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Obesity indicators among 7–9 year-old girls and boys in view of diversified physical activity: a two-year study

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Wskaźniki otyłości wśród dziewcząt i chłopców w wieku 7–9 lat w świetle zróżnicowanej aktywności fizycznej: badania dwuletnie

Streszczenie

Wobec negatywnych skutków niskiej aktywności fizycznej, w pracy przedstawiono wartości (oraz przyrosty) poszczególnych cech somatycznych i wskaźników proporcji ciała uznawanych za wyznaczniki nadwagi i otyłości wśród dziewcząt i chłopców w wieku 7–9 lat w świetle zróżnicowanej aktywności ruchowej. Materiał badawczy stanowią wyniki dwuletnich badań dziewcząt i chłopców w wieku 7–9 lat. W badaniach wzięło udział łącznie 253 uczniów: 167 uczniów klas ogólnych – niesportowych (75 dziewcząt i 92 chłopców) oraz 86 uczniów z klas sportowych – klas o profilu akrobatyka sportowa (50 dziewcząt i 36 chłopców). W ramach badań przeprowadzono 3 serie po-

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miarów, które obejmowały dwuletni okres edukacji wczesnoszkolnej. Dokonano pomiarów wysokości i masy ciała, obwodu talii, obwodu bioder oraz grubości czterech fałdów skórno-tłuszczowych. W oparciu o wyniki pomiarów antropometrycznych wyliczono wskaźniki proporcji ciała (BMI, WHR, WHtR). W analizowanym okresie ontogenezy (7–9 lat) uczniowie z klas ogólnych na tle sportowych wyróżniają się większymi parametrami wskaźników otyłości, zwiększającymi ryzyko zachorowania na choroby metaboliczne. Dzieci z klas ogólnych relatywnie do sportowych charakteryzują się przeciętnie większym wskaźnikiem BMI, obwodem talii i bioder, grubością fałdów skórno-tłuszczowych, wskaźnikiem WHtR.

Słowa kluczowe: otyłość, klasy sportowe, aktywność fizyczna, rozwój.

Abstract

Considering the negative effects of low physical activity, this study presents the values (and increases) of individual somatic features and body proportion indicators considered to be determinants of being overweight and obese among the examined girls and boys in view of differentiated physical activity. The research material includes the results of a two-year study of girls and boys aged 7–9. It involved 253 pupils: 167 from general classes and 86 from sports classes (sports acrobatics classes). Three series of measurements were carried out, covering a 2-year period of early primary education. As part of the research, measurements of body height and mass, waist circumference, hip circumference and the thickness of skin and fat folds were measured. The body proportions were calculated based on anthropometric measurements. In the analyzed period of ontogenesis (ages 7–9), pupils from general classes, when compared to those from sports classes, were distinguished by higher parameters of obesity indicators, increasing the risk of developing metabolic diseases. Children from the general classes, in contrast to those from the sports ones, were characterized by a higher Body Mass Index, waist and hip circumference, thickness of skin and fat folds, and waist-to-height ratio.

Keywords: obesity, sports classes, physical fitness, development.

Introduction

Overweight and obesity among children and adolescents have become serious public health problems in developed and developing countries. The prevalence of obesity in children and adolescents has increased dramatically. According to WHO data, in 2016, overweight or obesity was reported in over 380 million children and adolescents (aged 5–19) worldwide [46].

Obesity is directly related to many diseases such as type 2 diabetes, hypertension, coronary artery disease, nonalcoholic liver disease, chronic kidney disease, dyslipidemia, and cancer [6, 28]. Obesity also causes psychological problems and may lead to depression [38]. Childhood and adolescent obesity continue into adulthood [34, 28] and are causes of premature death [21]. A meta-analysis has shown that obese children have a five times higher risk of becoming obese in adult life than children with normal weight [42]. In another study, approximately 80% of adolescents with obesity remained obese in adulthood [14].

The growing percentage of overweight and obese people is becoming a serious medical, social, economic, personal, and family problem [35]. The causes of the overweight and obesity epidemic are very complex, but it should be borne in mind that one of the main reasons (along with improper nutrition, genetic conditions, etc.) is a low level of physical activity [35]. Unfortunately, according to a WHO report, three out of four teenagers (aged 11–17) worldwide do not meet WHO recommendations for physical activity. In Poland, according to the HBSC report [30], only 17.2% of young people aged 11-15 meet the recommendations for moderate physical activity, which is less than one-fifth of the surveyed population. Comparing the data obtained in the last two series of studies (from 2014 and 2018), a clear negative trend was observed in the decrease in the percentage of young people meeting the WHO recommendations regarding moderate physical activity, from 24.2% in 2014 to 17.2% in 2018.

The complexity of the factors in the development of overweight and obesity among children and adolescents leads to difficulties in the treatment of these demographic groups. Numerous preventive programs for childhood and adolescent obesity have been ineffective [28]. Research indicates that in preventing obesity in children (ages 6–12), focusing on activities related to physical activity may reduce the risk of reaching critical BMI values, but there is no conclusive evidence that activities focusing solely on diet are effective in this regard [7].

Early identification and prevention are the key to controlling the global obesity epidemic. Considering that the percentage of overweight children and adolescents is much higher than the percentage of obese children and adolescents, it seems reasonable to focus on overweight people who are at risk of developing obesity in the future [28]. Hence, the aim of this study was to present the values (and increments) of individual somatic features and body proportion indicators considered to be determinants of overweight and obesity among girls and boys (aged 7, 8, and 9) from general classes compared to girls and boys with a lot of physical activity (studying in sports classes).

Material and methods

Participants

The research material consists of the results of a two-year study of girls and boys aged 7–9. The study involved the purposeful selection of the research group. Schools from Western Polish towns and cities where sports acrobatics classes were conducted were selected. The research was conducted in Zielona Góra, Sulechów, Jawor, and Poznań. In the sports classes examined, the weekly number of hours spent on sports activities was 10. Additionally, students from these classes had two hours of physical education with their form teacher to implement the content of the core curriculum, while in general (non-sports) classes, students had three hours of physical education per week.

