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PHYSICAL FITNESS AND BODY COMPOSITION IN CORRELATION WITH BODY WEIGHT OF PUPILS IN PRIMARY SCHOOLS ON THE TERRITORY OF THE CITY OF SKOPJE

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Abstract

The paper presents one segment of a research carried out in 2019 in 19 primary schools that was aimed to determine the fitness level of Macedonian adolescents of both genders with different values of body mass index (ИТМ). The paper focuses on the correlation between the physical fitness and body composition compared to the body weight of pupils from primary schools on the territory of the City of Skopje. The research was conducted on a sample of 4,051 adolescents, 2,078 boys and 1,973 girls. The respondents were divided in 4 categories: underweight, normal weight, overweight and obese. Total of 7 test of EUROFIT battery were applied and 5 anthropometric measurements were taken into consideration in accordance to the IBP methodology. The results obtained were statistically processed by SPSS, v. 16.0 for WINDOWS (variance analysis, covariance analysis, and χ2 test). The conclusion based on the obtained results is that young adolescents of both genders with moderate or high BMI have higher blood pressure; lower percentage of muscle mass; achieve poorer results in the relative strength, explosive strength, agility, and coordination tests; and have lower aerobic capacity.

Key words: *EUROFIT, IBP, young adolescents, City of Skopje*

Introduction

The World Health Organization (WHO) defines overweight and obesity as abnormal or excessive fat accumulation that presents a risk to health. The body mass index (BMI), is used to broadly categorize a person as overweight or obese. It is defined as the body mass divided by the square of the body height and is universally expressed in units of kg/m2, resulting from mass in kilograms and height in metres (kg/m2). An adult person with a BMI equal to or more than 25 is considered overweight while an adult person with a BMI of 30 or more is generally considered obese.

According to data from the WHO, worldwide obesity has nearly tripled since 1975. In 2016, more than 1.9 billion adults, 18 years and older, were overweight, and of these over 650 million were obese. Presented as a percentage of the world population, 39% of adults aged 18 years (39% male and 40% female) were overweight and 13% were obese in 2016.

From 1975 to 2016, the prevalence of overweight or obese children and adolescents aged 5–19 years increased more than four-fold from 4% in 1975 to more than 18% in 2016. Over 340 million children and adolescents aged 5-19 were overweight or obese in 2016 (18% girls and 19% boys). 38 million children under the age of 5 were overweight or obese in 2019.

Once considered a problem only in high-income countries, overweight and obesity are now dramatically on the rise in low- and middle-income countries. For example, in Africa, the number of overweight children under 5 has increased by nearly 24% percent since 2000. According to the WHO, almost half of the children under 5 who were overweight or obese in 2019 lived in Asia.

The WHO European Childhood Obesity Surveillance Initiative (or COSI) (2015–2017) showed that countries in South Europe have the highest rate of child obesity. In Cyprus, Greece, Italy, Malta, San Marino and Spain an average 1 of 5 boys (18% to 21%) are obese. On the other hand, Denmark, France, Ireland, Latvia and Norway have the lowest rate of obesity which ranges between 5% to 9%.

Overweight and obesity are defined as follows for children aged between 5–19 years:

- overweight is BMI-for-age greater than 1 standard deviation above the WHO Growth Reference median; and
- obesity is greater than 2 standard deviations above the WHO Growth Reference median.

The fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. The modern way of living brings an increased intake of energy-dense foods that are high in fat and sugars; and decreased physical activity due to the increasingly sedentary nature of many forms of work, changing modes of transportation, and increasing urbanization.

Obesity is a serious health problem because it increases the risk for chronical, noncommunicable diseases such as: cardiovascular diseases, diabetes type 2, hypertension, cardiovascular disease, some types of cancers. For some individuals, obesity could be linked with a wide spectrum of psychological problems.

Childhood obesity is associated with a higher chance of obesity, premature death and disability in adulthood. But in addition to increased future risks, obese children experience breathing difficulties, increased risk of fractures, hypertension, early markers of cardiovascular disease, insulin resistance and psychological effects.

