.2042			
	Final	Sugar in coffee or tea	Negative	0.0008	3103.7	0.059	0.053
		Non-smoking	Positive	0.0085			
Native Language	Step 3	Gender (female)	Positive	0.0003	3461.0	0.112	0.093
		Biscuits	Positive	0.0124			
		Eggs	Negative	0.0274			
		Happiness	Positive	0.0479			
	Final	Gender (female)	Positive	< 0.0001	3468.6	0.065	0.060
		Happiness	Positive	0.0033			
Foreign Language	Step 3	Gender (female)	Negative	0.0013	3151.4	0.070	0.059
		Non-drinking alcohol	Positive	0.006			
		Boiled potatoes	Negative	0.0397			
	Final	Gender (female)	Positive	0.0005	3152.8	0.061	0.053
		Non-drinking alcohol	Positive	0.0106			
		Boiled potatoes	Negative	0.0398			
Biology	Step 3	Fresh vegetables	Positive	0.0003	2300.4	0.185	0.159
		Canned vegetables	Positive	0.0051			
		Eggs	Negative	0.0097			
		BMI	Negative	0.0215			
		Breakfast eating	Positive	0.0231			
		Non-smoking	Positive	0.0293			
		Sugar in coffee or tea	Negative	0.0334			
	Final	Canned vegetables	Positive	0.0072	2311.4	0.124	0.110
		Fresh vegetables	Positive	0.0124			
		Sugar in coffee or tea	Negative	0.0173			
		Breakfast eating	Positive	0.0385			

Table 3. Multivariable general linear models identifying significant lifestyle, dietary, and psychological predictors of academic achievement in secondary school (gymnasium) graduation examinations across four subjects. For each academic subject, both the initial multivariable model (Step 3) and the final optimized model are presented. Only predictors with p-values < 0.05 were retained in the final models. Positive or negative associations indicate the direction of effect on academic performance. AIC = Akaike Information Criterion; R^2 = coefficient of determination.

associated with lower performance in past biology exams, while waist circumference and blood pressure showed no significant relationship with school results. 2. Overeating was not related to secondary school (gymnasium) performance, but having breakfast was positively linked to higher scores in past Biology exams. Additionally, non-smoking was associated with better performance in both Mathematics and Biology in secondary school (gymnasium), while abstaining from alcohol correlated with higher scores in the Native Language exam. 3. Psychological factors, including perceived stress, depression, and vigor at the entrance to university studies, were not associated with performance in secondary school (gymnasium) graduation examinations. However, feelings

of happiness among university students were strongly linked to better performance in past Native Language exams. 4. Consuming fresh and canned vegetables was positively associated with past scores in mathematics and biology, and fresh fruit intake was linked to better performance in Mathematics. Furthermore, drinking unsweetened coffee or tea was positively associated with both Mathematics and Biology scores at earlier educational stages. Conversely, egg consumption was negatively associated with performance in Biology and Native Language exams, while boiled potato consumption was negatively associated with Foreign Language exam results. 5. Finally, gender had a significant influence on performance in secondary school (gymnasium) graduation examinations, with female students outperforming males in Native Language exams, whereas males performed better in Foreign Language exams. Thus, the results of the final general linear model indicate that Mathematics examination performance in secondary school (gymnasium) graduation examinations was most strongly linked to lower sugar consumption in coffee or tea and to non-smoking. Performance in secondary school (gymnasium) graduation examinations in Native Language was correlated with gender, showing that females tended to outperform males, as well as being associated with higher levels of happiness. In Foreign Language examinations, males outperformed females, and performance was also related to alcohol abstinence and lower consumption of boiled potatoes at the entrance to university studies. Biology examination performance, there was a positive correlation with the consumption of fresh and canned vegetables, lower sugar intake in coffee or tea, and more frequent breakfast consumption at the entrance to university studies. We identified that the interactions between secondary school (gymnasium) graduation examination achievements and healthy lifestyle and health indicators at the entrance to university studies are likely mutual. That is, lifestyle could have had the influence on academic performance, just as well-performing students could have had healthier lifestyle, such as healthy eating habits, good stress managing, not smoking, going to bed on time and monitoring their body weight. For example, it was found that well-performing students are characterized by better executive function [34–36], such as ignoring or hiding various temptations. Therefore, it can be assumed that they find it easier to resist unhealthy food. The final results of our general linear model indicate that performance in the Mathematics secondary school (gymnasium) graduation examination is most strongly linked to lower sugar consumption in coffee or tea at the entrance to university studies. Additionally, performance in the Foreign Language secondary school (gymnasium) graduation examination was found to correlate with reduced consumption of boiled potatoes at the entrance to university studies. Conversely, Biology secondary school (gymnasium) graduation examination performance demonstrated a positive correlation with the intake of both fresh and canned vegetables, as well as lower sugar consumption in coffee or tea at the entrance to university studies.

