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Anthropometric indicators and motor abilities of university students performing various types of physical activities (martial arts, volleyball, bodybuilding/fitness, jogging followed by sauna, golf, general PE classes)

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Abstract

Background and Study Aim. The aim of this study was to evaluate the relationship between various forms of physical activities undertaken by students of the University of Warmia and Mazury in Olsztyn and their body height, body mass, BMI scores and motor abilities.

Materials and Methods. Anthropometric measurements and motor ability tests were performed twice in 2010, at the beginning and at the end of the summer semester, and they involved 337 first-year full-time male students. At the beginning of the academic year, students selected the type of activity they would be involved in during physical education classes. The participants' body height, body mass and BMI were determined. Thirteen tests were carried out in the PE facilities of the University of Warmia and Mazury in Olsztyn to assess the students' motor abilities.

Results. Taller students opted for volleyball. Students with high body mass and high BMI scores chose less intensive forms of physical activity (golf) and strength-building workouts (bodybuilding, fitness). Slimmer students selected high-intensity activities, including general PE, martial arts, jogging followed by sauna, and volleyball.

Conclusions: The choice of physical activity was correlated with body height, body mass, BMI and motor fitness. Differences in the students' body mass, BMI and motor abilities at the beginning and at the end of the semester were influenced by the type of performed activity. In most motor ability tests, a significant improvement in results was observed in students who had opted for general PE, martial arts, jogging followed by sauna, and volleyball, which suggests that those activities had the most profound influence on the participants' motor fitness.

Keywords: male students • physical activity • motor fitness • anthropometric features • BMI

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Introduction

There exists vast scientific evidence that physical activity (PA) plays an important role in disease prevention and promotion of a healthy lifestyle. Children and adolescents should be provided with high-quality physical education (PE) and positive PA experiences that will encourage them to be physically active over a lifetime [1, 2]. A sedentary lifestyle increases the risk of serious chronic diseases, including heart disease, high blood pressure, stroke, certain types of cancer, diabetes and osteoporosis [3, 4]. Regular PA improves exercise capacity and motor fitness [5], and it delivers a variety of health benefits [6]. There is evidence to suggest that regular exercise improves immune function and alleviates symptoms of arthritis, asthma and fibromyalgia [7, 8]. Quality PE programs in high school contribute to higher levels of physical activity [9, 10], they improve self-esteem [11], self-efficacy [12], motor abilities and skills [13], enjoyment [14] motivation [15], PA levels in the long-term [16], and reduce sedentary behavior after graduation [17]. Over decades, physical activity has been gradually eliminated from most aspects of daily life, which is why PE plays a very important role in promoting an active lifestyle [1].

Most students are required to participate in some form of physical education in school, which is why PE classes make a significant contribution to public health [18]. The process of advocating for daily PE involves significant effort, cost and political strategy, but considerable success has been reported recently at elementary and middle levels. A high level of physical activity should be maintained until late in life, and an active and healthy lifestyle significantly contributes to the quality of life. Despite the above, the role of PE in promoting a pro-active attitude is marginalized at university. In Polish universities, the number of PE hours has been decreasing steadily in recent years, and in most countries in the world, PE is not an obligatory part of university curricula. The required number of PE credit hours was reduced from 165 in the 1998/1999 academic year to only 60 in the 2010/2011 academic year [19].

In accordance with a new regulation of the Ministry of Science and Higher Education, the number of PE credit hours at university can be reduced to thirty 45-minute classes during the entire degree program or obligatory PE classes can be eliminated entirely. Pursuant to the provisions of Art. 13 §7 of the Higher Education Law, Polish universities are merely required to *create a favorable environment for promoting students' involvement in physical activities* [20]. This provision is highly declarative, and it does not entail specific measures or legal sanctions. The global negligence towards the role played by PE in the promotion of an active and healthy lifestyle stems from the misapprehension that university students have developed healthy habits during earlier stages of education, therefore, this area of education can be disregarded at university. According to research, students' PA levels decrease significantly during the transition from high school to university [21] and in the first years of university [22]. Polish university students are characterized by low daily levels of physical activity [23-25], and the creation of daily opportunities for participation in PE classes is not always feasible. Physical activity levels of university students are low in most highly developed countries [3, 21, 26-28].

There is mounting scientific evidence to indicate that physical activity is indispensable to health and that people who remain physically active into old age derive significant health benefits. For this reason, physical education should not end in high school, but it should be continued at university. Health is not a given, and it has to be advanced and protected over a lifetime. The elimination of PE classes in university and the continuous reduction in PA levels is, therefore, unreasonable and highly detrimental to public health. There is no logic in the fact that young people are first taught to exercise for health, but are then deprived of the opportunity to participate in PE classes at university.

