PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Relationship between leisure-time physical activity and components of somatotype among university students

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Abstract

Background and Study Aim Physical activity (PA) has become a critical component of social, economic, and health policy worldwide. Leisure-time physical activity (LTPA) plays a particularly significant role in preventing lifestyle-related diseases. This study aimed to analyze students' LTPA and examine the relationship between LTPA levels and somatotype.

Material and Methods The study included 309 students, aged 20–24, from five Polish universities. Anthropometric measurements were taken, somatotypes were determined using the Heath-Carter method, and LTPA was assessed using the Minnesota Leisure-Time Physical Activity Questionnaire (MLTPAQ).

Results Among the students studied, 22.3% had a BMI above the normal range—31% of males and 13.6% of females. Men reported higher levels of LTPA than women and engaged in more physical activity across all intensity levels. In both male and female groups, one in four students did not reach the recommended leisure-time physical activity level of 1000 kcal/week. A statistically significant negative correlation was found between endomorphy and high-intensity LTPA in both sexes. Additionally, one in four Polish students in the study did not achieve a level of leisure-time physical activity sufficient to meet health-protective energy expenditure guidelines.

Conclusions These findings underscore the essential role of high-intensity exercise in achieving beneficial levels of leisure-time physical activity (LTPA). They also highlight the importance of considering individual somatotype characteristics when developing physical activity recommendations for university students. Promoting tailored, intensity-specific LTPA programs could enhance engagement and address diverse fitness needs, contributing to effective health interventions in young adult populations.

Keywords: MLTPAQ, body composition, exercise intensity, energy expenditure, university youth, preventive health.

Introduction

In light of current health challenges, physical activity (PA), as recommended for health, plays a critical role as a protective factor in preventing noncommunicable diseases. It contributes to lowering the risk of cardiovascular diseases and cancer, helps maintain healthy body composition and proper functioning of the musculoskeletal system, and improves mental health [1, 2, 3]. In an era of rapid societal progress, a marked decline in daily physical activity levels can be observed. Consequently, the quantity and quality of physical activity are no longer solely individual concerns but have become significant areas of focus within social, economic, and health policy worldwide [4, 5].

Eliminating inadequate physical activity, defined as engaging in less than 150 minutes of moderate-intensity physical activity per week, can provide substantial health benefits and reduce healthcare costs [5]. However, trends in adult physical activity levels worldwide are concerning. According to the latest data, in 2022, 31% of adults globally did not meet the WHO's recommended level of physical activity [6, 7]. This represents a five-percentage-point increase between 2010 and 2022. If this trend continues, by 2030, physical inactivity may affect 35% of adults [8]. Studies among university students across 23 countries indicate that 41.4% of students are physically inactive [9]. Additionally, a significant proportion of students show higher levels of sedentary behavior compared to the general young adult population [10].

Physical activity includes various categories, such as occupational, transport-related, and leisure-time activities [6, 11]. Leisure-time physical activity (LTPA) is thought to play a particularly important role in supporting good health [12]. Studies have shown that following LTPA guidelines is associated with a reduced risk of sleep disorders [13] and a lower risk of developing depression symptoms, regardless of sex, age, race, marital status, economic status, or

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BMI [11]. LTPA can also help prevent osteoporosis [14] and improve cardiorespiratory fitness (CRF) [15]. Current research suggests that engaging in sports activities during leisure time, with an energy expenditure of over 5 kcal/min and a total weekly expenditure of 1000–1499 kcal, may represent a threshold level effective for preventing coronary heart disease and promoting overall health [16].

Leisure-time physical activity (LTPA) among university students and its associated variables is a topic of interest for many researchers [17, 18, 19, 20]. Research on students from selected countries in the Carpathian Euroregion (Poland, Slovakia, and Ukraine) reveals significant differences in LTPA levels among these countries, with students from Slovakia participating in physical activities more frequently than those from Poland or Ukraine [21]. Research by Acebes-Sánchez et al. indicates that the LTPA levels among Spanish students are generally inadequate [22]. Motevalli et al. report that the majority of Austrian university students regularly engage in physical activity during their leisure time, while approximately one in five participate in club sports activities [23]. Findings also suggest that, regardless of sex, individuals with higher levels of LTPA tend to have a stronger health locus of control, which increases with higher LTPA levels [24]. Additional studies indicate that college students who engage in some weekly physical activity have a reduced risk of experiencing hopelessness, depression, and suicidal behaviors compared to inactive students [17]. Further research shows that university students who regularly participate in physical activity during their leisure time have lower BMIs and are less likely to be overweight than those who are inactive [23, 25].