Beside the health disorders, this risk factors are causing decreased level of functional abilities in children. Some researches (Korsten-Reck et al., 2007; Macfarlane & Tomkinson, 2007) determined that there is a significant trend in decrease of aerobic capacity of children which is closely connected with the nutrition status. Obese children usually participate less in physical activity and thus have lower level of aerobic capacity in comparison with children who have healthy diet. Lower level of motoric ability of overweigh and obese children relates to muscular weakness as a result of physical inactivity which also has an indirect impact on occurrence of various physical deformities. (De S De Pinto, De Barros Holanda, Radu, Villares, & Lima, 2006;

Alarming level of obesity on global level relates to low level of physical activity and consequently leads to lowering of the physical capacity. It is already confirmed that obesity results in gradual decrease of the physical fitness and vice versa inactivity results in increase body weight and obesity. Shang and collaborators present a research which indicates that overweight and obese children age of 6 to 12, have worse results on tests for physical fitness in comparison with children of same age with normal weight. Susuki and Tatsumi (1993) carried out a research of physical fitness of children age 9 and 10 with normal body weight and obese in Japan, before and after a combined diet and fitness program. Their results are consistent with the results of other studies which confirm that obese children have significantly lower level of physical fitness in comparison to children with normal weight (Thivel, D., Isacco, L., Lazaar, N., Aucouturier, J., Ratel, S., Doré, E., Meyer, M. & Duché, P. (2011). Effect of a 6-month school-based physical activity program on body composition and physical fitness in lean and obese schoolchildren. *European Journal of Pediatrics)*

This paper presents one segment of a larger research carried out in 2019 in 19 primary schools in the City of Skopje. It was aimed at determining the level of physical fitness of Macedonian adolescents of both sexes with different body mass index. The paper focuses on physical fitness and body composition in correlation with body weight of pupils in primary schools on the territory of the City of Skopje

Methods

In 2019, the Faculty of Physical Education, Sport and Health, "Ss. Cyril and Methodius University" Skopje implemented a research project in 19 primary schools on the territory of the City of Skopje, 8 in rural and 11 in urban areas. The research included students of final years and mentor professors. Representative sample of 4051 pupils participated in the research, 2078 boys and 1973 girls from primary schools. The research aimed at determining the level of motoric abilities of pupils of both sexes.

Parents provided consent for their children to participated in the research. The pupils were of good health and participated regularly in physical and health education classes. The measurements took place in March, April and May 2019, in regular schools, during the physical and health education classes. The measurements were performed by kinesiology experts and MD doctors trained for performing of functional tests and anthropometric measurements, supported by students participating in the project

Measurements were realized during the regular morning classes in schools, in sport halls or on open spaces assigned for sport activities, using standard measurement instruments. Official medical doctor was measuring blood pressure for each participant and was providing consent for participation of the pupil in the research.

All participants were measured using EUROFIT battery tests that are recommended by the Council of Europe, modified and accommodated in the international scientific projects "Feeding and Assessment of Nutritional Status of Spanish Adolescents (AVENA study)", "The Healthy Lifestyle in Europe by Nutrition in Adolescence" - (HELENA study) (Ruiz et al., 2006), "Identification and prevention of Dietary - and lifestyle-induced health Effects In Children and infants" (IDEFICS study) (Miguel-Etayo et al., 2014).

The following fitness tests were applied: 1) Standing broad jump; 2) Sit-ups in 30 sec.; 3) Bent arm hang; 4) Shuttle run 4 x 10 m; 5) Hand grip test; 6) Sit-and-reach; and 7) 3 min. step test

Each test was determining one motoric ability:

Motoric abilities	**Test for determining motoric ability**
Explosive leg power	Standing broad jump
Trunk strength	Sit-ups in 30 sec.
Muscular endurance/strenght	Bent arm hang
Seed, agility and coordination	Shuttle run 4 x 10 m
Static arm strenght	Hand grip test
Flexibility	Sit-and-reach
Aerobic capacity	3 min. step test

The measurement of anthropometric measures is based on the recommendations of the IBP International Biological Program (Lohman, Roche & Martorell, 1988). The following anthropometric measures were used to assess the morphological characteristics of this study: a) Body height; b) Body weight.

The body composition of the subjects was determined by the method of bioelectrical impedance (BIA). The measurement was performed using the Body Composition Monitor, a model "OMRON-BF511" that determined body weight, percentage of adipose tissue, percentage of muscle mass and body mass index. Before starting the measurement, the parameters were entered in the Body Composition Monitor: gender, age and body height of the respondent.