In most Polish universities, the number of PE credit hours has been reduced to thirty 45-minute classes during the academic year (two semesters). According to scientists and PE practitioners, such low PA requirements may not contribute to a noticeable improvement in the students' motor abilities [29], but this hypothesis has not yet been tested. In view of the above, the aim of this study was to analyze the relationship between the types of physical activities undertaken by the students of the University of Warmia and Mazury in Olsztyn (UWM) and their body mass, body height, BMI and motor abilities.

Materials and Methods

Ethics

The research was carried out upon the prior consent of the Ethical Committee of the UWM. The study involved male student volunteers who signed a written statement of informed consent.

Participants

The study was conducted in 2010, at the beginning and at the end of the summer semester, in physical education facilities of the UWM in Olsztyn, Poland. It involved 337 first-year full-time male students who were chosen from 260 groups of students attending obligatory PE classes with the use of a random selection method and statistical tables [30]. A total of 25 PE groups were randomly selected, and only those students who were absent, for whatever reason, on the day the tests and measurements were performed, were excluded from the study. More than 94% of students aged 19-20 from the selected groups were examined. The participants could choose from the following types of physical activities: martial arts, bodybuilding/fitness, volleyball, jogging followed by sauna, golf and general PE. teachers teaching basketball, soccer and swimming classes refused to participate in the study. The vast majority of participants resided permanently in the Region of Warmia and Mazury (NE Poland). First-year male students were specifically chosen as a particularly valuable research group because their motor habits can still be modified. In the UWM, obligatory PE classes take place mainly in the first year, and this study constitutes the sixth stage of cross-sectional research that has been conducted biannually since 2000 [31]. The participants were selected from among students who: did not take any medication or nutritional supplements, were in good health, had no record of blood diseases or diseases affecting biochemical and biomechanical factors, and did not participate in any physical activity programs other than the obligatory PE classes (fifteen 90-minute classes), conducted once a week during the summer semester (5 months). The students' physical activity levels were evaluated with the use of the Polish version of the standardized and validated International Physical Activity Questionnaire (IPAQ) [32]. The participants' energy expenditure did not exceed 600 METs per week, and none of the volunteers were included in the "sufficient physical activity" category. Questionnaire results revealed that the analyzed male students were characterized by low levels of physical activity and sedentary behavior. IPAQ was used only to select a homogenous sample, and its results are not presented in this study.

Instruments and procedures

The participants' body mass and body height were measured using the Radwag scale, and the results were used to calculate their BMI. Volunteers participated in thirteen motor ability tests: standing long jump [cm], 4×10 m shuttle run [s], skipping with hand clapping 8 s [number of claps], zig-zag run [s], sit-ups 30 s [number of sit-ups], medicine ball (4 kg) forward throw [cm], medicine ball (4 kg) backward throw [cm], pull-ups on bar [number of pull-ups], standing forward bend [cm], barbell overhead trunk rotation [cm], 1-minute and 3-minute Burpee tests [number of cycles], and 12-minute Cooper test on a rowing ergometer [m]. The accuracy and reliability of motor ability tests was confirmed by numerous studies on the subject [33-35]. In each student group, motor ability tests were conducted in the same order, beginning from coordination tests, through speed, agility, flexibility and strength tests, and ending in endurance and strength tests. Every student was shown how to perform the tasks in PE classes before the test and was given ample time to practice them. The participants warmed up for 10 minutes before performing the tests [36].

Statistical analysis

The results of every trial were averaged and standard deviation was computed using descriptive statistics. Maximum and minimum values were also given to classify the participants into the applicable ranges for every test. The differences in the motor abilities of students participating in different types of physical activities were determined by an analysis of variance (ANOVA). The mean values of the "physical activity factor" were compared by Duncan's test. Calculations were performed at a significance level of a = 0.05. Mean values and significant variations between participants attending different PE classes were shown in tables. Data were processed and the results were analyzed in the Statistica PL v. 10 software package [37].

Results

Body mass, body height and BMI of participants from different activity groups, measured at the beginning and end of the semester, as well as the significance of differences in the measured parameters between the analyzed groups are presented in Table 1. The significance of differences between the results of motor ability tests reported in each activity group at the beginning and end of the semester is shown in Tables 2-4.

The body mass of students attending bodybuilding/fitness classes increased significantly ($p = 0.0000$) between the beginning and the end of the semester. No significant increase was observed in the body mass of participants involved in martial arts, jogging with sauna, golf and general PE, whereas the body mass of volleyball players decreased significantly ($p = 0.0000$). Similar trends were noted in BMI values. The BMI scores of bodybuilding/fitness students increased significantly ($p = 0.0000$). No significant changes in BMI values were reported in students involved in martial arts, jogging with sauna, golf and general PE, whereas a significant drop in BMI scores was noted in volleyball players. The BMI values of students enrolled in bodybuilding/

Table 1. Body mass, body height and BMI values of students at the beginning and end of the summer semester.