A total of 253 students participated in the study. The research included 167 pupils from general, non-sports classes (75 girls and 92 boys) and 86 pupils from sports classes – sports acrobatics profile (50 girls and 36 boys). In general classes, the basic physical education curriculum was followed with the number of three hours a week, while in sports classes, students followed an extended physical education program with the amount of 10 hours of training classes per week (in accordance with the Regulation of the Minister of National Education of March 27 2017 on sports classes and schools as well as sports championship classes and schools [37].

The calendar age was calculated for each respondent using the decimal system [15]. As part of the study, three series of measurements were carried out, covering a 2-year period of early childhood education (grades 1–3 of primary school). The research was initiated in September 2017, when students started their first year of primary school, then in September 2018 (in the second year of primary school) and in September 2019 (at the beginning of the third year of primary school). The research protocol was approved by the Bioethics Committee of the Regional Medical Council in Zielona Góra (Bioethics Committee Resolution No. 17/82/2017 of 17 July 2017).

Measurements

As part of the research, measurements of body height and weight, waist circumference, hip circumference and the thickness of four skin and fat folds (on the abdomen, on the iliac crest, on the shoulder, at the lower angle of the scapula) were measured. The following body proportions were calculated based on anthropometric measurements: Body Mass Index (BMI, [kg]), body height [m], waist circumference (WHR), and waist circumference (WHtR) [47,17,23,18].

Data analysis

The arithmetic means (M), standard deviations (SD) of the examined features, and calculated body proportion indicators were calculated. The levels of the tested features of girls and boys from sports classes were compared against the background of their peers from general classes. The Student's t-test (t) was used to determine the significance between the mean values of the studied features [1,43]. Moreover, the average increases in the examined somatic traits between 7–8, 8–9 and 7–9 years of age among the examined girls and boys from sports and general classes were presented. To determine the influence of physical activity on the development of individual somatic features and body proportion indices, a two-factor analysis of variance with repeated measures was applied (η_p^2).

Results

Girls from sports classes in all series of measurements were, on average, shorter than their peers from general classes, with statistically insignificant differences (Table 1). During the 2-year observation period, the height gain in the acrobats was 11.67 cm, compared to 10.93 cm in the non-training girls (Table 2). In contrast to the female teams under investigation, the boys from sports classes were, on average, taller than their peers from general classes, with statistically insignificant differences (Table 1). During the 2-year observation period, the increase in body height was 11.83 cm in the acrobats and 11.16 cm in the boys from the general classes (Table 2).

Table 1. Numerical characteristics of somatic features and body proportions indices of the examined girls and boys aged 7, 8, 9

		Girls (n = 125)			**Boys (n = 128)**		
Feature	Age	sports classes (n = 50)	general classes (n = 75)	t	sports classes (n = 36)	general classes (n = 92)	t
		M ± SD	M ± SD		M ± SD	M ± SD	
Body height [cm]	7	122.39 ± 4.92	123.69 ± 6.39	−1.30	125.77 ± 6.43	125.65 ± 5.18	0.12
	8	128.10 ± 5.11	128.81 ± 6.62	−0.71	131.64 ± 6.79	131.03 ± 5.22	0.60
	9	134.06 ± 5.43	134.62 ± 6.73	−0.56	137.60 ± 6.92	136.81 ± 5.31	0.80
Body mass [kg]	7	23.99 ± 4.58	25.70 ± 5.39	−1.72	25.21 ± 4.31	25.68 ± 3.64	−0.47
	8	26.80 ± 4.80	28.81 ± 5.92	−2.01*	28.06 ± 4.66	29.62 ± 4.60	−1.56
	9	30.06 ± 5.28	32.85 ± 6.52	−2.78*	32.11 ± 5.13	34.16 ± 5.24	−2.05*
BMI	7	15.91 ± 2.10	16.67 ± 2.32	−0.76	15.84 ± 1.70	16.20 ± 1.41	−0.36
	8	16.24 ± 1.99	17.24 ± 2.41	−1.00*	16.10 ± 1.67	17.19 ± 1.92	−1.08**
	9	16.63 ± 2.00	18.00 ± 2.41	−1.37**	16.87 ± 1.70	18.19 ± 2.04	−1.31**
Waist circumference [cm]	7	54.33 ± 5.49	55.56 ± 6.18	−1.23	56.72 ± 5.21	57.75 ± 6.45	−1.03
	8	55.76 ± 5.36	57.92 ± 6.18	−2.16*	58.35 ± 5.36	59.83 ± 6.57	−1.47
	9	57.84 ± 5.54	60.30 ± 6.16	−2.46*	60.05 ± 5.47	62.59 ± 6.87	−2.55
Hip circumference [cm]	7	64.84 ± 5.76	66.05 ± 5.60	−1.21	65.98 ± 4.54	67.01 ± 5.04	−1.03
	8	66.96 ± 5.81	69.39 ± 5.48	−2.43*	67.96 ± 5.03	69.37 ± 5.45	−1.41
	9	70.11 ± 5.83	72.82 ± 5.78	−2.70*	70.65 ± 4.98	72.82 ± 5.75	−2.18
WHR	7	0.84 ± 0.05	0.84 ± 0.07	0.00	0.86 ± 0.06	0.86 ± 0.06	0.00
	8	0.83 ± 0.05	0.84 ± 0.07	−0.01	0.86 ± 0.06	0.86 ± 0.06	0.00
	9	0.83 ± 0.04	0.83 ± 0.06	0.00	0.85 ± 0.05	0.86 ± 0.06	−0.01

Table 1. Numerical characteristics of somatic features… (cont.)