In order for the obtained results of the measurement, i.e. the assessment of the body composition to be as accurate and precise as possible, the following preconditions were met before each measurement (ACSM, 2005, Heyward, 2006):- The measurement should always be realized at the same time;

- The respondent should have an empty bladder;
- 4 hours before the measurement, the respondents did not consume food and / or liquid;
- 12 hours before the measurement, the respondent did not have any physical activities;
- During the measurement, the respondent should be barefoot, in a standing position.

From the existing methods for data processing were applied those that enable condensation and transformation of basic information, and with which in the exact scientific sense it is possible to answer the objectives, and to check the basis of the hypotheses from the research. For all variables that are on the interval and ratio (measured) scale, the basic statistical parameters were calculated: arithmetic mean (X), standard deviation (SD), variability coefficient (KV%), minimum score (MIN), maximum score (MAX), asymmetry (skewness) of the distribution of results, elongation, i.e. flattening (kurtosis - kurtosis) of the distribution of results, Kolmogorov-Smirnov method for testing the normality of the distribution of results (KS).

For some of the variables the following are calculated: frequencies; percentage (%); and they are graphically represented. Differences in anthropometric measurements, body composition, blood pressure, and motor tests in terms of age and sex, percentage of adipose tissue, and body mass index were determined by analysis of variance (ANOVA). To determine which sub-samples differ statistically from each other, the LSD test is used in variables where there is a statistically significant difference. Differences between males and females categorized into different distinct groups by percentage of adipose tissue, body mass index, were determined by χ^2 square tests.

The submissions are processed with the statistical packages SPSS for Windows Version 22.0 (SPSS Inc., Chicago, IL, USA).

Results and Discussion

Table 1 shows the characteristics of the sample of respondents by gender. The results of the analysis of variance show that only in the variables average age and BMI there are no statistically significant

differences between boys and girls, and in all other variables there are statistically significant differences in gender ($p < 0.00$)

Table 1. Characteristics of the sample by gender

	Male (2078)		Female (1973)		P*
Age (years)	12,4	(1,1)	12,4	(1,1)	ns;
Systolic pressure (mmHg)	115,0	(10,9)	113,9	(10,2)	**,00**
Diastolic pressure (mmHg)	71,0	(8,8)	72,2	(8,2)	**,00**
Height(cm)	157,7	(10,9)	156,1	(8,1)	**,00**
Weight (kg)	52,8	(14,7)	51,1	(12,1)	**,00**
BMI(kg/m^2)	21,0	(4,2)	20,8	(4,1)	ns
Body fat (%)	20,6	(8,5)	25,0	(7,7)	**,00**
Adipose tissue (kg) Fat tissue	11,5	(7,1)	13,5	(7,0)	**,00**
Fat free mass (kg)	41,5	(10,2)	37,6	(6,3)	**,00**
Muscular mass (%)	36,5	(3,4)	33,0	(2,5)	**,00**
Standing long jump (cm)	162,4	(28,7)	133,9	(22,6)	**,00**
Sit-ups 30 sec.	18,2	(5,1)	15,2	(4,5)	**,00**
Bent arm hand (sc)	10,4	(11,8)	3,8	(5,2)	**,00**
Handgrip (kg)	35,6	(16,7)	28,4	(11,3)	**,00**
Sit and reach (cm)	14,0	(6,9)	18,2	(7,3)	**,00**
Shuttle run 4x10 m	12,9	(1,5)	14,1	(1,5)	**,00**
Pulse (bmp)	134,8	(17,7)	152,4	(16,4)	**,00**

* P <0.001 for differences between boys and girls (ANOVA); ns, insignificant

Table 2. Percentage frequency of subjects with below average weight (malnourished), normal weight, overweight and obese, by gender and age group