Activity	Anthropometric indicators	Beginning of semester	End of semester	(p)
		x̄ *SD* (min÷max)	x̄ *SD* (min÷max)	
Martial arts	Body mass (kg)	76.47 ± 6.99 (63÷103)	76.66±6.92 (63÷103)	0.0865
	Body height (cm)	180.39 ± 5.87 (164÷193)	180.29±5.12 (168÷193)	ns
	BMI (kg/m^2)	23.68 ± 2.33 (18.99÷35.43)	23.62±2.40 (18.70÷36.49)	ns
Bodybuilding /fitness	Body mass (kg)	82.81 ± 9.24 (72÷119)	83.36±8.99 (72÷121)	0.0000
	Body height (cm)	181.51 ± 7.12 (167÷196)	181.51±7.05 (167÷196)	ns
	BMI (kg/m^2)	25.20 ± 3.07 (20.78÷37.22)	25.37±2.99 (20.78÷37.22)	0.0000
Volleyball	Body mass (kg)	74.96 ± 6.80 (63÷91)	75.73±6.72 (63÷93)	0.0000
	Body height (cm)	182.60 ± 6.16 (168÷195)	182.60±6.09 (168÷195)	ns
	BMI (kg/m^2)	22.96 ± 1.86 (19.58÷27.47)	22.73±1.89 (18.99÷27.47)	0.0000
Jogging followed by sauna	Body mass (kg)	71.16 ± 3.83 (63÷81)	71.15±4.13 (60÷81)	ns
	Body height (cm)	179.68 ± 4.08 (174÷192)	179.68±4.03 (174÷192)	ns
	BMI (kg/m^2)	22.04 ± 0.98 (19.87÷24.45)	22.03±0.93 (19.37÷24.45)	ns
Golf	Body mass (kg)	80.44 ± 5.06 (73÷93)	80.60±4.88 (73÷93)	ns
	Body height (cm)	180.56 ± 5.97 (165÷189)	180.56±5.89 (165÷189)	ns
	BMI (kg/m^2)	24.71 ± 1.59 (22.12÷29.38)	24.75±1.55 (21.84÷29.38)	ns
General PE classes	Body mass (kg)	78.56 ± 7.25 (63÷107)	78.72±7.33 (63÷110)	ns
	Body height (cm)	178.67± 6.60 (146÷176)	178.67±5.63 (164÷194)	ns
	BMI (kg/m^2)	24.63 ± 2.18 (19.44÷33.77)	24.68±2.17 (19.44÷33.77)	ns

Key: x̄ – arithmetic mean, ± – standard deviation, max – maximum value, min – minimum value, *ns* – no significant difference, (p) - probability that the calculated chi-square value will be exceeded.

fitness classes were in the overweight range (BMI ≥ 25.0) both at the beginning and at the end of the semester. BMI scores were within the norm in the remaining activity groups (martial arts, volleyball, jogging with sauna, golf and general PE). The highest body mass and BMI values at the beginning and end of the semester were reported in the bodybuilding/fitness group, and the lowest – in the group of participants who jogged and used a sauna. The tallest students played volleyball, and the shortest participants attended general PE classes.

At the end of the semester, students performing martial arts improved their results in 5 motor ability tests: medicine ball forward throw (p = 0.050), pull-ups on bar (0.0137), 1–minute and 3-minute Burpee tests (p = 0.0090 and p = 0.0005), and 12-minute Cooper test on a rowing ergometer (p = 0.0416). No significant differences between the results noted at the beginning and end of the semester were observed in the remaining 8 tests: standing long jump, 4×10 m shuttle run, skipping with hand clapping 8 s, zig-zag run, standing forward bend, barbell overhead trunk rotation, sit-ups 30 s, and medicine ball (4 kg) backward throw. In the bodybuilding/fitness group, an improvement in results was reported in the medicine ball (4 kg) forward throw test (p = 0.0033), whereas negative changes were observed in the following 6 trials: 4×10 m shuttle run (shorter time is a better result, p = 0.0275), skipping with hand clapping 8 s (p = 0.0118), standing forward bend (p = 0.0012), 1-minute and 3-minute minute Burpee tests (p = 0.0000 for both) and 12-minute Cooper test on a rowing ergometer (p = 0.0009). No significant differences in results were reported in the following tests: standing long jump, zig-zag run, barbell overhead trunk rotation, sit-ups 30 s, medicine ball backward throw, and pull-ups on bar (Table 2).