		Girls (n = 125)			Boys (n = 128)		
Feature	Age	sports classes (n = 50)	general classes (n = 75)	t	sports classes (n = 36)	general classes (n = 92)	t
		M ± SD	M ± SD		M ± SD	M ± SD	
WHtR	7	0.44 ± 0.04	0.45 ± 0.04	−0.01	0.45 ± 0.03	0.46 ± 0.05	−0.01
	8	0.44 ± 0.03	0.45 ± 0.04	−0.01*	0.44 ± 0.03	0.46 ± 0.04	−0.01
	9	0.43 ± 0.03	0.45 ± 0.04	−0.02*	0.44 ± 0.03	0.46 ± 0.04	−0.02*
The sum of 4 folds [mm]	7	33.91 ± 14.77	37.46 ± 20.19	−3.54	31.95 ± 15.46	35.06 ± 19.21	−3.12
	8	34.07 ± 14.96	39.53 ± 21.49	−5.45	31.96 ± 15.58	37.26 ± 20.25	−5.30
	9	35.72 ± 15.97	43.50 ± 22.55	−7.78*	33.04 ± 13.88	41.12 ± 21.86	−8.08*

BMI: Body Mass Index, WHR: Waist-to-hip ratio, WHtR: Waist-to-height ratio

* statistically significant differences at $p \leq 0.05$
** statistically significant differences at $p \leq 0.01$

With regard to body weight, it was noted that both the girls and boys from sports classes in each series of measurements (between 7-9 years of age) were, on average, lighter than their peers from general classes. With each consecutive year, the differences in body weight between the teams from the sports and general classes increased (Table 2). In the examined girls, in the first series of measurements (the age of 7), there were no statistically significant differences between the average body weight, while in the second (the age of 8) and the third series (the age of 9), statistical significance at the level of $p<0.05$ was noted (Table 1). In the girls from sports classes, the annual weight gain in the first period of the study was 2.82 kg, while in the girls from general classes it was 3.11 kg. In the second series of tests, the acrobats gained 3.26 kg on average, and their non-training peers 4.04 kg. During the 2-year observation period, girls from sports classes increased their body weight by 6.08 kg, while their peers gained 7.14 kg. (Table 2). In the examined boys, statistically significant differences between average body weight were noted in the third series of measurements (the age of 9). In the boys from sports classes, the annual weight gain in the first period of the study was 2.8 kg, and in the boys from general classes, it was 3.94 kg. In the second series of tests, the acrobats gained 4.05 kg on average, and their non-training peers 4.54 kg. (Table 1.) During the 2-year observation period, the weight gain in the boys from sports classes was 6.90 kg, and 8.48 kg in their peers (Table 2).

Table 2. Characteristics of somatic increments in examined girls and boys

Feature	period	Girls (n=125) sports classes (n=50) increase	Girls (n=125) general classes (n=75) increase	t	Boys (n=128) sports classes (n=36) increase	Boys (n=128) general classes (n=92) increase	t
Body height [cm]	7–8	5.71 ± 0.59	5.12 ± 0.47	6.20**	5.87 ± 0.91	5.39 ± 0.63	3.40**
	8–9	5.96 ± 0.82	5.81 ± 0.68	1.10	5.96 ± 0.74	5.77 ± 0.83	1.22
	7–9	11.67 ± 1.27	10.93 ± 0.77	4.04**	11.83 ± 1.06	11.16 ± 1.13	3.09**
Body mass [kg]	7–8	2.82 ± 1.00	3.11 ± 1.13	−1.47	2.85 ± 1.14	3.94 ± 1.89	−3,24**
	8–9	3.26 ± 1.19	4.04 ± 1.09	−3,78**	4.05 ± 1.27	4.54 ± 1.18	−2.07*
	7–9	6.08 ± 1.80	7.14 ± 2.00	−3.04**	6.90 ± 1.95	8.48 ± 2.66	−3.23**
Waist circumference [cm]	7–8	1.44 ± 0.89	2.36 ± 0.38	−8.01**	1.63 ± 1.37	2.07 ± 0.62	−2.50*
	8–9	2.08 ± 0.60	2.38 ± 0.75	−2.34*	1.69 ± 0.88	2.77 ± 0.90	−6.10**
	7–9	3.51 ± 1.37	4.74 ± 1.10	−5.53**	3.33 ± 1.92	4.84 ± 1.52	−4.69**
Hip circumference [cm]	7–8	2.12 ± 0.78	3.34 ± 0.95	−7.58**	1.97 ± 1.64	2.36 ± 0.76	−1.80
	8–9	3.15 ± 1.86	3.42 ± 1.05	−1.05	2.69 ± 1.39	3.45 ± 1.26	−2.98**
	7–9	5.27 ± 1.98	6.77 ± 1.36	−5.01**	4.66 ± 1.93	5.81 ± 1.51	−3.56**
The sum of 4 folds [mm]	7–8	0.16 ± 0.59	2.07 ± 4.69	−2.87**	0.01 ± 0.44	2.19 ± 3.37	−3.86**
	8–9	1.65 ± 4.27	3.98 ± 2.53	−3.83**	1.08 ± 3.87	3.87 ± 3.13	−4,22**
	7–9	1.80 ± 4.29	6.05 ± 5.61	−4.54**	1.09 ± 3.74	6.06 ± 5.27	−5.16**

BMI: Body Mass Index, WHR: Waist-to-hip ratio, WHtR: Waist-to-height ratio

* statistically significant differences at $p \leq 0.05$
** statistically significant differences at $p \leq 0.01$

Large differences between the teams from sports and general classes were noted in the waist and hip circumferences. Girls and boys from sports classes, compared to girls and boys from general classes, were characterized by smaller waist and hip circumferences in all series of measurements. In the girls, statistically significant differences between the average waist and hip circumferences were recorded in the second (age 8) and third series of measurements (age 9), while in the boys in the third series of measurements (age 9). Each year, the differences in waist and hip circumference between teams from sports and general classes increased. In the two-year observation period (the ages between 7–9), the increase in hip circumference among the training girls was 5.27 cm, and 6.77 cm in the non-training girls, while the increase in waist circumference in the acrobats was 3.51 cm and 4.74 cm in their peers (Table 2). During the two-year observation period, the increase in hip circumference in the training boys was 4.66 cm, and 5.8 cm in the non-training boys, while the increase in waist circumference in the acrobats was 3.33 cm, and 4.84 cm in their peers (Table 2).

With regard to the thickness of the skin and fat folds, in the first series of measurements (the age of 7), no statistically significant differences were found between the teams from sports and general classes. However, in the next year (the age of 8), the differences became more visible, and in the third series of measurements (following two years of observation, at the age of 9), statistically significant differences in the total thickness of four skin and fat folds were noted. Annual increases in the thickness of the skin and fat folds were greater in the case of students from general rather than sports classes. During the two-year observation period, the average increase in the thickness of 4 folds in the training girls was 1.80 cm, and 6.05 cm in the non-training ones, while in the boys from sports classes – 1.09 cm, and 6.06 cm in their peers from general classes (Table 2).