The measurement of a person's current body shape and composition is referred to as somatotyping. Each individual's somatotype represents a unique combination of body fat, musculoskeletal development, and body linearity, captured through the components of endomorphy, mesomorphy, and ectomorphy [26]. While a person's body type and constitution are largely determined by genetics, they are also shaped by external factors, such as lifestyle, nutrition, and physical activity, and naturally change with age [27, 28, 29, 30]. Fat and muscle tissues, in particular, are highly responsive to environmental influences [31]. A study of boys aged 8–15 found that average endomorphy was significantly higher among inactive boys and lower among physically active ones, both before and during puberty. Additionally, among pubescent boys, average somatotype components differed significantly depending on the hours spent walking to and from school and the time spent in sedentary activities [32].

Studies of adults aged 18–40, including both men and women, have shown that as physical fitness increases, the mesomorphy component of the somatotype also increases, while the endomorphy and ectomorphy components tend to decrease [33]. Research examining the relationship between somatotype components and the prevalence of certain chronic diseases suggests that a somatotype dominated by mesomorphy with prominent endomorphy constitutes a risk factor, indicating a predisposition to certain conditions, such as hypertension or liver diseases, and underscores the importance of body mass control [34].

The diversity of research on somatotype reflects an ongoing exploration of correlations between its components and various factors. Nevertheless, the specific relationship between leisure-time physical activity and somatotype components among university students remains underexplored, highlighting the need for more focused investigation in this area.

The study aim is to present the level of physical activity and its intensity during leisure time among Polish students and to assess the correlation between the level and intensity of LTPA and somatotype components.

Materials and Methods

Participants

The study included 309 full-time students (154 female and 155 male) in their first-cycle (Bachelor's) studies from five Polish universities: Krosno State College, the University of Rzeszów, Maria Curie-Skłodowska University in Lublin, Cracow University of Technology, and Poznań University of Life Sciences. Participants were between the ages of 20 and 24 and represented a variety of academic profiles. All students were actively engaged in physical education classes as part of their university curriculum. All study procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki.

Research Design

The study was conducted during physical education (PE) classes held in gymnasiums (sports halls). The criterion for participation was voluntary consent, while the exclusion criterion – any medical contraindications to participation in PE classes. Recruitment was carried out through randomized sampling from specific departments. In each university where authorities had granted consent for the study, a list was compiled of all student groups with mandatory PE classes. Then, using a random draw without repetitions conducted in Statistica, two student groups – one male and one female – were selected to participate.

Anthropometric measurements were taken for each participant to calculate the three components of somatotype – endomorphy, mesomorphy, and ectomorphy – using the Heath-Carter method [26]. Endomorphy indicates body fat, mesomorphy reflects muscle development, and ectomorphy refers to body slenderness. Body height (BH) was measured with a mobile stadiometer (SECA 2012, Germany) with an accuracy of 1 mm, and body weight (BW) was recorded using Tanita TBF 300 (Japan) scales. Upper arm and calf circumferences were measured with a Gulick anthropometric measuring tape of constant tension, accurate to 1 mm. Four skinfolds (triceps, subscapular, supraspinal, and medial calf) were measured using a Harpenden skinfold caliper with an accuracy of 0.1 mm. The breadths of the humerus and femur bones were measured with a small Martin caliper, accurate to 1 mm. All measurements were conducted by a trained research team following standard anthropometric procedures. Additionally, body mass index (BMI) was calculated using the standard formula, and BMI classification was performed according to WHO norms [35].

To assess leisure-time physical activity, the Polish version of the Minnesota Leisure-Time Physical Activity Questionnaire (MLTPAQ) was used [36, 37]. This questionnaire collects data on physical activity over the course of a year, focusing specifically on activities outside of professional work. It enables the assessment of energy expenditure in kcal per week. The study analyzed students' leisure-time physical activity (outside university obligations), excluding mandatory PE classes, and covered the six months prior to the study (from October 2016 to March 2017).

