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PHYSICAL FITNESS AND MOTOR SKILLS OF FIVE-YEAR-OLDS WITH DIFFERENT WEIGHT-HEIGHT PROPORTIONS

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Abstract
Introduction. Along with the progress of civilization, we observe changes in the growth environment of children and youth. Lifestyle changes translate into the morphofunctional development of adolescents. The aim of the study was to show the influence of underweight and overweight on gross motor skills and physical fitness. ***Material and methods.*** A total of 435 five-year-old children participated in the study. Body height and weight were measured. Body mass index (BMI) was calculated. The research material was divided into three groups: underweight, with normal BMI, and overweight. The Test of Gross Motor Development TGMD II was used to assess motor skills. Fitness was assessed with the Sekita physical fitness test for preschoolers. For all test samples, arithmetic means and standard deviation were calculated. The statistical significance of differences between the groups taking into account the size of BMI was assessed using ANOVA and the Newmann-Keuls test. Moreover, the percentage of underweight and overweight girls and boys as well as those with normal BMI was estimated. Sexual dimorphism between the groups was calculated using the χ^2 test. ***Results.*** There were no statistically significant differences in the locomotor skills and the ability to handle sports equipment in 5-year-olds with different BMI. On the other hand, a trend of better motor skills was observed in children with normal BMI compared to their underweight and overweight peers. Such significant correlations were not found in motor skills. ***Conclusions.*** It can be assumed that the 5th year of life is still too early a period in ontogenesis to search for significant correlations between motor skills, physical fitness, and body build.

Key words: preschoolers, physical fitness, BMI

Introduction

Along with the progress of civilization, we observe changes in the growth environment of children and youth. Changes in lifestyle translate into morphofunctional development of adolescents. The improvement in the daily living conditions of the community has revealed many previously unknown threats to human health. The most dangerous of them is limiting physical activity, especially in children and adolescents, which leads to a reduction in physical fitness and the accumulation of adipose tissue. This was confirmed in the literature describing changes among school children [1, 2, 3, 4, 5, 6]

Obesity is one of the most common medical conditions in developed societies. Over the past several decades, there has been a constant increase in the number of obese children and adolescents [7]. Based on a review of the world literature on children aged 2.0-9.9 years, Ahrens et al. [8] found a much higher incidence of obesity in populations living in southern Europe compared to those from northern Europe. According to the mentioned authors, this problem is greater in populations with lower levels of parents' education and income. It was also found that the environment differentiates the level of gross motor skills and physical fitness of preschool children [9, 10].

The results of epidemiological studies indicate that obesity predisposes to arterial hypertension, hyperlipidemia, and type 2 diabetes, increasing the risk of developing cardiovascular diseases, cancers of the colon, prostate, etc. [11]. It should be remembered that being overweight and obese in childhood may contribute to the diseases described above in adulthood [12, 13]. The problem of being underweight is much less frequently discussed in the literature. The occurrence of underweight in children may indicate their malnutrition and result in the occurrence of bronchial and lung inflammation, asthma, malfunctioning of the digestive system, and emotional disorders [14, 15, 16].

In the literature, you can find studies showing the relationship between overweight or underweight children and teenagers with physical fitness [17]. However, there are few studies describing the influence of overweight or underweight on the motor skills and physical fitness of preschoolers, and their results are not unanimous. Such results were presented by Robinson et al. [18], who observed the negative impact of overweight and obesity on the level of motor skills of preschoolers. Also, Kit et al. [19] found no effect of excess body weight on the results of TGMD. However, those researchers did not study underweight and the level of motor skills, but only motor skills. Therefore, the authors of this report want to join the discussion on this problem. The aim of the study was to show the influence of underweight and overweight on gross motor skills and physical fitness.

Material and methods

A total of 435 five-year-old children (180 girls and 255 boys) from Biala Podlaska participated in the study. The legal guardians of the children gave their consent for participation in the research. The study was preceded by a medical examination during which children's health was assessed. The research was carried out in accordance with the principles of the Helsinki Declaration and received a positive opinion of the Senate Committee on Ethics of Scientific Research (SKE 01-01/2014).

The anthropometric measurements were performed in accordance with generally accepted anthropometric techniques (based on IBP recommendations). The data collected regarding body weight and height were used to calculate the Body Mass Index (BMI), which measures the ratio of weight in kilogrammes to squared height in meters.

The Test of Gross Motor Development (TGMD II) [20] was used to assess motor skills, in which the examiner rated the technique of performing exercises. This test allows the assessment of motor abilities with the help of 6 tests:

- run (8 points) – the ability to advance steadily by springing steps so that both feet leave the ground for an instant with each stride;
- gallop (8 points) – the ability to perform a fast, natural three-beat gait;
- hop (10 points) – the ability to hop a minimum distance on each foot;
- leap (8 points) – the ability to perform all of the skills associated with leaping over an object;
- horizontal jump (8 points) – the ability to perform a horizontal jump from a standing position;
- slide (8 points) – the ability to slide in a straight line from one point to another.