At the end of the semester, volleyball players improved their results in 5 motor ability tests: skipping with hand clapping 8 s (p = 0.0035), medicine ball (4 kg) backward (p = 0.0017) and forward (p = 0.0000) throw, and 1-minute and 3-minute Burpee tests (p = 0.0018 and p = 0.0007, respectively). No significant differences were reported in 7 tests: standing long jump, 4×10 m shuttle run, zig-zag run, barbell overhead trunk rotation, sit-ups 30 s, pull-ups on bar, and 12-minute Cooper test on a rowing ergometer. A significant deterioration in results was noted only in the standing forward bend trial (p = 0.0137). Students who jogged and used a sauna significantly improved their results in 4 tests: 4×10 m shuttle run (shorter time is a better result, p = 0.0169), zig-zag run (shorter time

Table 2. Average results of motor ability tests scored at the beginning and end of the semester by students enrolled in martial arts and golf classes.

Activity	Motor ability test	Beginning of semester	End of semester	(p)
		x̄ *SD* (min÷max)	x̄ *SD* (min÷max)	
Martial arts	Standing long jump	221.32 ± 17.70 (187÷265)	221.49±18.33 (180 ÷ 270)	ns
	4×10 m shuttle run	10.65 ± 0.72 (9.28÷12.84)	10.65±0.71 (9.28 ÷ 12.84)	ns
	Skipping with hand clapping 8 s	27.72 ± 3.13 (20÷34)	27.80±2.86 (20 ÷ 34)	ns
	Zig-zag run	25.35 ± 1.43 (21.45÷28.43)	25.34±1.48 (21.20 ÷ 28.60)	ns
	Standing forward bend	9.96 ± 5.46 (0÷24)	10.07±5.92 (-2 ÷ 26)	ns
	Barbell overhead trunk rotation	85.41 ± 11.24 (60÷112)	85.64±10.87 (60 ÷ 112)	ns
	Sit-ups 30 s	25.04 ± 2.88 (19÷34)	25.13±2.67 (19 ÷ 34)	ns
	Medicine ball backward throw	1038.10 ± 155.80 (720÷1550)	1038.67±163.87 (700 ÷ 1600)	ns
	Medicine ball forward throw	848.73 ± 153.18 (550÷1200)	854.46±142.41 (550 ÷ 1200)	0.0050
	Pull-ups on bar	5.75 ± 3.72 (0÷18)	5.95±3.51 (0 ÷ 18)	0.0137
	1-min Burpee test	25.39 ± 3.12 (20÷34)	25.68±2.78 (19 ÷ 34)	0.0090
	3-min Burpee test	53.38 ± 6.20 (43÷67)	53.87±5.75 (43 ÷ 69)	0.0005
	12-min Cooper test on rowing ergometer	2481.39 ± 241.87 (1900÷2950)	2487.28±231.58 (1900 ÷ 2950)	0.0416
Bodybuilding /fitness	Standing long jump	216.43 ± 15.77 (161÷245)	216.54±15.20 (161 ÷ 245)	ns
	4×10 m shuttle run	11.48 ± 0.99 (9.78÷14.45)	11.49±0.98 (9.78 ÷ 14.52)	0.0275
	Skipping with hand clapping 8 s	25.26 ± 2.54 (21÷30)	25.54±2.31 (20 ÷ 30)	0.0118
	Zig-zag run	25.94 ± 1.32 (23.79÷30.28)	25.92±1.30 (23.22 ÷ 30.28)	ns
	Standing forward bend	3.49 ± 3.35 (-3÷10)	3.11±3.98 (-6 ÷ 11)	0.0012
	Barbell overhead trunk rotation	93.70 ± 8.33 (79÷110)	93.94±8.67 (78 ÷ 112)	ns
	Sit-ups 30s	23.89 ± 3.95 (14÷31)	24.05±3.62 (14 ÷ 32)	ns
	Medicine ball backward throw	1107.92 ± 198.53 (100÷1550)	1122.03±181.19 (100 ÷ 1610)	ns
	Medicine ball forward throw	920.00 ± 155.71 (600÷1360)	928.02±145.57 (600 ÷ 1360)	0.0033
	Pull-ups on bar	3.92 ± 2.35 (0.00÷10)	4.08±2.21 (0 ÷ 11)	ns
	1-min Burpee test	24.04 ± 2.92 (14÷28)	23.42±3.28 (11 ÷ 29)	0.0000
	3-min Burpee test	45.60 ± 4.90 (37÷58)	44.16±5.07 (33 ÷ 58)	0.0000
	12-min Cooper test on rowing ergometer	2129.25 ± 209.03 (1650÷2500)	2117.45±218.27 (1550 ÷ 2500)	0.0009

Key: x̄ – arithmetic mean, ± – *SD* – standard deviation, max – maximum value, min – minimum value, *ns* – no significant differences, (p) - probability that the calculated chi-square value will be exceeded.

is a better result, p = 0.0133), and medicine ball (4 kg) backward (p = 0.0201) and forward (p = 0.0000) throw. No significant differences were observed in the remaining 9 tests: standing long jump, skipping with hand clapping, standing forward bend, barbell overhead trunk rotation, sit-ups 30 s, pull-ups on bar, 1-minute and 3-minute Burpee tests, and 12-minute Cooper test on a rowing ergometer (Table 3).