Exercise intensity was categorized according to Metabolic Equivalent of Task (MET) values on a three-level scale: low intensity (L) [$\leqslant$ 4 MET], medium intensity (M) [4.5–5.5 MET], and high intensity (H) [$\geqslant$ 6 MET]. The MLTPAQ score was calculated as the sum of metabolic activity indexes for low, medium, and high intensities [36]. Data was collected using the PAPI (Paper-and-Pen Personal Interview) method, with participants completing the paper questionnaire in the presence of research team members, who provided detailed instructions and addressed any questions.

Statistical Analysis

Basic statistical measures were calculated, including the arithmetic mean ($\bar{x}$), standard deviation (SD), median (Me), and percentiles (C_{25} and C_{75}). The significance of differences between the analyzed groups was assessed using the Mann-Whitney nonparametric test. Correlations between selected somatic variables and the level of leisure-time physical activity were analyzed using Spearman's rank correlation method. A significance level of $\alpha = 0.05$ was assumed. All statistical analyses were conducted using Statistica 13.3 software (StatSoft).

Results

Detailed somatic characteristics, including central tendency and dispersion measures, are presented in Table 1. In general, female students in the analyzed group demonstrated lower body mass, body height, and BMI values compared to male students. Most students had a BMI within the normal range, with a smaller proportion classified as either above or below the normal range. The p-values for differences between sexes were calculated using the Mann-Whitney test.

The classification of BMI with regard to sex for the entire group of students is presented in Table 2. Statistically significant differences were observed in BMI distribution between male and female students. Female students showed a higher percentage of individuals with underweight and normal body mass. In contrast, male students had a greater percentage of individuals classified as overweight or obese. Overall, the proportion of students above the normal BMI range was higher among males than females. The p-values for differences in BMI distribution between sexes were calculated using the chi-square test of independence.

The somatotype components by sex are presented in Table 3. In the tested group, endomorphy was the most common somatotype component among female students, while mesomorphy was most common among male students. These differences were highly statistically significant ($p < 0.001$). For ectomorphy, however, no statistically significant differences between sexes were observed. The p-values were calculated using the Mann-Whitney test.

The detailed results of LTPA levels by sex are presented in Table 4. Analysis using the MLTPAQ showed that male students reported higher levels of leisure-time physical activity than female students, including more activity across low, medium, and high intensities. However, a statistically significant correlation ($p < 0.001$) between sex and leisure-time physical activity was observed only for high-intensity activity and the total physical activity measure. Additionally, it was noted that one in four female students (Total = 671 kcal/week) and one in four male students (Total = 950 kcal/week) did not reach the recommended leisure-time physical activity level of 1000 kcal/week. The p-values were calculated using the Mann-Whitney test.

The correlations between somatotype components and LTPA level and intensity are presented in Table 5. Among female students, endomorphy showed a significant negative correlation only with high-intensity physical activity. In contrast, among male students, endomorphy demonstrated a significant negative correlation with both medium- and high-intensity physical activity, as well as with total LTPA. No statistically significant correlations were observed for mesomorphy or ectomorphy in either group.

Table 1. Somatic characteristics of the study group (n = 309, n=154 – female, n=155 – male)

Variables	Sex	X±SD	Me	c_{25}	c_{75}	*p*-Value
BH (cm)	Female	165.0±5.7	165.0	161.0	169.0	< 0.001
	Male	177.8±6.8	178.0	172.0	183.0	
BW (kg)	Female	58.9±9.8	57.5	52.8	64.0	< 0.001
	Male	75.5±11.9	74.6	67.4	83.4	
BMI (kg/ m²)	Female	21.6±3.2	21.4	19.6	23.3	< 0.001
	Male	23.9±3.7	23.5	21.4	26.1	

Note. C_{25} and C_{75} – percentiles, BH - body height, BW - body weight, BMI - body mass index