Age	Malnutrition		Normal weight		Overweight		Obese	
Male								
11	42*	(6,74)	349	(56,02)	142	(22,79)	90	(14,45)
12	24	(4,59)	317	(60,61)	127	(24,28)	55	(10,52)
13	22	(4,15)	325	(61,32)	143	(26,98)	40	(7,55)
14	12	(2,98)	240	(59,55)	109	(27,05)	42	(10,42)
Total	**100**	**(4,81)**	**1231**	**(59,21)**	**521**	**(25,06)**	**227**	**(10,92)**
Female								
11	50	(8,94)	337	(60,29)	123	(22,00)	49	(8,77)
12	42	(8,20)	316	(61,72)	113	(22,07)	41	(8,01)
13	35	(6,92)	329	(65,02)	109	(21,54)	33	(6,52)
14	20	(5,05)	262	(66,16)	88	(22,22)	26	(6,57)
Total	**147**	**(7,45)**	**1244**	**(63,05)**	**433**	**(21,95)**	**149**	**(7,55)**

* The results are expressed as the number of respondents and the percentage

Table 2. shows the distribution of the state of malnutrition, overweight, and obesity assessed by BMI, in terms of age and gender. The analysis of Table 2 and the review of the $\chi 2$ test ($\chi 2 = 30.558$, $p < 0.00$) indicate that in both sexes there are statistically significant differences in all parameters for blood pressure assessment, body composition and fitness between groups of respondents formed based on the classification of BMI.

Percentage values show that a higher percentage of girls are malnourished, while a higher percentage of boys are high in BMI (overweight).

From the values of the arithmetic mean and the level of statistical significance (Table 2), it can be seen that malnourished adolescents of both sexes show poorer results in the hand grip test than normal-weight adolescents ($p < 0.00$).

Table 3. Motor abilities and body composition according to the weight status of the groups

	Malnutrition (1)		Normal weight (2)		Overweight (3)		Obese (4)		P for trend **	Post hoc pairwise comparisons***					
	X*	SD	X	SD	X	SD	X	SD		1-2	1-3	1-4	2-3	2-4	3-4
Male															
Systolic pressure (mmHg)	107,50	9,17	113,09	10,52	118,63	10,23	120,76	10,17	**,00**	>	>	>	>	>	>
Diastolic pressure (mmHg)	68,16	8,56	69,54	8,40	73,19	8,77	75,12	8,74	**,00**	ns	>	>	>	>	>
Height(cm)	9,88	2,69	16,45	5,33	26,88	5,66	33,52	5,07	**,00**	<	<	<	<	<	<
Weight (kg)	3,39	1,02	7,54	2,82	16,51	3,78	25,09	5,30	**,00**	<	<	<	<	<	<
BMI(kg/m^2)	31,00	4,70	38,71	8,44	45,66	9,51	50,13	9,67	**,00**	<	<	<	<	<	<
Body fat (%)	36,90	2,93	37,81	3,10	35,08	2,57	32,72	2,53	**,00**	ns	>	>	>	>	>
Adipose tissue (kg) Fat tissue	164,43	24,68	169,89	26,66	153,78	27,22	137,13	23,32	**,00**	ns	>	>	>	>	>
Fat free mass (kg)	18,03	4,37	19,25	4,51	17,34	5,07	14,11	5,86	**,00**	ns	ns	>	>	>	>
Muscular mass (%)	15,35	13,36	14,19	12,09	4,26	7,45	,98	3,29	**,00**	ns	>	>	>	>	>
Standing long jump (cm)	27,37	12,09	34,82	16,24	37,49	17,52	38,83	17,38	**,00**	<	<	<	<	<	ns
Sit-ups 30 sec.	13,27	6,99	14,51	6,83	13,24	6,76	13,21	7,23	**,00**	ns	ns	ns	>	ns	ns
Bent arm hand (sc)	12,67	1,24	12,58	1,37	13,21	1,43	14,04	1,63	**,00**	ns	>	>	>	>	>
Handgrip (kg)	127,49	16,57	130,35	16,39	141,30	17,01	147,19	15,70	**,00**	ns	>	>	>	>	>
Female															
Systolic pressure (mmHg)	106,76	10,86	113,11	9,64	116,48	9,61	119,92	9,66	**,00**	>	>	>	>	>	>
Diastolic pressure (mmHg)	69,37	8,19	71,70	8,09	73,54	7,79	75,81	8,40	**,00**	>	>	>	>	>	>
Height(cm)	12,93	3,73	22,59	5,05	32,08	3,81	37,19	5,99	**,00**	<	<	<	<	<	<
Weight (kg)	4,76	1,98	10,90	3,66	19,37	4,02	27,44	7,59	**,00**	<	<	<	<	<	<
BMI(kg/m^2)	31,13	4,50	36,34	4,93	40,83	5,53	45,45	7,86	**,00**	<	<	<	<	<	<
Body fat (%)	35,18	1,96	33,95	1,78	31,16	1,43	28,73	2,04	**,00**	>	>	>	>	>	>
Adipose tissue (kg) Fat tissue	135,71	21,00	138,60	22,10	125,44	21,03	117,20	17,93	**,00**	ns	>	>	>	>	>
Fat free mass (kg)	15,50	4,13	15,69	4,28	14,56	4,44	12,62	5,27	**,00**	ns	ns	>	>	>	>
Muscular mass (%)	6,83	5,93	4,93	5,54	0,86	1,85	0,32	1,34	**,00**	>	>	>	>	>	ns
Standing long jump (cm)	21,73	9,21	28,22	10,99	29,92	11,50	32,44	12,30	**,00**	<	<	<	<	<	<
Sit-ups 30 sec.	16,20	6,50	18,24	7,19	18,68	7,65	18,85	7,62	**,00**	<	<	<	ns	ns	ns
Bent arm hand (sc)	14,05	1,51	13,92	1,45	14,47	1,61	14,80	1,68	**,00**	ns	>	>	>	>	ns
Handgrip (kg)	145,79	15,40	150,47	16,25	156,43	14,96	163,61	14,46	**,00**	>	>	>	>	>	>