In the group of golf players, a significant deterioration in results was noted in the following tests: zig-zag run (shorter time is a better result, p = 0.0029), standing forward bend (0.0460), barbell overhead trunk rotation (p = 0.0094), sit-ups 30 s (p = 0.0138), medicine ball (4 kg) forward throw (p = 0.0105), pull-ups on bar (p = 0.0419) and 1-minute Burpee test (p = 0.0005). No significant variations in results were observed in the 6 remaining trials: standing long jump, 4×10 m shuttle run, skipping with hand clapping 8 s, medicine ball backward throw, 3-minute Burpee test, and 12-minute Cooper test on a rowing ergometer.

Students attending general PE classes significantly improved their results in 6 motor ability tests: standing long jump (p = 0.0413), medicine ball (4 kg) backward (p = 0.0000) and forward (p = 0.0006) throw, pull-ups on bar (p = 0.0000), and 1-minute and 3-minute Burpee tests (p = 0.0001 and p = 0.0041, respectively). No significant

Table 3. Average results of motor ability tests scored at the beginning and end of the semester by volleyball players and joggers.

Activity	Motor ability test	Beginning of semester	End of semester	(p)
		x̄ *SD* (min÷max)	x̄ *SD* (min÷max)	
Volleyball	Standing long jump	226.21 ± 14.69 (200÷256)	226.49±15.11 (193 ÷ 260)	ns
	4×10 m shuttle run	10.70 ± 0.68 (9.61÷12.87)	10.70±0.67 (9.61 ÷ 12.87)	ns
	Skipping with hand clapping 8 s	26.68 ± 2.18 (20÷32)	27.00±2.01 (20 ÷ 32)	0.0035
	Zig-zag run	25.69 ± 1.56 (21.12÷28.70)	25.66±1.50 (21.12 ÷ 28.70)	ns
	Standing forward bend	4.72 ± 2.84 (-2.00÷11.00)	4.47±3.19 (-5 ÷ 11)	0.0137
	Barbell overhead trunk rotation	87.38 ± 7.96 (74÷102)	87.66±7.54 (74 ÷ 102)	ns
	Sit-ups 30 s	22.47 ± 3.60 (13÷30)	22.66±3.2 (13 ÷ 30)	ns
	Medicine ball backward throw	1036.17 ± 171.70 (630÷1750)	1046.28±158.50 (630 ÷ 1750)	0.0017
	Medicine ball forward throw	824.68 ± 112.75 (590÷1070)	836.97±110.44 (590 ÷ 1100)	0.0000
	Pull-ups on bar	3.00 ± 2.10 (0÷7)	3.12±1.84 (0 ÷ 7)	ns
	1-min Burpee test	24.36 ± 3.48 (18÷34)	24.79±3.00 (18 ÷ 34)	0.0018
	3-min Burpee test	50.28 ± 7.19 (32÷67)	50.93±6.62 (32 ÷ 67)	0.0007
	12-min Cooper test on rowing ergometer	2302.34 ± 272.86 (1800÷3000)	2302.77±259.54 (1800 ÷ 3000)	ns
Jogging followed by sauna	Standing long jump	219.19 ± 25.52 (172÷265)	219.24±25.13 (171 ÷ 268)	ns
	4×10 m shuttle run	10.44 ± 0.82 (9.02÷12.06)	10.42±0.80 (9.02 ÷ 12.06)	0.0169
	Skipping with hand clapping 8 s	25.22 ± 3.88 (16÷38)	25.53±4.14 (16 ÷ 38)	ns
	Zig-zag run	25.38 ± 2.18 (22.06÷30.72)	25.31±2.19 (21.53 ÷ 30.80)	0.0133
	Standing forward bend	3.59 ± 3.75 (-3÷10)	3.80±3.66 (-3 ÷ 10)	ns
	Barbell overhead trunk rotation	82.59 ± 6.03 (72÷98)	82.78±6.46 (70 ÷ 99)	ns
	Sit-ups 30 s	24.14 ± 4.52 (10÷31)	24.12±4.55 (10 ÷ 31)	ns
	Medicine ball backward throw	995.81 ± 164.35 (580÷1240)	998.24±162.26 (580 ÷ 1260)	0.0201
	Medicine ball forward throw	856.49 ± 155.05 (520÷1200)	861.08±153.95 (520 ÷ 1220)	0.0000
	Pull-ups on bar	4.35 ± 2.45 (0÷9)	4.36±2.50 (-1 ÷ 10)	ns
	1-min Burpee test	25.76 ± 3.39 (18÷30)	26.07±3.24 (18 ÷ 30)	ns
	3-min Burpee test	56.24 ± 7.47 (28÷65)	56.34±6.80 (28 ÷ 66)	ns
	12-min Cooper test on rowing ergometer	2631.08 ± 222.16 (2200÷3100)	2637.16±224.79 (2150 ÷ 3150)	ns