Based on the examined features, body proportions were calculated. The BMI, both among the girls and boys from sports classes, was, on average, lower than that of their peers from general classes. In the first series of measurements (the age of 7), no statistically significant differences were recorded, but from year to year, the differences in the level of this indicator increased. In the 2^{nd}, and 3^{rd} series of studies (ages 8 and 9), some statistically significant differences were noted (Table 1).

As for individual assessment, cases of overweight and obese people were reported (based on the criteria of the International Obesity Task Force) [10,11]. This phenomenon concerns, to a greater extent, the pupils from general rather than sports classes. In the first series of measurements (the age of 7), in sports classes, the number of persons who were overweight or obese accounted for 13.96% of all students in these classes, while in general classes, it was 20.36%. In the second series of measurements (the age of 8), the percentage of overweight and obese students (11.63%) among the sports class students decreased, while in general classes, it increased to 25.74%. In the following year, there was an increase in the number of overweight and obese people in both sports and general classes. At the age of 9, the proportion of overweight or obese students in sports classes was 12.78%, while in general classes, it reached 28.74% (Figure 1).

The WHR index did not show much differentiation between teams in sports and general classes. There were no statistically significant differences in the average values for this indicator. The WHtR index, as opposed to the WHR index, revealed differentiation between teams from sports and general classes. With regard to this indicator, in the first series of measurements (the age of 7), no statistically significant differences were found between the teams from sports and general classes, while statistical significance was noted in the second series of studies (the girls) and the third series of studies (the girls and boys). Higher WHtR values were observed in the groups from general classes (Table 1).

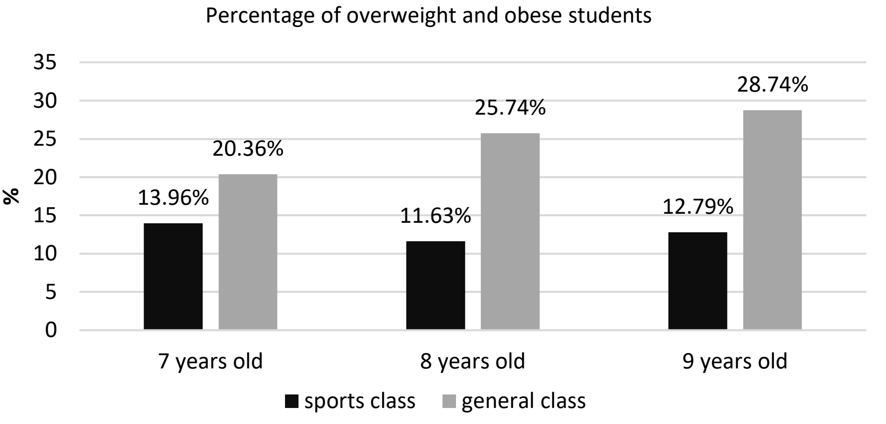

Figure 1. Percentage of overweight and obese students in general and sports classes at the age of 7, 8, 9

When assessing the impact of physical activity on the development of individual features and indicators of body proportions, a two-factor analysis of variance was used, and 'class' (i.e., sports class or general class) was adopted as the factor determining the level of physical activity.

Regarding the eta-square partial analysis (η_p^2, Table 3), it was noted that the development of each examined feature and each body proportion indicator was more influenced by 'time,' i.e., the age of those examined (7, 8, 9 years old), than the 'class' factor (sports or general classes).

Table 3. Partial eta-square analysis (η_p^2) for somatic features and indicators of body proportions of the examined girls and boys

Girls (n = 125)				**Boys (n = 128)**			
Class		Time		Class		Time	
Feature	(η_p^2)	Feature	(η_p^2)	Feature	(η_p^2)	Feature	(η_p^2)
BMI	0.05*	Body height	0.99**	BMI	0.06**	Body height	0.99**
Body mass	0.04*	Waist circ.	0.91**	WHtR	0.02	Body mass	0.87**
Hip circ.	0.03*	Body mass	0.91**	Body mass	0.02	Hip circ.	0.86**
Waist circ.	0.02	Hip circ.	0.90**	Hip circ.	0.02	Waist circ.	0.82**
WHtR	0.02	BMI	0.48**	4 folds	0.02	BMI	0.53**
4 folds	0.02	4 folds	0.32**	Waist circ.	0.01	4 folds	0.28**
Body height	0.00	WHtR	0.28**	Body height	0.00	WHtR	0.27**
WHR	0.00	WHR	0.16*	WHR	0.00	WHR	0.04**

BMI: Body Mass Index, WHR: Waist-to-hip ratio, WHtR: Waist-to-height ratio

* statistically significant differences at $p \leq 0.05$
** statistically significant differences at $p \leq 0.01$

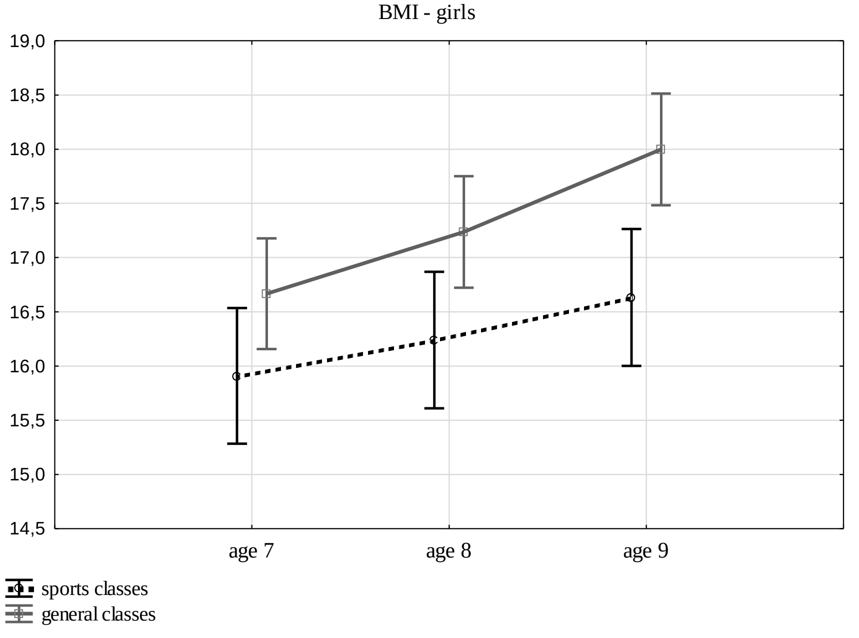

Figure 2. Graphical depiction of the two-way analysis of variance for the BMI indicator of the examined girls