Table 2. Classification of BMI

Classification of BMI (kg/m²)	Sex (*p* - Value < 0.001		Total (*n* = 309) n (%)
	Female (*n* = 154) n (%)	Male (*n* = 155) n (%)	
Underweight	21 (13.6)	8 (5.2)	29 (9.4)
Normal weight	112 (72.7)	99 (63.9)	211 (68.3)
Overweight	19 (12.3)	35 (22.6)	54 (17.5)
Obesity	2 (1.3)	13 (8.4)	15 (4.8)

Table 3. Components of the somatotype of the study group by sex

Components of the somatotype	Sex	X±SD	Me	c_{25}	c_{75}	p-Value
Endomorphy	Female	3.50±0.97	3.40	2.80	4.10	< 0.001
	Male	2.72±1.10	2.40	1.90	3.30	
Mesomorphy	Female	2.80±1.22	2.95	1.90	3.70	< 0.001
	Male	3.98±1.50	3.90	3.00	5.00	
Ectomorphy	Female	2.66±1.39	2.60	1.70	3.50	0.323
	Male	2.49±1.48	2.50	1.20	3.60	

Note. C_{25} and C_{75} – percentiles

Table 4. Level of leisure-time physical activity by sex based on MLTPAQ

Intensity activity (kcal/week)	Sex	X±SD	Me	c_{25}	c_{75}	p-Value
Light (L)	Female	488±497	398	184	622	0.195
	Male	595±663	434	198	796	
Moderate (M)	Female	386±493	219	61	495	0.184
	Male	493±628	256	62	635	
Hight (H)	Female	932±1798	377	149	845	< 0.001
	Male	1579±1986	884	219	1846	
Total (L+M+H)	Female	1806±2071	1158	671	2039	< 0.001
	Male	2669±2449	1931	950	3220	

Note. C_{25} and C_{75} – percentiles

Discussion

The aim of this study was to analyze the level and intensity of leisure-time physical activity (LTPA) among Polish university students and to examine the correlations between LTPA and somatotype components. The findings revealed that male students had higher levels of LTPA across all intensities compared to female students. Significant negative correlations were observed between endomorphy and high-intensity LTPA in both sexes. Among male students, a negative correlation was also found between endomorphy and medium-intensity LTPA. No significant correlations were

Table 5. Correlation of body type with leisure-time physical activity intensity level by sex

Components of the somatotype	Sex	L	M	H	Total
Endomorphy	Female	-0.02	0.05	-0.16*	-0.09
	Male	-0.16	-0.17*	-0.21*	-0.28*
Mesomorphy	Female	0.08	0.09	0.06	0.15
	Male	-0.09	0.05	-0.02	-0.02
Ectomorphy	Female	0.02	-0.05	0.04	-0.05
	Male	0.08	0.02	0.00	0.02

Note. * - p<0.05

identified for mesomorphy or ectomorphy with LTPA levels.

These results align with existing studies on physical activity (PA) among Polish and international students, which show that men engage in physical activity more frequently than women [21, 22, 38]. However, a study by Motevalli et al. [23] did not find significant sex-related differences in the frequency of leisure-time physical activity among students, except for sports club participation, which was significantly more common among male participants. Our previous international studies indicated that the average level of leisure-time physical activity among women is approximately one-third lower than that of men [24]. Similarly, global trends in PA show that men are generally more physically active than women. According to the OECD/WHO report from 2023 [5], in Europe, 73% of men and 58% of women aged 15–24 participate in sports or exercise at least once a week.

The results of our study indicate that the prevalence of overweight and obesity among Polish students was 22.3%, slightly below the average of 26% for young adults aged 18–24 with higher education in Poland, reported in 2019 [39]. This finding is notably higher than results from other studies, such as those on Austrian students (17.8%) [23] and Spanish students (16.5%) [22]. In our sample, male students (31%) made up a larger proportion of individuals with excess body weight according to BMI, compared to female students (13.6%).

The obtained results on the somatotype of the tested group indicate a more frequent occurrence of endomorphy among women than men, a finding also reported in a study by Chandel et al. [33] involving individuals aged 18–40. Among the Polish female students, the endomorphic component was predominant over the other somatotype components (3.5 – 2.8 – 2.6). In contrast, among male students, the mesomorphic component was dominant (2.7 – 3.9 – 2.4). Portuguese studies on siblings observed that participants who were more physically active showed higher values of mesomorphy [28]. Research on Polish university students has also demonstrated that the intensity and duration of additional physical activity are correlated with body composition [25, 40, 41].