Key: x̄ – arithmetic mean, ± – standard deviation, max – maximum value, min – minimum value, *ns* – no significant differences, (p) - probability that the calculated chi-square value will be exceeded.

differences were observed in 6 drills: 4×10m shuttle run (p=0.5348), skipping with hand clapping 8 s, zig-zag run, standing forward bend, sit-ups 30 s, and 12-minute Cooper test on a rowing ergometer. The students' results deteriorated significantly in the barbell overhead trunk rotation test (p = 0.0295) (Table 4).

Discussion

The observed differences in anthropometric indicators (body mass and body height), BMI scores and motor ability test results between the beginning and end of the semester varied across the evaluated activity groups and relative to the results for the entire analyzed population [24]. The results describing the entire population (without accounting for the type of physical activity) indicate that the participants' average body mass and BMI scores increased during the experiment. After attending PE classes for one semester, students performed significantly worse in 8 motor ability tests (sit-ups 30 s, skipping with hand clapping 8s, downward forward bend, 1-minute and 3-minute Burpee test, 12-minute Cooper test on a rowing ergometer, medicine ball (4 kg) forward throw, and pull-ups on bar). No significant differences in results were observed in the 5 remaining trials (standing long jump, zig-zag run, medicine ball (4 kg) backward throw, 4×10 m shuttle run and barbell overhead trunk rotation) [24].

Table 4. Average results of motor ability tests scored at the beginning and end of the semester by students enrolled in golf and general PE classes

Activity	Motor ability tests	Beginning of semester	End of semester	(p)
		x̄ *SD* (min÷max)	x̄ *SD* (min÷max)	
Golf	Standing long jump	212.28 ± 16.84 (180÷240)	211.60±17.60 (176 ÷ 245)	ns
	4×10 m shuttle run	11.49 ± 1.04 (10.12÷13.74)	11.52±1.01 (10.12 ÷ 13.79)	ns
	Skipping with hand clapping 8 s	23.14 ± 3.59 (13÷30)	23.22±3.81 (13 ÷ 30)	ns
	Zig-zag run	26.40 ± 1.49 (24.00÷31.03)	26.44±1.49 (23.97 ÷ 31.15)	0.0029
	Standing forward bend	4.14 ± 2.67 (-2÷10)	3.89±2.77 (-2 ÷ 10)	0.0460
	Barbell overhead trunk rotation	87.03 ± 10.97 (60÷102)	87.81±11.54 (60 ÷ 110)	0.0094
	Sit-ups 30 s	22.75 ± 3.95 (16÷30)	22.17±3.68 (16 ÷ 31)	0.0138
	Medicine ball backward throw	1006.94 ± 128.84 (780÷1270)	997.99±165.85 (100 ÷ 1270)	ns
	Medicine ball forward throw	878.06 ± 108.94 (640÷1110)	875.69±107.14 (640 ÷ 1110)	0.0105
	Pull-ups on bar	2.31 ± 1.74 (0÷8)	2.07±1.87 (0 ÷ 8)	0.0419
	1-min Burpee test	23.11 ± 3.71 (16÷30)	22.42±3.39 (16 ÷ 30)	0.0005
	3-min Burpee test	43.67 ± 4.50 (32÷51)	43.33±4.25 (32 ÷ 51)	ns
	12-min Cooper test on rowing ergometer	2149.72 ± 269.29 (1550÷2650)	2144.31±259.69 (1550 ÷ 2650)	ns
W-F	Standing long jump	211.10 ± 25.19 (156÷260)	212.55±24.87 (156 ÷ 270)	0.0413
	4×10 m shuttle run	10.83 ± 1.01 (9.34÷14.56)	10.86±1.00 (9.32 ÷ 14.58)	ns
	Skipping with hand clapping 8 s	26.65 ± 3.35 (16÷36)	26.66±3.38 (16 ÷ 38)	ns
	Zig-zag run	25.86 ± 2.13 (21÷30.07)	25.86±2.13 (21.00 ÷ 30.10)	ns
	Standing forward bend	3.83 ± 5.50 (-15÷16)	4.00±5.41 (-15 ÷ 17)	ns
	Barbell overhead trunk rotation	86.77 ± 12.04 (60÷120)	86.84±12.57 (60 ÷ 127)	0.0295
	Sit-ups 30 s	22.23 ± 4.06 (9÷29)	22.45±4.28 (9 ÷ 30)	ns
	Medicine ball backward throw	997.82 ± 177.55 (550÷1400)	1004.04±176.21 (550 ÷ 1430)	0.0000
	Medicine ball forward throw	831.15 ± 142.22 (510÷1300)	834.10±141.01 (510 ÷ 1310)	0.0006
	Pull-ups on bar	3.99 ± 3.51 (0÷12)	4.42±3.36 (0 ÷ 14)	0.0000
	1-min Burpee test	22.92 ± 4.27 (13÷30)	23.53±4.29 (13 ÷ 31)	0.0001
	3-min Burpee test	46.08 ± 8.70 (30÷62)	46.47±8.74 (30 ÷ 62)	0.0041
	12-min Cooper test on rowing ergometer	2270.51 ± 416.89 (1400÷2850)	2271.47±412.67 (1350 ÷ 2900)	ns