*Results expressed as adjusted mean (SEM).
** P for the trend was calculated after age adjustment (ANCOVA)
. ***Example of pairwaise comparison: the symbol > in the column 1–2 indicates a significant difference ($P < 0.05$) in the direction 1 > 2. Ns: non-significant.

Girls who are in the malnourished group achieve better results than girls with normal body weight in the endurance test and a 3-minute step test, while they achieve weaker results sit-and-reach. Respondents of both sexes who are moderately overweight and overweight achieve better results in the hand rip test than those with normal body weight ($p < 0.00$) (Table 3), and poorer results in other fitness tests. The sit-and-

reach test did not show a statistically significant difference between the respondents classified with normal, moderate and increased body mass index.

Many studies show that in most countries the prevalence of obesity in adolescents is higher in boys. On the other hand, the prevalence of obesity does not increase or decrease between the two age groups (Currie et al., 2004). Ortega and co-workers conducted a survey of a representative sample of Spanish adolescents (n = 2,859) and found a prevalence of overweight including obesity of 25.7% in boys and 19.1% in girls (Ortega, 2007).

The results of the research on which this paper is based, show that the percentage of overweight and obese children classified based on their BMI among Macedonian adolescents on the territory of the City of Skopje is 33%. The survey also found that boys tend to have a higher prevalence of obesity than girls (10.92% in boys and 7.55% in girls).

According to a survey conducted as part of this research, it is assumed that these numbers are probably due to the fact that at this age girls care more about their appearance and pay more attention to their diet. On the other hand, boys are less and less involved in spontaneous physical activity and spend most of their free time in sedentary activities (computer work, watching television, etc.).

Macedonian adolescents of both sexes who have a moderately elevated or high body mass index (BMI) have a lower percentage of muscle mass, a higher percentage of body fat, and achieve lower test scores on relative strength, explosive strength, speed, agility, and coordination, and also have a lower aerobic capacity.

In most of these tests, success depends on moving the body in space or overcoming the resistance of one's own body or a certain part of the body, with the fat component being a ballast mass. These are motor manifestations that are influenced by the mechanisms for regulating the intensity and duration of excitation (Kurelić et al., 1975). Obviously, these mechanisms are more effective in young respondents with a balanced weight and height ratio, i.e. lower values of BMI, which in turn is in line with several international studies conducted in children aged 5 to 17 years. (Baine et al., 2009; Malina et al., 1995; Minck et al., 2000; Deforche et al., 2003; Prista et al., 2003; Graf et al., 2004; Kim et al., 2005a, b; Brunet et al., 2007; Casajus et al., 2007; Haerens et al., 2007; Huang and Malina, 2007; Fogelholm et al., 2008).