This study has shown a significant correlation between the endomorphic component and both the level and intensity of LTPA. In both sexes, the correlation between endomorphy and LTPA was negative, particularly for high-intensity physical activity. This suggests that for healthy individuals at this age, physical activity should not rely solely on low-intensity exercises. Therefore, if physical activity is to serve a health-protective role, the intensity level of activity is crucial, as supported by other studies [2, 15, 42, 43, 44, 45]. It has been observed, for example, that changes in HDL cholesterol are more favorable in groups with high physical activity compared to those with a sedentary lifestyle or low activity [43]. High-intensity exercises also appear to be more effective than moderate-intensity activities in reducing cardiovascular risk factors [2].

In a Spanish male population aged 20–90, assessment of physical activity using the MLTPAQ showed that only high-intensity activity (H) was associated with cardiorespiratory fitness (CRF) [42]. Similar conclusions were drawn by Tuero et al. [44], who found that high-intensity physical activity, as estimated by the MLTPAQ, was significantly correlated with VO2max values in both women and men. Another study confirmed that LTPA intensity is significantly correlated with CRF, noting that CRF is influenced more by the intensity of LTPA than by its duration [15]. Additionally, a study of Turkish students showed that intensive physical activity is correlated with mindful awareness, suggesting that increased physical activity, particularly at high intensity, may have a positive effect on mindful awareness [45].

One prospective study on the optimal dose of physical exercise for reducing risk factors associated with ischemic heart disease found that in the Polish population, given regional dietary habits, this dose, measured as energy expenditure, ranges from 1000 to 2000 kcal per week. Physical activity with an energy expenditure of 2000 kcal or more per week is linked to additional benefits, particularly in positively modifying HDL cholesterol levels [43]. In our study, however, one in four female students had an energy expenditure of 671 kcal per week, and one in four male students had 950 kcal per week. This indicates that 25% of the students tested do not reach a level of leisure-time physical activity sufficient to achieve health-protective energy expenditure.

These findings align with those of Moreno [46], who observed that approximately one in four students in his study did not meet the PA levels recommended by the WHO. Our previous observations also indicated that women made up the largest percentage of individuals with physical activity levels below recommended health standards (below 1000 kcal/week) [24]. Studies on university students suggest that those most at risk of not reaching the WHO-recommended PA level are women with a normal or below-normal body fat percentage who are not employed outside the home [46]. This pattern suggests that maintaining a lifestyle with low levels of leisure-time physical activity among young adults may lead to an increased risk of noncommunicable diseases in the future.

A certain limitation of this study is that the female group included more underweight individuals than the male group. This may be due to the inclusion criterion of self-reported health status, which excluded women with overweight or obesity who did not participate in the PE curriculum. Although high-intensity physical activity is negatively correlated with the endomorphy component, this correlation is slightly stronger in the male group, potentially due to the higher proportion of overweight and obese individuals. A broader study focusing exclusively on individuals with diagnosed overweight and obesity is recommended to confirm or refute these observations.

Conclusions

This study underscores the importance of achieving sufficient levels of leisure-time physical activity (LTPA) for health protection among university students. The findings highlight the critical role of high-intensity activity in contributing to beneficial health outcomes, particularly for individuals with higher endomorphic components. These observations suggest that physical activity guidelines for young adults should emphasize not only the quantity but also the intensity of LTPA to effectively support health and prevent lifestyle-related diseases.

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Conflicts of Interest

The authors declare no conflicts of interest.