Key: x̄ – arithmetic mean, ± – standard deviation, max – maximum value, min – minimum value, *ns* – no significant differences, (p) - probability that the calculated chi-square value will be exceeded.

An analysis of results scored in various groups indicates that body height, body mass and BMI scores influenced the students' choice of physical activity. The tallest students had a preference for volleyball, whereas the shortest participants attended general PE classes. The heaviest students with the highest body fat percentage preferred bodybuilding/fitness, and the lightest participants with the lowest body fat percentage decided on jogging followed by sauna. Students with the highest BMI scores opted for bodybuilding/fitness workouts which are characterized by simple, isolated movements with added resistance. Participants in the upper limit of normal BMI chose golf and general PE classes which involve recreational activities of low (golf) and varied (general PE) intensity. Students with the lowest BMI scores (mid-range) had a preference for martial arts, volleyball and jogging with sauna, which are high-intensity activities [38]. Morphological fitness measures are often related to metabolic fitness components and body composition is often recognized as a component of health-related fitness [39]. A similar dependency is noted in motor fitness – individuals with higher motor ability levels may find it easier to be physically active and may be more inclined to engage in physical activity than their peers with lower levels of motor competence [40]. Our results validate the general rule that overweight or obese individuals are less physically active and, consequently, choose less intensive and less time-consuming activities, whereas slimmer subjects are more physically active and able to engage in high-intensity activities [39, 41, 42].

Strength-building exercises contribute to an increase in body mass [43], whereas aerobic workouts help burn adipose tissue and improve circulation and respiratory function [44]. Similar observations were made in our study where a significant increase in body mass between the beginning and end of semester was reported in students participating in bodybuilding/fitness activities, whereas a decrease in body mass was noted in volleyball players who, together with students involved in martial arts and jogging with sauna, where characterized by the lowest BMI scores.

The changes in motor ability levels observed during the summer semester were correlated with the type of physical activity. In the group of students performing martial arts, a significant improvement in results was observed in endurance tests (12-minute Cooper test on a rowing ergometer), strength-building tests (medicine ball forward throw), endurance and strength-building tests (1-minute and 3-minute Burpee tests) [45], whereas no significant changes were noted in speed, agility and flexibility drills. It should be noted, however, that martial arts students generally scored highest in motor ability tests at the beginning of the semester, therefore, the improvement noted at the end of the experiment was not as striking as that reported in the remaining groups. Volleyball players significantly improved their results in speed and agility tests (skipping with hand clapping 8 s), endurance and strength-building drills (1-minute and 3-minute Burpee tests) and strength-building trials (4 kg medicine ball backward and forward throw), whereas their sagittal spinal flexibility markedly deteriorated (standing forward bend). Joggers significantly improved their results in strength-building tests (4 kg medicine ball backward and forward throw) and speed and agility drills (zig-zag run). Only a minor improvement was noted in their endurance performance (12-minute Cooper tests on a rowing ergometer), but they clearly outpaced students from the remaining groups.

The motor abilities of students enrolled in golf and bodybuilding/fitness classes deteriorated in the highest number of trials. Golf players' results deteriorated significantly in 7 tests: sit-ups – 30 s, pull-ups on bar (strength-building), 1-minute Burpee test (endurance and strength-building), standing forward bend, barbell overhead trunk rotation (flexibility) and zig-zag run (speed and agility). The results scored by bodybuilding/fitness students deteriorated significantly in 6 trials evaluating endurance, speed, agility and flexibility. Strength-building exercises contributed to a significant improvement in results only in the medicine ball forward throw, whereas no significant changes were observed in the remaining trials of this category. The above results could indicate that golf and bodybuilding/fitness programs had been poorly designed or executed. Despite their specificity, golf and bodybuilding/fitness curricula should promote overall physical development and should include exercises targeting all motor abilities. Endurance exercises contribute to cardiorespiratory fitness, and they should be a part of every PE program, regardless of the chosen type of physical activity [46-48]. Despite the above, a drop in endurance test results was noted in several types of activities undertaken by the UWM students.