Six trials with the use of sports equipment were carried out:

- striking a stationary ball (10 points) – the ability to strike a stationary ball with a plastic bat;
- stationary dribble (8 points) – the ability to dribble a basketball a minimum of four times with the dominant hand before catching the ball with both hands, without moving feet;
- catch (6 points) – the ability to catch a plastic ball that has been tossed underhand;
- kick (8 points) – the ability to kick a stationary ball with the preferred foot.
- overhand throw (8 points) – the ability to throw a ball at a point on a wall with the preferred hand;
- underhand roll (8 points) – the ability to roll a ball between two cones with the preferred hand.

Physical fitness (PF) was assessed according to the Polish Physical Fitness Test for preschoolers [21]. It consisted of four trials:

- explosive power of lower limbs – standing broad jump (SBJ);
- agility – 4 x 5 m shuttle run with moving the block (4x5mSR);
- speed – 20 m run (20mR);
- dynamic force of the trunk and shoulder girdle – throwing a 1 kg medicine ball with both hands above the head (1kgTB).

The obtained results were analyzed in absolute values.

Statistica 13.0 software was used for statistical data processing. In the sex groups, descriptive statistical parameters (mean, standard deviation) were calculated. To calculate physical fitness (PF) the individual results of 4 physical fitness trials (PF) were converted into points on the T scale. In order to standardize the units, the individual results of girls and boys were normalized on the T scale to the mean and standard deviation of all subjects using the formula:

$$T = ((Xi - \bar{x})/SD)*10+50$$

T – number of points; Xi – measurement result; $\bar{x}$ – sample mean; SD – standard deviation.

The mean score from all test trials assesses physical fitness (PF). Next, the following groups were established:

- Group I – underweight children,
- Group II – children with normal BMI,
- Group III – overweight children.

On the basis of the recommendations of the International Obesity Task Force and the cut-off points determined by Cole et al. [22, 23], the participants were divided into groups, taking into account underweight and excess body weight. For all samples of both tests, arithmetic means and standard deviation were calculated. The statistical significance of differences between the groups was assessed using ANOVA and the Newmann-Keuls test.

When performing statistical calculations of physical fitness and motor skills, the study material was not divided by gender, because the differences between these groups are small and statistically insignificant in the trials of the TGMD II test and the Sekita test [24]. The level of the incidence of underweight, overweight, and normal BMI in both sexes is also similar. The number of study participants in particular groups also allowed us to calculate the percentage of girls and boys who were underweight, overweight, and with normal BMI. Sexual dimorphism between these groups was calculated using the χ^2 test.

Results

Before the analysis of the main issue, the dimorphic differences in the weight-to-height proportions of 5-year-old children were determined. The results presented in Table 1 indicate that boys were underweight more often (by 4.15%) than girls. In turn, higher values were found in girls with normal BMI (by 1.54%) and overweight girls (by 2.62%). These differences were not statistically significant.

Table 1. Percentage of surveyed boys and girls divided into groups with normal BMI, underweight and overweight, and the χ^2 test values for dimorphic differences

Sex	Underweight	Normal BMI	Overweight
boys	18.04	69.02	12.94
girls	13.89	70.56	15.56
test χ^2	0.976	0.021	3.029
total	15.96	69.79	14.25

When analyzing the influence of the body mass index on gross motor skills of 5-year-olds, it was noticed that the differences in results between the two groups were small and statistically insignificant. However, some trends can be observed already at this age. It was found that five-year-olds with normal BMI (68.18 points) had the highest level of motor skills, followed by those who were underweight (65.90 points) and overweight (64.29 points). Such results were influenced by the results obtained in all trials of the Test of Gross Motor Development TGMD II.

When analyzing the locomotor skills only, the same distribution of results was noted, but with smaller differences (Tab. 2). Children from group II scored 33.59 points, those from group I had 32.36 points, while children from group III scored 32.22 points. The results were not consistent across all locomotor skills tests. Children with normal BMI obtained the best results in the following trials: hop, horizontal jump and leap. There were no trials in which 5-year-olds with normal BMI scored the worst. On the other hand, underweight preschoolers were the best in the run only, while they obtained the worst results in gallop, hop, leap and slide. Overweight children achieved the best results in the gallop and slide, while the worst in the run. However, it should be emphasized that none of the differences described above was statistically significant (Tab. 2).