References

1. Crooke R, Haseler C, Haseler T, Collins J, Crockett A. Physical Activity and Moving More for Health. *Journal of the Royal College of Physicians of Edinburgh*, 2020;50(2): 164–165. https://doi.org/10.4997/jrcpe.2020.223
2. Franklin BA, Eijsvogels TMH, Pandey A, Quindry J, Toth PP. Physical activity, cardiorespiratory fitness, and cardiovascular health: A clinical practice statement of the American Society for Preventive Cardiology Part I: Bioenergetics, contemporary physical activity recommendations, benefits, risks, extreme exercise regimens, potential maladaptations. *American Journal of Preventive Cardiology*, 2022;12: 100424. https://doi.org/10.1016/j.ajpc.2022.100424
3. WHO. *Physical activity* [Internet]. 2022 [updated 2022 Jun; cited 2023 Aug 24]. Available from: https://www.who.int/news-room/fact-sheets/detail/physical-activity
4. Haseler T, Haseler C. Lack of physical activity is a global problem. *BMJ*, 2022; o348. https://doi.org/10.1136/bmj.o348
5. OECD/WHO. OECD. *Physical activity in Europe: Trends and patterns* [Internet]. 2023 [updated 2022 Jun; cited 2024 Oct 1]. Available from: https://www.oecd.org/en/publications/2023/02/step-up-tackling-the-burden-of-insufficient-physical-activity-in-europe_20fba4c9/full-report/component-6.html
6. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, 2020;54(24): 1451–1462. https://doi.org/10.1136/bjsports-2020-102955
7. Strain T, Flaxman S, Guthold R, Semenova E, Cowan M, Riley LM, et al. National, regional, and global trends in insufficient physical activity among adults from 2000 to 2022: a pooled analysis of 507 population-based surveys with 5·7 million participants. *The Lancet Global Health*, 2024;12(8): e1232–e1243. https://doi.org/10.1016/S2214-109X(24)00150-5
8. WHO. *Global levels of physical inactivity in adults: off track for 2030* [Internet]. 2022 [updated 2022 Jun; cited 2024 Oct 1]. Available from: https://www.who.int/publications/i/item/9789240096905