During the summer semester, students attended only fifteen 90-minute PE classes, held once a week, which could explain their low levels of physical activity. According to physical activity recommendations formulated by the World Health Organization (WHO) for aircrew members aged 18-64 years, moderate-intensity activities should be performed for minimum 150 minutes per week, and they can be replaced by high-intensity activities (which increase the heart rate, respiratory rate and precipitation levels) performed for minimum 75 minutes per week [48]. In an attempt to maximize the health benefits of physical activity, fitness experts recently suggested that the volume of moderate-intensity activities should be increased to 300 minutes and the volume of high-intensity activities – to 150 minutes per week. Exercises of the recommended length and intensity level improve muscle strength, respiratory and circulatory system function, and they reduce the risk of non-infectious chronic illnesses and depression [49].

In this study, the number of PE classes was insufficient to promote a significant improvement in test results, but other research has demonstrated that rowing for 500 m on an ergometer only once a week delivered numerous benefits for sedentary male students [50]. Interestingly, the cited study demonstrated that the participants were able to improve their rowing times only up to a certain level (5-6 training sessions), after which, their results ceased to improve. Twelve-station high intensity interval training (HIIT) consists of jumping jacks, wall sits, push-ups, abdominal crunches, chair step-ups, chair tricep dips, high-knee planks/running in place, lunges, push-ups with rotation, and side planks, were each exercise is performed for 30 seconds with 10 seconds of transition time between stations. The entire circuit is completed in approximately 7 minutes, and it can be repeated 2-3 times a day to lower body fat, increase insulin sensitivity, improve maximal oxygen consumption (VO_{2max}) and muscular fitness [44].

Practical applications

Despite a limited number of PE classes during the academic year (thirty 45-minute classes), university students can participate in various types of physical activities, some of which contribute to a significant improvement in motor abilities, whereas others do not result in any significant differences or even lead to a clear deterioration in motor abilities. Physical education teachers can strive to improve the students' motor fitness levels by encouraging them to participate in high-intensity workouts as part of general PE, martial arts, jogging and volleyball classes. The physical activity levels of university students have been deteriorating steadily in recent years, and PE teachers can influence students' self-determination through motivational strategies [51]. The results of this experiment indicate that a professionally guided university-level PE program can significantly improve the students' agility, endurance, strength, coordination, flexibility, and lower their body fat percentage (BMI). Workouts that produce poor results or lead to a deterioration in general motor ability levels should be carefully revised and improved. Our results can be used to design a new PE program within the allocated number of class hours, where the rigid system of fifteen 90-minute weekly classes can be replaced with more flexible and attractive options. High-intensity workouts could be split into 30- to 60-minute training sessions held more than once a week, whereas 90-minute classes could be held at the end of the semester when the participants' motor fitness levels have improved. The results of this study can also be used to develop motor fitness standards for university students.

Limitations

International classification standards have not been developed for several tests in the applied battery of 13 motor ability tests, therefore, the students' average fitness levels in all tests (total T-score) or selected drills could not be evaluated. An extended number of tests was designed for a more reliable assessment of specific motor abilities. The study was performed on the assumption that fifteen 90-minute PE classes per semester (5 months) are not sufficient to induce not only a significant improvement but an adequate improvement in the students' motor fitness levels. Coordination abilities were evaluated in only one test, skipping with hand clapping [52], and additional coordination trials could not be incorporated into the study due to time constraints. The study was performed only in the UWM in Olsztyn, and the evaluated population included only male students performing six types of physical activities because the instructors teaching basketball, soccer and swimming classes refused to participate in the study.

Conclusions

In this study, sedentary male students' choice of physical activity was correlated with their body height, body mass, BMI and motor fitness. Participants with higher body mass and higher BMI scores opted for less intensive forms of physical activity (golf, bodybuilding/fitness), whereas slimmer students selected activities characterized by a higher level of intensity (general PE, martial arts, jogging followed by sauna, and volleyball). Differences in body mass, BMI and motor abilities at the beginning and at the end of the semester were determined by the type of performed activity. In most motor ability tests, a significant improvement in motor abilities was observed in students who had participated in general PE classes, martial arts, jogging with sauna, and volleyball, which suggests that those physical activities had the most profound influence on the participants' motor fitness. Future research should incorporate other types of physical activities as well as students from other Polish and foreign universities. The results can be used to develop international motor fitness standards for university students.

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