Tapia-Serrano et al. identified three key factors of healthy behavior in children from preschool to adolescence, namely physical activity, screen time, and sleep duration [16]. One of the latest systematic reviews indicated a small but positive association between adherence to all three recommendations of the 24-h movement guidelines (regular physical activity, reduced screen time, and optimal sleep duration) and enhanced academic achievement in children and adolescents [37]. Other researchers also have found positive correlations between meeting these movement behavior recommendations and improved mental health indicators among children and adolescents [38].

In our study, students' secondary school (gymnasium) graduation examination achievements were not significantly associated with moderate-to-vigorous physical activity (MVPA), sitting time, or sleep quality as measured by the Pittsburgh Sleep Quality Index at the entrance to university studies.

Systemic analyses clearly show that physical activity, diet, and other behavioral interventions significantly improve cognitive process and achievements at school, especially in Mathematics, in obese or overweight children and adolescents [39,40]. Sneck et al. [41] conducted an extensive meta-analysis and revealed that enhancing physical activity among children results in better performance in Mathematics [41]. A recent meta-analysis revealed that although physical activity breaks increase children's physical activity and time spent on tasks during lessons, they do not significantly impact cognitive functions (attention components, working memory and executive functions) and academic achievements (Mathematics and reading) [42]. A comprehensive systematic analysis suggested that classroom-based physical activity may positively impact academic outcomes [43]. Another meta-analysis demonstrated that physical activity enhances classroom behaviors and positively influences various aspects of academic achievement, particularly Mathematics-related skills, reading, and composite scores in children [4]. The findings of meta-analyses indicated that school-based physical activity interventions are an effective strategy for enhancing language-related skills in children and adolescents [45]. However, studies investigating the links between physical activity, fitness, physical education, and academic achievement have reported mixed results [22,41,42,45,44]. For instance, one study might find improvements in Math and reading, while another found improvements in reading and spelling but not in Math and reading. Similar inconsistencies were observed when comparing girls and boys [45].

Additionally, Gallotta et al. [22] discovered that physical activity and aerobic fitness can moderately predict proficiency in Mathematics and the Native Italian Language. The relationship between MVPA and academic achievement may not be direct but may be mediated by cardiorespiratory fitness, cognitive flexibility, and inhibition via cardiorespiratory fitness. Physical activity interventions aimed at improving academic achievement should focus on enhancing cardiorespiratory fitness and executive function [46]. A recent systematic analysis showed that no definitive conclusions can be made about the significant impact of physical activity and motor competence on cognitive functions, as many various factors distort this interaction [47]. Finally, one of the most comprehensive umbrella reviews showed that physical activity has the most benefits on cognitive functioning during the early and late periods of the lifespan [48]. However, our research does not encompass this age group, because our subjects were undergraduate students.

Our previous research showed that logical thinking of adults was not associated with sleep, moderate-to-vigorous physical activity (MVPA), impulsivity, subjective health, or components of a healthy lifestyle [7]. Additionally, according to another our previous research, women in professional sports solved the fewest logic

tasks [8]. We also concluded that females and males with the highest emotional intelligence have the highest MVPA, while logical thinking is not associated with MVPA [4]. Our previous study showed that 10 weeks of yoga training does not improve cognitive functions in older adults [49]. Thus, these findings from our study align with the data presented in this article, indicating that physical activity is not associated with logical thinking, as exemplified by Mathematical achievement in this study.

It is firmly established that nutrition serves as a pivotal lifestyle factor capable of modifying the risk of future cognitive impairment and dementia [13,15]. Extensive systematic analysis underscores the significant influence of diet on children's learning success, particularly in relation to food insufficiency, iron deficiency and supplementation, micronutrient adequacy, and the importance of breakfast [50]. While school feeding programs have improved micronutrient status, increased enrollment, and enhanced attendance among students, their impact on growth, cognitive abilities, and academic achievement remains limited [51]. Other studies indicated that a two-year healthy eating initiative improved Math and literacy skills in children [52]. In conclusion, there remains a notable dearth of experimental research exploring the influence of nutrition on students' learning outcomes. Our studies, we believe, complement previously cited research by demonstrating that, as shown by our study data, performance in past Mathematics and Biology secondary school (gymnasium) graduation examinations were directly associated with the consumption of fresh and canned vegetables, and inversely associated with sugar intake from coffee and tea at the entrance to university studies. Other scientific studies have demonstrated that the glycemic index, influenced by complex carbohydrates in undergraduate diets, can enhance specific types of information processing [53]. More specifically, their findings indicate that certain macronutrients—particularly complex carbohydrates and fiber—may play a significant role in modulating social cognition and emotional processing. This highlights the importance of diet as a relevant factor in psychological well-being [53]

Studies have shown that cognition can be influenced by factors such as hypertension, dyslipidemia, midlife obesity, diabetes mellitus, smoking, physical inactivity, depression, and low levels of education [54]. Our GLM analysis did not reveal any significant associations between secondary school (gymnasium) graduation examination performance and either systolic blood pressure or waist circumference at the entrance to university studies. There is often an inverse relationship between BMI, mental health, and cognition: both obesity and BMI that is too low can negatively affect mental health [55]. Additionally, mood is one of the indicators of psychological well-being and mental health [56]. This supports our findings of a strong correlation between Native Language exam scores and happiness. It is surprising that performance in none of the exams was significantly associated with perceived stress, depression, or vigor. It is clear that some limitations of our study may have influenced our findings. Furthermore, we should also consider the complex and dynamic interactions among cognitive abilities, logical reasoning, emotional intelligence, mental health, genetic factors, personality traits, and healthy lifestyle behaviors, as these may serve as potential influencing factors.