9. Pengpid S, Peltzer K, Kassean HK, Tsala Tsala JP, Sychareun V, Müller-Riemenschneider F. Physical inactivity and associated factors among university students in 23 low-, middle- and high-income countries. *International Journal of Public Health*, 2015;60(5): 539–549. https://doi.org/10.1007/s00038-015-0680-0
10. Castro O, Bennie J, Vergeer I, Bosselut G, Biddle SJH. How Sedentary Are University Students? A Systematic Review and Meta-Analysis. *Prevention Science*, 2020;21(3): 332–343. https://doi.org/10.1007/s11121-020-01093-8
11. He F, Li Y, Hu Z, Zhang H. Association of domain-specific physical activity with depressive symptoms: A population-based study. *European Psychiatry*, 2023;66(1): e5. https://doi.org/10.1192/j.eurpsy.2022.2350
12. Ramirez Varela A, Hallal PC. Does every move really count towards better health? *The Lancet Global Health*, 2024;12(8): e1215–e1216. https://doi.org/10.1016/S2214-109X(24)00173-6
13. Yang J, Zheng X, Song G. *The Relationship Between Leisure-time Physical Activity and Sleep Disorders in American Adults*. 2024 Sep [Accessed 13th November 2024]. https://doi.org/10.21203/rs.3.rs-4845991/v1
14. Cao Y, Hu Y, Lei F, Zhang X, Liu W, Huang X, et al. Associations between leisure-time physical activity and the prevalence and incidence of osteoporosis disease: Cross-sectional and prospective findings from the UK biobank. *Bone*, 2024;187: 117208. https://doi.org/10.1016/j.bone.2024.117208
15. Singhal N, Siddhu A. Association of Leisure-Time Physical Activity With Cardiorespiratory Fitness in Indian Men. *Journal of Physical Activity and Health*, 2014;11(2): 296–302. https://doi.org/10.1123/jpah.2012-0029
16. Drygas W, Jegler A, Kunski H. Study on Threshold Dose of Physical Activity in Coronary Heart Disease Prevention. Part I. Relationship Between Leisure Time Physical Activity and Coronary Risk Factors*. *International Journal of Sports Medicine*, 1988;09(04): 275–278. https://doi.org/10.1055/s-2007-1025021
17. Taliaferro LA, Rienzo BA, Pigg RM, Miller MD, Dodd VJ. Associations Between Physical Activity and Reduced Rates of Hopelessness, Depression, and Suicidal Behavior Among College Students. *Journal of American College Health*, 2009;57(4): 427–436. https://doi.org/10.3200/JACH.57.4.427-436
18. Molina-García J, Castillo I, Pablos C. Determinants of Leisure-time Physical Activity and Future Intention to Practice in Spanish College Students. *The Spanish journal of psychology*, 2009;12(1): 128–137. https://doi.org/10.1017/S1138741600001542
19. Zadarko E, Barabasz Z, Nizioł-Babiarz E, Zadarko Domaradzka M, Barabasz M, Sobolewski M, et al. Leisure time physical activity of young women from the Carpathian Euroregion in relation to the Body Mass Index. *Annals of Agricultural and Environmental Medicine*, 2014;21(3): 622–626. https://doi.org/10.5604/12321966.1120614
20. Joseph RP, Royse KE, Benitez TJ, Pekmezi DW. Physical activity and quality of life among university students: exploring self-efficacy, self-esteem, and affect as potential mediators. *Quality of Life Research*, 2014;23(2): 659–667. https://doi.org/10.1007/s11136-013-0492-8
21. Zadarko-Domaradzka M, Zadarko E, Barabasz Z. Leisure-Time Physical Activity as a Component of University Students' Lifestyle in Selected Countries of the Carpathian Euroregion. *Sci Rev Phys Cult.* 2016;6:107–14.
22. Acebes-Sánchez J, Diez-Vega I, Rodriguez-Romo G. Physical Activity among Spanish Undergraduate Students: A Descriptive Correlational Study. *International Journal of Environmental Research and Public Health*, 2019;16(15): 2770. https://doi.org/10.3390/ijerph16152770
23. Motevalli M, Drenowatz C, Tanous DR, Wirnitzer G, Kirschner W, Ruedl G, et al. Determinants of Engagement in Leisure-Time Physical Activity and Club Sports among University Students: A Large-Scale Study. *Journal of Functional Morphology and Kinesiology*, 2024;9(3): 151. https://doi.org/10.3390/jfmk9030151
24. Zadarko E, Zadarko-Domaradzka M, Barabasz Z, Czarny W. The level of leisure time physical activity of students vs. the health locus of control. *Studia sportiva*, 2016;10(1): 70–75. https://doi.org/10.5817/StS2016-1-6
25. Janiszewska R. Evaluation of body composition in students with different degrees of physical activity by the method of bioelectrical impedance. *Med Ogólna Nauki O Zdrowiu,* 2013;19(2):173–6. (In Polish).
26. Carter JEL. *The Heath-Carter Anthropometric Somatotype - Instruction Manual* - [Internet]. San Diego, CA. U.S.A.: Department of Exercise and Nutritional Sciences San Diego State University; 2002 [updated 2002 Jun; cited 2024 Oct 1]. Available from: https://www.mdthinducollege.org/ebooks/statistics/Heath-CarterManual.pdf
27. Peeters MW, Thomis MA, Claessens AL, Loos RJF, Maes HHM, Lysens R, et al. Heritability of somatotype components from early adolescence into young adulthood: a multivariate analysis on a longitudinal twin study. *Annals of Human Biology*, 2003;30(4): 402–418. https://doi.org/10.1080/0301446031000102744
28. Pereira S, Katzmarzyk PT, Gomes TN, Souza M, Chaves RN, Santos FKD, et al. Multilevel modelling of somatotype components: the Portuguese sibling study on growth, fitness, lifestyle and health. *Annals of Human Biology*, 2017;44(4): 316–324. https://doi.org/10.1080/03014460.2016.1243727
29. Andreenko E. Changes in somatotype characteristics in the middle-aged Bulgarian men. *Nutricion Hospitalaria*, 2015;(6): 2910–2915. https://doi.org/10.3305/nh.2015.32.6.9810
30. Villaroman AA. The Role of Macromolecules in the Metabolism and Health of Different Somatotypes. *Glob. Sci. J.* 2022;10:1220–1226.
31. Skibińska A. Typologia budowy ciała [Body build typology]. In: Charzewski JI, editor. *Antropologia* [Anthropology]. Warsaw, Poland: AWF Publishing;