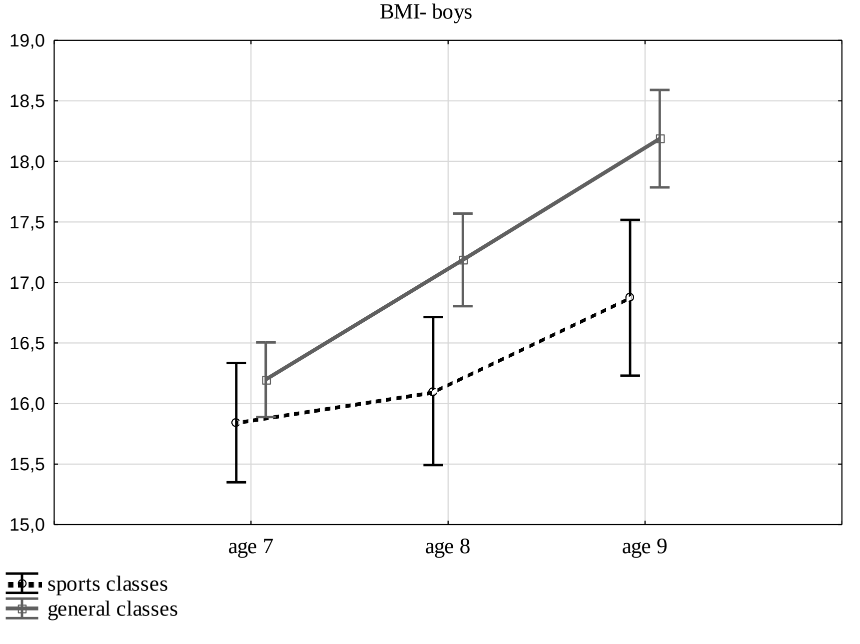

Figure 3. Graphical depiction of the two-way analysis of variance for the BMI indicator of the examined boys

In the girls, physical activity (class) had a significant impact on BMI, body weight, and hip circumference, while time had a significant impact on all variables, with the greatest impact on body height, waist circumference, and body weight (Table 3). Among the boys, physical activity (class) had a significant influence on BMI. Time had a significant impact on all variables, with the greatest effect on body height, weight, and hip circumference (Table 3).

Discussion

In both sports and general classes, the majority of students were characterized by the correct weight-to-height ratio (based on the classification of Cole et al. 2000, 2007) [10, 11]. However, the varying level of physical activity between sports and general class teams resulted in a greater increase in the number of overweight and obese students among the non-sports class students.

These results partially confirm this secular trend. The results of research in recent years indicate a dynamic increase in height and weight in the 80s and 90s, while a slowdown in the secular trend has been noted in the last decade [2, 4, 45]. According to the authors, significant weight gain accompanied by lower body height gains (for most age ranges) is a disturbing phenomenon. It reflects the tendency to increase body build (an increase in BMI) and attests to an increase in the percentage of overweight and obese children [2, 45].

The health risk of obesity depends not only on excess body fat but also on its location. Abdominal obesity (android type) is associated with an increased cardiovascular risk and the occurrence of metabolic syndrome [13, 25, 36]. Waist circumference is independent of BMI and is a better measure of abdominal obesity in some cases [12, 24, 26, 31, 32, 40]. Waist and hip circumferences are among the basic anthropometric parameters, and their measurement is of fundamental importance in the diagnosis of obesity and assessment of adipose tissue distribution [12, 32, 16]. Until recently, there were no nationwide anthropometric studies allowing for the development of waist and hip percentile grids representative of the Polish population. It is assumed that a waist circumference exceeding the 95th percentile is the basic diagnostic criterion for metabolic syndrome. The development of the waist and hip percentile grids was undertaken by researchers from the Institute of the Children's Memorial Health Institute as part of the OLAF-PL0080 research project: „Development of blood pressure standards for the population of children and adolescents in Poland" [27].

Comparing the results of our own research against the standards from the OLAF-PL0080 project, it was noted that the average waist and hip circumferences of the surveyed students from general and sports classes were within the range of M±1 SD (despite the fact that the studies were conducted more than

10 years apart). Nevertheless, the average waist and hip circumferences of the girls from sports classes were below the average values, whereas those from general classes were above the average values of the OLAF project. Moreover, the average waist and hip circumferences of the girls and boys from general classes reflected the average for the higher age categories in the OLAF-PL0080 project [27]. The waist-to-hip ratio (WHR) was calculated based on waist and hip measurements [15, 25, 35]. There were no WHR reference values for children and adolescents. Moreover, the clinical usefulness of measuring WHR has declined in recent years owing to its weaker association with cardiovascular and metabolic risk factors compared to other clinical measures of obesity [16]. According to some researchers, waist circumference as a measure of abdominal obesity correlates with cardiovascular risk more than WHR [26, 31, 32]. Our research also indicates a low diagnostic value for WHR. Although there were statistically significant differences in waist and hip circumferences between sports teams and general classes (in the 2nd and 3rd series of studies in the girls, in the 3rd series of studies in the boys), there were no statistically significant differences between the mean WHR index. This can be explained by the fact that in the early school period, slim children are characterized by narrow hips and slight differences in the proportions of hip circumference in relation to waist size (the WHR is high). Especially in pre-pubertal girls who do not yet have a fully developed pelvis, WHR may incorrectly suggest abdominal obesity. Perhaps, the WHtR index, which determines the ratio of waist circumference to body height, will be of greater diagnostic value for children at that developmental age. As for this indicator, significant differences were noted between the teams from sports and general classes after one year of research for the girls and two years of observation for the boys.

The waist circumference-to-height ratio (WHtR) has recently been suggested as an effective anthropometric index for assessing abdominal obesity [22, 19] correlated with cardiovascular risk factors. The WHtR is also independent of age and sex percentiles in pediatric patients. Studies suggest that WHtR is an easier, faster, and more sensitive screening indicator than BMI and WC for detecting obesity and related metabolic disorders in children and adolescents [3, 16]. The variability of abdominal adipose tissue distribution in girls from sports and non-sports classes aged 9-16 years was assessed by Sudera et al. [44]. Based on these results, it was found that girls from sports classes differed in the mean values of waist circumference, WHtR, and plasma leptin and ghrelin levels (despite the lack of significant differences in height and weight).