Limitations

The limitations of this study include its reliance on self-reported data regarding lifestyle factors and dietary habits, which may be prone to recall bias or inaccuracies. For example, we did not provide a specific definition of "happiness" in the questionnaire; instead, participants rated their overall happiness based on their own subjective understanding. Furthermore, the study may not have accounted for all potential confounding variables that could affect academic performance, such as socioeconomic status or study habits. A significant limitation is the time gap between the academic performance data (collected at the end of secondary school) and the current health-related measurements at the entrance to university studies. This gap restricts causal interpretation and allows for the observation of associations rather than direct effects. This limitation is particularly important for lifestyle indicators that tend to change rapidly during the transition from secondary school (gymnasium) to university. For example, sleep patterns can vary significantly, which may help explain why our study found no significant associations with secondary school (gymnasium) graduation examination performance. A longitudinal actigraphy study demonstrated that students' total sleep time and mid-sleep timing shifted notably during this transition, showing a clear circadian phase shift observed over a five-year period [57]. This highlights that lifestyle factors, such as sleep, can fluctuate considerably during this critical transition, which could be a key reason our study did not find significant associations with secondary school (gymnasium) graduation examination performance. One limitation of our study is the modest sample size, which did not allow for reliable comparisons among subgroups within the three study programs: Health Sciences, Law, and Sports Science. This limitation is significant because previous research has indicated that lifestyle habits can vary considerably across different fields of study. For instance, students in Health Sciences tend to adopt healthier behaviors—such as reduced screen time, lower levels of sedentary activity, and greater adherence to the Mediterranean diet—compared to their peers in non-Health Science disciplines [58]. Additionally, the sample was predominantly composed of women. Future research could address these limitations by using more objective measures of lifestyle factors and dietary habits, such as accelerometer data for physical activity and dietary assessments conducted by trained professionals. The cross-sectional design of this study also limits the ability to draw conclusions about causality or long-term effects. Therefore, future longitudinal and interventional studies, similar to those conducted in primary school settings [22], are necessary to better understand the long-term impact of lifestyle and dietary habits on academic achievement. Additionally, longitudinal studies could provide insights into the long-term effects of lifestyle and dietary habits on academic performance. Moreover, exploring the underlying mechanisms driving the observed associations, such as physiological or psychological factors, could deepen our understanding of the relationships among lifestyle, diet, and academic achievement.

Conclusions

Our findings show that factors such as physical activity, sedentary behavior, sleep quality, and most psychological aspects measured when students entered university—except for happiness—were not consistently linked to their prior academic performance, as reflected in their secondary school (gymnasium) graduation examination. Instead, these exam results exhibited modest yet systematic links with various health-related traits assessed at university entry, including body composition, dietary habits, and lifestyle choices like smoking, alcohol use, and breakfast routines. Notably, we also found gender differences in these associations. These findings do not suggest cause-and-effect relationships, as the academic results preceded the health and behavioral assessments. Instead, they imply that certain lifestyle and psychological traits present at the start of university may be related to earlier academic achievement patterns. Importantly, no single factor stood out as a key predictor, highlighting that academic success likely results from complex interactions among biological, behavioral, psychological, and social factors. This underscores the importance of future research adopting comprehensive models that include cognitive, motivational, and socioeconomic factors to better understand the broader influences shaping student performance at different educational stages.

Data availability

The data supporting the findings of this study are included in this published article and its Supplementary Information files, including Supplementary Table S1. Further information can be requested from the corresponding author, Daiva Majauskiene.

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Author contributions

D.M. conceived and designed the study, conducted the research, analyzed the data, reviewed the screening questionnaires, wrote the manuscript, and had final responsibility for the content of the paper. T.A., E.S., R.Z., and M.G. conducted the research. N.I. and R.D. conducted the research and analyzed the data. D.V. conducted the

research, analyzed the data, reviewed the screening questionnaires, and wrote the manuscript. A.S. (Sidlauskienė) and A.S. (Sarkauskiene) conducted the research and wrote the manuscript. A.S. (Skurvydas) conducted the research, analyzed the data, reviewed the screening questionnaires, and wrote the manuscript. All authors read and approved the final manuscript.

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Declarations

Competing interests
All other authors declare no competing interests.

Ethical approval
All participants were informed about the purpose of the research. The study received ethical approval from the Human Research Ethics Committee at Klaipėda University (Protocol No. STIMC-BTMEK-09). Participants were informed that the information provided in the anonymous survey would be used for the purposes of this study. We followed ethical standards for research with human subjects (Declaration of Helsinki) and obtained written informed consent from all participants involved in the study.

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