Table 2. The results of the locomotor skill tests of 5-year-olds and the values of the Newman-Keuls test calculated for group differences

Test trials	Group I (n = 71)	Group II (n = 303)	Group III (n = 61)	ANOVA	Newmann-Keuls test values		
	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD		I-II	I-III	II-III
run	6.68 ± 2.04	6.45 ± 1.78	6.00 ± 1.69	2.41	1.36	3.04	2.50
gallop	4.98 ± 2.63	5.18 ± 2.29	5.20 ± 2.25	0.23	0.92	0.76	0.09
hop	5.26 ± 2.57	5.97 ± 2.49	5.48 ± 2.24	2.92	3.08	0.72	2.00
leap	4.58 ± 1.78	4.67 ± 1.45	4.59 ± 1.67	0.14	0.63	0.05	0.52
horizontal jump	5.53 ± 2.55	5.94 ± 2.23	5.39 ± 2.33	2.02	1.91	0.49	2.41
slide	5.32 ± 2.16	5.37 ± 2.13	5.57 ± 2.10	0.27	0.25	0.95	0.95
total	32.36 ± 9.24	33.59 ± 7.48	32.22 ± 7.47	1.27	1.69	0.15	1.77

Group I – underweight children, Group II –children with normal BMI, Group III – overweight children.

When assessing the results for the ability to handle sports equipment of 5-year-olds in groups with different BMI, it was noticed that also in these trials most of the results were at a similar level because there were no statistically significant differences between them. Despite the lack of major differences in the total points obtained for the ability to handle sports equipment, the highest level was also found in children with normal BMI (31.79 points) (Tab. 3). A statistically significant difference was found only between the study participants from group II and group III ($p \leq 0.05$).

In individual attempts to handle sports equipment, the test results were not the same, either. Five-year-olds with correct BMI obtained the best results in stationary dribbling, catching, overhand throwing and underhand rolling. There were no exercises assessing mastery of equipment skills in which children with normal BMI achieved the worst results. The underweight preschoolers obtained the best results in striking a stationary ball and kicking, while the worst results were noted in the test of catching. On the other hand, overweight children did not achieve the best results in any test related to handling sports equipment. The worst results were observed in striking a stationary ball, stationary dribbling, kicking, throwing, and underhand rolling. Statistical significance of differences was noted only in throwing between group III and group I and group II ($p \leq 0.05$).

The comparisons of the results of the physical fitness test of preschoolers in groups with different body mass index also show small, statistically insignificant differences in overall physical fitness (PF). However, there are also some trends here. The best results were achieved by children with normal BMI (50.04 points), followed by overweight children (49.91 points). The lowest level of physical fitness was found in underweight children (Tab. 4). Taking into account individual motor skills, it was observed that underweight 5-year-olds obtained the worst results in all trials of the fitness test. Overweight children achieved the best results in 20 m run and throwing a medicine ball (1 kg) with both hands above the head, while their peers with normal BMI scored the highest in 4 x 5 m shuttle run with moving the block and standing broad jump. Statistically significant differences were found between underweight preschoolers and the remaining groups in 20 m run and throwing a medicine ball (1 kg) with both hands above the head.

Discussion and conclusions

The analysis of the processes taking place in the body with simultaneous monitoring of individual aspects of the child's life may support their psychophysical development. This is important because, according to many experts, it is up to the age of five that children form their habits and the way they perceive the world to the greatest extent. Appropriate targeting of it during this period may contribute to better functioning in later periods of life [25, 26]. It is also significant to shape proper nutrition habits and to spend free time actively. It was noted that children's motor skills were positively related to their physical ac-

Table 3. The results for the ability to handle sports equipment of 5-year-olds and the Newmann-Keuls test values calculated for group differences

Test trials	Group I (n = 71)	Group II (n = 303)	Group III (n = 61)	ANOVA	Newmann-Keuls test values		
	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD		I-II	I-III	II-III
striking	7.06 ± 1.90	7.11 ± 2.30	6.96 ± 2.23	0.12	0.24	0.36	0.68
dribbling	3.51 ± 2.88	3.94 ± 2.72	3.46 ± 2.78	1.25	1.67	0.13	1.76
catching	4.15 ± 1.66	4.43 ± 1.47	4.26 ± 1.41	1.17	2.01	0.60	1.15
kicking	5.92 ± 1.98	5.82 ± 1.80	5.37 ± 2.05	1.74	0.57	2.39	2.43
throwing	5.57 ± 1.75	5.78 ± 1.47	4.83 ± 1.45	10.00	1.49	3.95*	6.31*
rolling	4.70 ± 1.85	4.71 ± 1.68	4.63 ± 1.78	0.05	0.06	0.33	0.47
total	30.91 ± 7.23	31.79 ± 6.53	29.50 ± 6.46	3.19	1.42	1.72	3.48*

* – statistically significant difference at the level of $p \leq 0.05$; Group I – underweight children, Group II – children with normal BMI, Group III – overweight children.