There is consensus that body fat and its anatomical distribution are separate or independent factors [9]. Studies on the distribution of adipose tissue indicate that some metabolic disorders show much more direct and stronger relationships with the distribution of adipose tissue than with the degree of adiposity

[20, 5, 39, 29]. According to the authors, the measurement of the thickness of the skin and fat folds (as a measure of fatness independent of the BMI and the circumference of the waist and hips) is of the greatest usefulness in screening for obesity in some age and sex groups of children and adolescents [41]. In relation to our own research, a significant variation was observed in the thickness of the skin and fat folds, as well as in the annual increments between the teams from sports and general classes, which points to a significant influence of physical activity on the shaping of this body component.

Research shows that the students from general classes, compared to sports classes, are distinguished by higher parameters of obesity indicators, increasing the risk of developing metabolic and cardiovascular diseases [8, 33, 25]. The children from general classes, unlike those from sports classes, are characterized by a higher BMI, waist and hip circumference, thickness of skin and fat folds, and WHtR index. Although in the research (at the stage of early childhood education) the average results did not reach the critical values, the gains in these traits were greater in the children from general classes than in the children from sports classes. This suggests negative health effects in the future.

Based on the presented results, it is possible to consider the reason for this phenomenon. Since children and adolescents spend a significant part of their time at school, does the Polish education system create appropriate conditions for physical activity? This problem may be due to the low number of hours of physical education in schools. In the Polish education system, children in grades 1–3 take 3 lessons in physical education per week. What is 135 minutes of physical activity per week compared with the WHO recommendation of 60 minutes a day? It is different in sports classes. Students in these classes had a minimum of 10 lesson hours of sports activities per week, thus fulfilling the WHO recommendations for the hourly amount of physical activity.

In light of the research results and opinions of many teachers, trainers, and parents, the number of hours of physical education is insufficient. Another (yet equally important) aspect is the quality of physical education classes in grades 1–3, which are conducted by early school education teachers rather than qualified physical education teachers. Currently, students are less likely to engage in spontaneous physical activity. Therefore, teachers, trainers, and instructors face an extremely important task: encouraging schoolchildren and youth to participate in organized sports and recreational activities.

Limitations

The limitation of this study lies in the fact that in individual acrobatic classes from different Polish towns and cities, sports training is somewhat different, as is enrolment in these classes. Hence, the training intensity may differ between individual classes. In general classes, on the other hand, there are people who participate in extracurricular sports activities, and their level of physical activity is high. The limitations of this study include the small number of boys, so the research should be extended to more sports schools from other regions of the country. It also seems justified to conduct a larger number of studies that would show the development of physical fitness of the studied students over a longer period of time.

Conclusions

In the analyzed period of ontogenesis (7–9 years), the girls and boys from general classes were distinguished by higher parameters of obesity indicators against the background of sports ones, increasing the risk of developing metabolic and cardiovascular diseases. The children from general classes, in contrast to those from sports ones, are characterized by a higher BMI, waist and hip circumference, thickness of skin and fat folds, and WHtR index. Although in the research (at the stage of early childhood education) the average results did not show critical values, the gains in these traits were greater in the children from general classes than in the children from sports classes. This could result in negative health effects in the future. The health and development values of physical activity, and in particular of organized forms of systematically conducted sports activities, remain fundamental arguments in favor of undertaking it at an increasingly younger age. Therefore, it is important to increase the number of hours of physical education in grades 1–3 of primary school.

Statement of Ethics

This study was conducted in accordance with the World Medical Association Declaration of Helsinki. The study protocol was reviewed and approved by the Bioethics Committee of the Regional Medical Council in Zielona Góra (Bioethics Committee Resolution No. 17/82/2017 of 17th July 2017). All participants provided written informed consent to participate in this study.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interests with respect to the research, authorship, and/or publication of the article *Obesity indicators among 7–9 year-old girls and boys in view of diversified physical activity: a two-year study.*

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References

[1] Arska-Kotlińska M., Bartz J., Wieliński D. (2002): *Wybrane zagadnienia statystyki dla studentów studiujących wychowanie fizyczne*, 3 wyd. zmienione i poprawione. Skrypt nr 85 [*Selected statistical issues for students studying physical education. 3rd ed. changed and amended*]. Script Textbook, no. 85.] Poznań University of Physical Education.

[2] Asienkiewicz R., Tatarczuk J. (2018): *Tendencje zmian w rozwoju fizycznym dzieci i młodzieży wiejskiej Ziemi Lubuskiej w wieku 7–18 lat* [*Tendencies of changes in the physical development of children and youth from the rural area of Lubusz Region at the age of 7–18*]. [in:] Asienkiewicz R., Tatarczuk J. (ed.), Rocznik Lubuski [Lubusz Yearbook], vol. 44, part 2a. Lubuskie Towarzystwo Naukowe. Zielona Góra, pp. 155–171.

[3] Baioumi A.Y.A.A. (2019): *Comparing Measures of Obesity: Waist Circumference, Waist-Hip, and Waist-Height Ratios*. [in:] Watson R.R. (ed.), *Nutrition in the Prevention and Treatment of Abdominal Obesity*. Academic Press, pp. 29–40; https://doi.org/10.1016/B978-0-12-816093-0.00003-3.

[4] Bartkowiak S. (2018): *Trendy sekularne rozwoju somatycznego i motorycznego dzieci z regionu Wielkopolski w kolejnych dekadach od 1986 do 2016 w świetle wybranych zmian środowiskowych* [*Secular trends in the somatic and motor development of children from the Greater Poland region in the subsequent decades from 1986 to 2016 in the light of selected environmental changes*]. Outline of a doctoral dissertation. Poznan University of Physical Education.

[5] Bouchard C. (1988): *Inheritance of human fat distribution. Fat distribution during growth and later health outcome.* Current Topics in Nutrition and Disease, 17, pp. 103–125.

[6] Boyer B.P., Nelson J.A., Holub S.C. (2015): *Childhood body mass index trajectories predicting cardiovascular risk in adolescence*. Journal of Adolescent Health, 56(6), pp. 599–605; http://dx.doi.org/10.1016/j.jadohealth.2015.01.006.