It is not entirely clear why malnourished girls achieve poorer test scores in the sit and reach test, a test that depends on the elasticity of the muscles and tendons of the posterior muscles of the lag. The reason may be the weaker musculature of the anterior abdominal wall in the malnourished group of respondents, but this needs to be further investigated whether the weaker abdominal muscles really affects the respondent's ability to perform large-amplitude movements and keep it in the final position. Although greater flexibility is believed to be beneficial to health, existing evidence is unconvincing (Artero et al., 2009; Prista et al., 2003; Chen et al., 2002; Bovet, 2007).

Prista et al. found that malnourished adolescents had weaker endurance than normal-weight adolescents (Prista et al., 2003). Another study found that weaker girls performed better on tests to assess the aerobic capacity of normal-weight girls (Malina et al., 1995).

Macedonian adolescents of both sexes who are moderately overweight or obese show poorer results in broad jump test, Bent arm hang, run 4 x 10 meters and squats in 30 seconds ($p < 0.001$). Similar results have been confirmed in several previous studies (Deforche et al., 2003; Kim et al., 2005; Graf et al., 2004).

In terms of flexibility, the research of Macedonian adolescents showed that respondents who are moderately overweight or overweight achieve similar results as respondents with normal weight, which is also determined in two Taiwanese studies. However, research in some Western countries has shown that only obese girls achieve better results than normal-weight girls do, and this is not the case for boys (Prista et al., 2003).

The obtained data refer to scientific planning and programming of the teaching contents in order to optimize the ratio in the amount of subcutaneous fat and muscle mass, which will create an opportunity to maximize motor function in a wide range of abilities, especially in the dimensions of strength and endurance (Katya, 2003). The purpose of teaching physical and health education in this period of life, among other things, should be aimed at reducing fat and increasing muscle mass, especially on large muscle groups. Teaching should be filled with content that will achieve the stated goals such as optimization of somatotype phylogeny, proper direction of motor development and most importantly, proper functioning of the health status of the student.

The relatively large sample of adolescents included in the study, the large number of variables for assessing body composition and health fitness levels, as well as international BMI cut-off point norms are

significant advantages of this study. However, the sample does not represent the total population of adolescents in the country, as it includes only respondents from the capital city. However, the sample is large enough and representative to determine the relationship between health fitness and body mass index values.

Conclusion

The percentage of overweight and obese respondents is 33%, with the most at-risk age group being 11-year-olds of both sexes. In terms of gender differences, a higher percentage of respondents who are overweight and obese are boys, and a higher percentage of those who are malnourished are girls.

Being overweight and obese, as well as diseases that occur in overweight and obese people, in most cases can be prevented. The simplest way to do this, which is available to everyone at the same time, is regular physical activity, as well as a healthy diet. Parents can change their children's diet habits by reducing / excluding foods rich in fats and sugars, increasing the consumption of fruits and vegetables, as well as stimulating physical activity (at least 60 minutes a day). The state, on the other hand, needs to create conditions and create policies that will ensure an adequate level of physical activity in schools and a healthy diet in school kitchens.

The Global Action Plan for Physical Activity 2018-2030: More Active People for a Healthier World of the World Health Organization provides guidelines for effective policies and actions to increase physical activity globally. The WHO has also issued a package of technical recommendations, ''ACTIVE'', to help countries plan and implement actions at the national level.

The Commission for Ending Childhood Obesity, in its final report presented to the WHO General Assembly in 2016, provides a series of recommendations for governments aimed at stopping the growing trend of overweight and obesity in children under 5 years of age. Among the most important recommendations are promoting a healthy diet, promoting physical activity and reducing sedentary behavior in children and adolescents, as well as quality physical education.

Our country has already started promoting physical education in the lower grades of primary education, but researches are needed that will confirm the results in terms of health and physical fitness of students involved in such teaching, as well as comparative analysis of school results in which there is a trial system introduced of tandem physical education teacher with schools where that system has not been introduced.

It is also necessary in the future to stimulate research that will create relevant database for the entire territory of the country, which will allow determining the correlation of body mass index and motor abilities of Macedonian children and adolescents in primary schools.

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