Table 4. The results for motor skills of 5-year-olds from Biala Podlaska presented in absolute units and the values of the Newmann-Keuls test calculated for group differences

Test trials	Group I (n = 71)	Group II (n = 303)	Group III (n = 61)	ANOVA	Newmann-Keuls test values		
	x̄ ± SD	x̄ ± SD	x̄ ± SD		I-II	I-III	II-III
4x5mSR	10.55 ± 1.31	10.35 ± 1.12	10.37 ± 1.26	0.84	1.83	1.24	0.17
1 kg TB	191.11 ± 49.93	211.15 ± 54.51	221.41 ± 61.34	5.57	3.92*	4.48*	1.89
20mR	6.01 ± 0.75	5.75 ± 0.79	5.60 ± 0.57	5.22	3.69*	4.39*	2.00
SBJ	88.52 ± 22.33	92.91 ± 22.41	91.99 ± 18.72	1.15	2.15	1.28	0.42
PF	49.89 ± 6.28	50.04 ± 6.40	49.91 ± 5.29	0.02	0.26	0.03	0.21

* – statistically significant difference at the level of $p \leq 0.05$; Group I – underweight children, Group II – children with normal BMI, Group III – overweight children.

tivity but inversely related to the time spent in front of a TV or a computer screen [27]. An inactive lifestyle and improper nutrition lead, inter alia, to disturbances in weight-height proportions [28].

Based on the analysis of the national literature, Malczyk [29] indicates significant irregularities in the nutritional status of children and adolescents in Poland. On average, 3% to 18% of boys are underweight, and even up to 20% of girls are underweight. The percentage of overweight children and adolescents fluctuates around 12-15%, and with obesity around 5-11%. Despite the growing knowledge about risk factors for their development, it continues to increase. The problem of being overweight is increasing in younger age groups. Obesity is taking epidemic proportions and is becoming a public health problem.

Ahrens et al. [8], who analyzed the European literature, documented that in children aged 2.0-9.9 years, the total incidence of overweight ranges from over 40% in southern Europe to less than 10% in the north of the continent. Overall, the prevalence of overweight was higher in girls (21.1%) compared to boys (18.6%). Moreover, these authors proved that low-income and/or less educated groups of the population show the highest prevalence of obesity. Dimorphic analyses of five-year-olds from Biala Podlaska confirm the trend in line with the nationwide trend, where the higher incidence of underweight was noted in boys (18.04%), and overweight in girls (15.56%).

As 5-year-old children are at the beginning of their path in terms of motor development, the differences in locomotion and control skills in individual BMI groups may be small. However, Barros et al. [30] proved that childhood obesity may have an adverse effect on motor development. This is also confirmed by our observations, as overweight subjects obtained worse results in terms of locomotion skills and the ability to handle sports equipment. Similar results were presented by Robinson et al. [18], who observed a negative impact of overweight and obesity on the level of motor skills of preschoolers. Kit et al. [19], showed no effect of overweight on the results of TGMD. The results obtained by us indicate that the differences between the BMI groups were statistically insignificant in both locomotor skills and the ability to handle sports equipment. However, there was a trend that children with normal BMI obtained the best results, followed by those who were underweight and overweight. Such a distribution of results in physical fitness, with much larger differences, was also observed in school children and adolescents [17].

The differences in the level of physical fitness in groups of five-year-old children with different weight and height proportions found little confirmation in our observations. Statistically significant differences were found only in two out of four trials of the physical fitness test assessing the locomotor speed and dynamic force of the trunk and shoulder girdle. Overweight five-year-olds achieved the best results in the above-mentioned trials. On the other hand, underweight children scored the worst results for all motor skills. It should be emphasized that five-year-olds from Biala Podlaska are not sports-active children. 41.75% of girls and 30.71% of boys participate in additional physical activities, apart from the compulsory program in kindergartens. At the same time, children spend a lot of their free time in front of the TV or computer, especially during the autumn and winter season [31]. Therefore, it can be assumed that the motor skills of the five-year-olds assessed by us are still at a low level and do not affect the level of their physical fitness.

In conclusion, the incidence of underweight and overweight in five-year-old children from Biala Podlaska is at a similar level to that of their peers from other regions of Poland and Europe. There were no statistically significant differences in the locomotor skills and the ability to handle sports equipment in 5-year-olds with different BMI. However, there was a trend that children with normal BMI had the best motor skills, followed by underweight children, whereas overweight children manifested the lowest levels of motor skills. Such clear correlations were not found with regard to physical fitness. It can therefore be assumed that the 5th year of life is still too early a period in ontogenesis to search for significant correlations between motor skills, physical fitness, and body build.

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