[7] Brown T., Moore T.H., Hooper L., Gao Y., Zayegh A., Ijaz S., … Summerbell C.D. (2019): *Interventions for preventing obesity in children*. Cochrane Database of Systematic Reviews, 7; https://doi.org/10.1002/14651858.CD001871.pub4.

[8] Charzewska J., Bergman P., Kaczanowski K., Piechaczek H. (2006): *Otyłość – epidemią XXI wieku* [*Obesity – an epidemic of the 21st century*]. University of Physical Education in Warsaw.

[9] Chrzanowska M. (1993): *Zmiany rozwojowe dystrybucji podskórnej tkanki tłuszczowej oraz ich przebieg u dzieci otyłych i szczupłych* [*Developmental changes in the distribution of subcutaneous adipose tissue and their course*

in obese and slim children]. [in:] Gładykowska-Rzeczycka J. (ed.), *Człowiek w czasie i przestrzeni*. Wydawnictwo Gdańskie, pp. 88–94.

[10] Cole T.J., Bellizzi M.C., Flegal K.M., Dietz W.H. (2000): *Establishing a standard definition for child overweight and obesity worldwide: international survey*. British Medical Journal, 320, 7244, pp. 1240–1243; https://doi.org/10.1136/bmj.320.7244.1240.

[11] Cole T.J., Flegal K.M., Nicholls D., Jackson A.A. (2007): *Body mass index cut offs to define thinness in children and adolescents: international survey*. British Medical Journal, 335, 7612, pp. 194–197; https://doi.org/10.1136/bmj.39238.399444.55.

[12] Daniels S.R., Khoury P.R., Morrison J.A. (2000): *Utility of Different Measures of Body Fat Distribution in Children and Adolescents*. American Journal of Epidemiology. 152(12), pp. 1179–1184; https://doi.org/10.1093/aje/152.12.1179.

[13] Daniels S.R., Morrison J.A., Sprecher D.L., Khoury P., Kimball T.R. (1999): *Association of body fat distribution and cardiovascular risk factors in children and adolescents*. Circulation, 99(4), pp. 541–545; https://doi.org/10.1161/01.CIR.99.4.541.

[14] Dietz W.H. (1994): *Critical periods in childhood for the development of obesity*. American Journal of Clinical Nutrition, 59(5), pp. 955–959; https://doi.org/10.1093/ajcn/59.5.955.

[15] Drozdowski Z. (1998): *Antropometria w wychowaniu fizycznym* [*Anthropometry in physical education*]. Poznań University of Physical Education.

[16] Ejtahed H.S., Kelishadi R., Qorbani M., Motlagh M.E., Hasani-Ranjbar S., Angoorani, P., Beshtar S., Ziaodini H., Taheri M., Heshmat, R. (2019): *Utility of waist circumference-to-height ratio as a screening tool for generalized and central obesity among Iranian children and adolescents: The CASPIAN-V study*. Pediatric Diabetes, 20(5), pp. 530–537; https://doi.org/10.1111/pedi.12855.

[17] Fan H. et al. (2016): *Abdominal obesity is strongly associated with cardiovascular disease and its risk factors in elderly and very elderly community-dwelling Chinese*. Scientific Reports, 6, pp. 21521; https://doi.org/10.1038/srep21521.

[18] Fang H., Berg E., Cheng X., Shen W. (2018): *How to best assess abdominal obesity.* Current Opinion in Clinical Nutrition and Metabolic Care, 21(5) pp. 360–365; https://doi.org/10.1097/MCO.0000000000000485.

[19] Filgueiras M.D.S., Vieira S.A., de Almeida Fonseca P.C., Pereira P.F., Ribeiro A.Q., Priore S.E., do Carmo Castro Franceschini S., de Novaes, J.F. (2019): *Waist circumference, waist-to-height ratio and conicity index to evaluate android fat excess in Brazilian children*. Public Health Nutrition, 22(1), pp. 140–146; https://doi.org/10.1017/S1368980018002483.

[20] Foster C.J., Weinsier R.L., Birch R., Norris D.J., Bernstein R.S., Wang J., Pierson R.N., Van Itallie T.B. (1987): *Obesity and serum lipids: an evaluation of the relative contribution of body fat and fat distribution to lipid levels*. International Obesity Journal, 11(2), pp. 151–161.
[21] Franks P.W., Hanson R.L., Knowler W.C., Sievers M.L., Bennett P.H., Looker H.C. (2010): *Childhood obesity, other cardiovascular risk factors and premature death*. New England Journal of Medicine, 362(6), pp. 485–493; https://doi.org/10.1056/NEJMoa0904130.
[22] Fredriksen P.M., Skår A., Mamen A. (2018): *Waist circumference in 6–12-year-old children: the Health Oriented Pedagogical Project* (*HOPP*). Scandinavian Journal of Public Health, 46(21), pp. 12–20; https://doi.org/10.1186/s12889-017-4282-z.
[23] Hu L. et al. (2017): *Prevalence of overweight, obesity, abdominal obesity and obesity-related risk factors in southern China*. PLoS ONE, 12(9), pp. e0183934; https://doi.org/10.1371/journal.pone.0183934.
[24] Janssen I. Heymsfield S.B., Allison D.B., Kotler D.P., Ross R. (2002): *Body mass index and waist circumference independently contribute to the prediction of nonabdominal, abdominal subcutaneous, and visceral fat*. The American Journal of Clinical Nutrition, 75(4), pp. 683–688; https://doi.org/10.1093/ajcn/75.4.683.
[25] Jarosz M., Kłosiewicz-Latoszek L. (2015): *Otyłość. Zapobieganie i leczenie. Porady lekarzy i dietetyków* [*Obesity. Prevention and treatment. Advice from doctors and nutritionists*]. Wydawnictwo Lekarskie PZWL. Warsaw.
[26] Katzmarzyk P.T., Srinivasan S.R., Chen W., Malina R.M., Bouchard C., Berenson G.S. (2004): *Body Mass Index, Waist Circumference, and Clustering of Cardiovascular Disease Risk Factors in a Biracial Sample of Children and Adolescents*. Pediatrics, 114(2), pp. 198–205; https://doi.org/10.1542/peds.114.2.e198.
[27] Kułaga et al. (2008): *Porównanie wartości obwodów talii i bioder dzieci i młodzieży polskiej w wieku 7–18 lat z wartościami referencyjnymi dla oceny ryzyka sercowo-naczyniowego – wyniki wstępne projektu badawczego OLAF* (*PL0080*) [*Comparison of waist and hip circumference values in Polish children and adolescents aged 7–18 with reference values for the assessment of cardiovascular risk – preliminary results of the OLAF research project* (*PL0080*)]. *Standardy medyczne* [*Medical standards*]. Pediatria, 5, pp. 473–485.
[28] Lee E.Y., Yoon K.H. (2018): *Epidemic obesity in children and adolescents: risk factors and prevention*. Frontiers of Medicine, 12(6), pp. 658–666; https://doi.org/10.1007/s11684-018-0640-1.
[29] Manolopoulos K.N., Karpe F., Frayn K.N. (2010): *Gluteofemoral body fat as a determinant of metabolic health*. International Journal of Obesity, 34(6), pp. 949–959; https://doi.org/10.1038/ijo.2009.286.