1999. P. 183–225. (In Polish)
32. Longkumer T. Physical Activity and Somatotypes among Ao Naga Boys. *The Anthropologist*, 2014;17(2): 669–675. https://doi.org/10.1080/09720073.2014.11891476
33. Chandel S, Rhetso A, Malik SL, Kulshreshtha M. The association between Body Physique and Physical Fitness: a cross-sectional study among a tribal community of Dadra and Nagar Haveli, India. *International Journal of Applied Exercise Physiology*, 2017;7(1): 11–20. https://doi.org/10.22631/ijaep.v7i1.161
34. Koleva M, Nacheva A, Boev M. Somatotype and Disease Prevalence in Adults. *Reviews on Environmental Health*, 2002;17(1). https://doi.org/10.1515/REVEH.2002.17.1.65
35. WHO. *A healthy lifestyle - WHO recommendations* [Internet]. 2023 [updated 2023 Jun; cited 2024 Oct 1]. Available from: https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle---who-recommendations
36. Barabasz M, Lwow F, Zadarko E. Minnesota Leisure Time Physical Activity Questionnaire in medical practice and health promotion. *Physiotherapy*, 2015;23(2). https://doi.org/10.1515/physio-2015-0009
37. Taylor HL, Jacobs DR, Schucker B, Knudsen J, Leon AS, Debacker G. A questionnaire for the assessment of leisure time physical activities. *Journal of Chronic Diseases*, 1978;31(12): 741–755. https://doi.org/10.1016/0021-9681(78)90058-9
38. Duda M, Rżany M, Dudło A, Suszyński K, Górka D, Dogońska A. Students' attitude towards taking up physical activities apart from university classes. *Quality in Sport*, 2015;1(2): 53–59. https://doi.org/10.12775/QS.2015.011
39. World Obesity Federation. *World Obesity Federation Global Obesity Observatory. Poland - Overweight/obesity by age and education*. [Internet]. 2024 [updated 2024 Jun; cited 2024 Oct 6]. Available from: https://data.worldobesity.org/country/poland-173/#data_population-breakdowns
40. Saczuk J, Wasiluk A. *Wpływ aktywności ruchowej na poziom rozwoju fizycznego i wytrzymałość krążeniowo-oddechową studentek wychowania fizycznego. Aktywność Ruchowa Ludzi W Różnym Wieku* [The influence of physical activity on the level of physical development and cardiorespiratory endurance of female students of physical education. Physical activity of people of different ages] [Internet]. 2004 [updated 2024 Jun; cited 2024 Oct 10]. Available from: http://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-e382b8b4-d393-435f-ac91-80197cfa2d7d (In Polish)
41. Jaremków A, Markiewicz-Górka I, Hajdusianek W, Czerwińska K, Gać P. The Relationship between Body Composition and Physical Activity Level in Students of Medical Faculties. *Journal of Clinical Medicine*, 2023;13(1): 50. https://doi.org/10.3390/jcm13010050
42. Elosua R, Marrugat J, Molina L, Pons S, Pujol E. Validation of the Minnesota Leisure Time Physical Activity Questionnaire in Spanish Men. *American Journal of Epidemiology*, 1994;139(12): 1197–1209. https://doi.org/10.1093/oxfordjournals.aje.a116966
43. Drygas W, Kostka T, Jegier A, Kuński H. Long-Term Effects of Different Physical Activity Levels on Coronary Heart Disease Risk Factors in Middle-Aged Men. *International Journal of Sports Medicine*, 2000;21(4): 235–241. https://doi.org/10.1055/s-2000-309
44. Tuero C, De Paz JA, Marquez S. Relationship of measures of leisure time physical activity to physical fitness indicators in Spanish adults. *J Sports Med Phys Fitness*. 2001;41(1):62–7.
45. Yıldız ME, Günel İ, Dalbudak İ. The relationship between physical activity and mindful awareness of university students. *Physical Education of Students*, 2024;28(4): 234–241. https://doi.org/10.15561/20755279.2024.0406
46. Moral Moreno L. Perfil del estudiante universitario con un estilo de vida insuficientemente activo (Profile of university student with an inadequately active lifestyle). *Retos*, 2023;48: 610–618. (In Spanish). https://doi.org/10.47197/retos.v48.95840

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