[30] Mazur J., Małkowskiej-Szkutnik A. (2018): *Zdrowie uczniów w 2018 roku na tle nowego modelu badań HBSC* [*Students' health in 2018 against the background of the new HBSC research model*]. Instytut Matki i Dziecka [Institute of Mother and Child]. Warsaw.
[31] McCarthy H.D., Jarrett K.V., Emmett P.M., Rogers I. (2005): *Trends in waist circumference in young British children: a comparative study*. International Journal of Obesity, 29(2), pp. 157–162; https://doi.org/10.1038/sj.ijo.0802849.
[32] Noevius M., Linne Y., Rossner S. (2005): *BMI, waist circumference and waist-hip-ratio as diagnostic tests for fatness in adolescents*. International Journal of Obesity, 29(2), pp. 163–169; https://doi.org/10.1038/sj.ijo.0802867.
[33] Ogden C.L., Carroll M.D., Kit B.K. (2012): *Centers of Disease Control and Prevention. Prevalence of Obesity in the United States, 2009–2010*. NCHS Data Brief, 82, pp. 1–8.
[34] Ogden C.L., Carroll M.D., Kit B.K., Flegal K.M. (2014): *Prevalence of childhood and adult obesity in the United States, 2011–2012*. JAMA, 311(8), pp. 806–814; https://doi:10.1001/jama.2014.732.
[35] Osiński W. (2017): *Nadwaga i otyłość. Aktywność fizyczna w profilaktyce i terapii*. [*Being Overweight and Obese. Physical Activity in Prevention and Therapy*]. Wydawnictwo Lekarskie. Warsaw.
[36] Paley C.A., Johnson M.I. (2018): *Abdominal obesity and metabolic syndrome: exercise as medicine?* BMC Sports Science, Medicine and Rehabilitation, 10(1), pp. 1–8; https://doi.org/10.1186/s13102-018-0097-1.
[37] Polish Journal of Laws of 2017, item 59. Educational Law of December 14th 2016. Retrieved from: http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20170000671.
[38] Quek Y.H., Tam W.W., Zhang M.W., Ho R.C. (2017): *Exploring the association between childhood and adolescent obesity and depression: a meta-analysis*. Obesity Reviews, 18(7), pp. 742–754; https://doi.org/10.1111/obr.12535.
[39] Ross R., Janssen I. (2007): *Physical activity fitness and obesity*. [in:] Bouchard C.N., Blair S.N., Haskell W.L. (ed.), *Physical Activity and Health. Human Kinetics*. Champaign, pp. 311–336.
[40] Sahakyan K.R., Somers V.K., Rodriguez-Escudero J.P., Hodge D.O., Carter R.E., Sochor O., Coutinho T., Jensen M.D., Roger V.L., Singh P., Lopez-Jimenez F. (2015): *Normal-weight central obesity: implications for total and cardiovascular mortality*. Annals of Internal Medicine, 163(11), pp. 827–835; https://doi.org/10.7326/M14-2525.
[41] Sardinha L.B., Going S.B., Teixeira P.J., Lohman T.G. (1999): *Receiver operating characteristic analysis of body mass index, triceps skinfold thickness, and arm girth for obesity screening in children and adolescents*. American

Journal of Clinical Nutrition, 70(6), pp. 1090–1095; https://doi.org/10.1093/ajcn/70.6.1090.

[42] Simmonds M., Burch J., Llewellyn A., Griffiths C., Yang H., Owen C., Duffy S., Woolacott N. (2015): *The use of measures of obesity in childhood for predicting obesity and the development of obesity-related diseases in adulthood: a systematic review and meta-analysis*. Health Technology Assessment, 19(43), pp. 1–336; https://doi.org/10.3310/hta19430.

[43] Statistica. Statistical Package. Polish Version. StatSoft Polska. Kraków 2016.

[44] Sudera A., Płonka M., Jagielski P., Piórecka B., Głodzik J. (2015): *Związki wskaźnika WHtR z czynnikami biologicznymi i środowiskowymi u dziewcząt o różnym poziomie aktywności fizycznej* [*Relationships of the WHtR index with biological and environmental factors in girls with different levels of physical activity*]. [in:] *XLV Ogólnopolska Konferencja Naukowa Polskiego Towarzystwa Antropologicznego*. *Człowiek wobec wyzwań środowiska życia* [*Man in the face of the challenges of the living environment*]. Collegium Biologicum in Poznań. Poznań, pp. 143–144.

[45] Wilczewski R., Wilczewski A. (2018): *Trendy sekularne w rozwoju fizycznym i sprawności motorycznej chłopców w wieku szkolnym ze środkowo-wschodniego regionu Polski w latach 1986–2016* [*Secular trends in the physical development and motor skills of school-age boys from the Central-Eastern region of Poland in the years 1986–2016*]. [in:] Asienkiewicz R., Tatarczuk J. (ed.), Rocznik Lubuski [Lubusz Yearbook 44 (2a)] vol. 44, part 2a. Lubuskie Towarzystwo Naukowe, Zielona Góra, pp. 173–192.

[46] World Health Organization (2020): *Obesity and overweight. Key facts*. Retrieved from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.

[47] World Health Organization (2011): *Waist circumference and waist-hip ratio: report of a WHO expert consultation*, Geneva, 8–11 December 2008.