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Trabajo Original

Pediatría

Association between body mass index, muscle-to-fat ratio, and handgrip strength-to-BMI ratio with physical fitness in children from North Macedonia

Asociación entre el índice de masa corporal, la relación músculo-grasa y la relación fuerza de prensión manual-IMC con la aptitud física en niños de Macedonia del Norte

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Abstract

Background: this cross-sectional study, conducted on a convenience sample of 2197 Macedonian primary school children, aimed to examine how certain anthropometric indices (body mass index (BMI), muscle-fat ratio (MFR), hand grip strength-BMI ratio) are related to the physical fitness of individuals.

Methods: the sample was split into two groups based on gender: 1096 boys and 1101 girls (average age 8.1 ± 1.3 years). Data on anthropometric measurements (BMI, MFR) were taken and the physical fitness was measured with the following tests: sit and reach, handgrip strength, standing long jump, sit-ups 30 sec., shuttle run 4 x 10 m, and 20 meters shuttle-run test (20-mSRT).

Results: the findings from the study indicate that children with normal weight exhibit superior levels of cardiorespiratory, muscular, and motor fitness in comparison to those who are categorized as obese, irrespective of gender. Both muscle-to-fat ratio (MFR), and grip strength-to-BMI ratio showed correlation with most fitness tests. Grip strength-to-BMI ratio showed a positive correlation with the results of the handgrip test in boys and girls.

Conclusion: in this population, BMI, MFR, and handgrip strength-to-BMI ratio can serve as indicators of health and physical fitness.

Keywords:

Body composition. Physical fitness. Children. Physical activity.

Resumen

Introducción: este estudio transversal, realizado en una muestra de conveniencia de 2197 niños de escuelas primarias de Macedonia, tiene como objetivo examinar cómo ciertos índices antropométricos (índice de masa corporal (IMC), relación músculo-grasa (MFR), relación fuerza de agarre manual-IMC) están relacionados con la aptitud física de los individuos.

Métodos: la muestra se dividió en dos grupos según el género: 1096 niños y 1101 niñas (edad promedio: 8,1 ± 1,3 años). Se tomaron datos sobre mediciones antropométricas (IMC, MFR) y la aptitud física se midió con las siguientes pruebas: dedos-planta *(sit and reach),* fuerza de agarre manual, salto de longitud de pie, abdominales durante 30 segundos, carrera de ida y vuelta de 4 x 10 m y prueba de carrera de ida y vuelta de 20 metros (20-mSRT).

Resultados: los hallazgos del estudio indican que los niños con peso normal exhiben niveles superiores de aptitud cardiorrespiratoria, muscular y motora en comparación con los que se clasifican como obesos, independientemente del género. Tanto la relación músculo-grasa (MFR) como la relación fuerza de agarre-IMC mostraron correlación con la mayoría de las pruebas de aptitud física. La relación fuerza de agarre-IMC mostró una correlación positiva con los resultados de la prueba de agarre manual en niños y niñas.

Conclusión: en esta población, el IMC, la MFR y la relación fuerza de agarre manual-IMC pueden servir como indicadores de salud y aptitud física.

Palabras clave:

Composición corporal. Aptitud física. Niños. Actividad física.

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INTRODUCTION

The escalation of obesity rates among children and adolescents is a significant global health issue that is increasingly prevalent in low- and middle-income nations (1). Furthermore, numerous high-income countries are also grappling with elevated levels of obesity within their young populations.

Research suggests that childhood obesity is a risk factor for obesity in adulthood. This phenomenon is linked to various health conditions such as cardiometabolic disorders and psychological challenges. Children who are afflicted with obesity face an elevated risk of premature death (2-4).

Public health issues are exacerbated by prolonged sedentary behavior, reliance on modern technology, poor dietary choices, inadequate physical fitness, and insufficient quality sleep. These factors play a significant role in the development and exacerbation of these health challenges (5). Due to this rationale, it is imperative to enhance capabilities in formulating policies and developing interventions, strategies, and educational initiatives aimed at enhancing physical activity, physical fitness, and fostering awareness to mitigate sedentary behavior through monitoring systems encompassing various parameters. The implementation of physical activity monitoring is widespread across most European Union countries. Only a limited number of countries within the EU have established structured systems for the ongoing monitoring of physical fitness and body composition in children and adolescents. Field fitness assessments offer a means to consistently assess different aspects of physical fitness such as musculoskeletal strength, cardiovascular endurance, motor skills, and body composition. This enables a thorough assessment of an individual's overall physical fitness levels and assists in pinpointing areas that may need enhancement or additional training.

This allows for a comprehensive assessment of an individual's overall physical fitness levels in a real-world setting. However, the process of standardizing this data in order to create benchmarks for health indicators poses a significant challenge.

The body mass index (BMI) has been widely utilized as a primary indicator of obesity for numerous years (6). It serves as a prevalent method for evaluating an individual's weight status. However, it has limitations as it does not take into account the distribution of body fat and fails to differentiate between fat and lean mass components. The pursuit of innovative markers and equations for assessing body fat is presently ongoing in order to improve the accuracy of evaluating health risks and to provide an alternative to relying solely on body mass index (BMI). The ongoing search for new indicators and formulas to assess body fat aims to enhance the precision of evaluating health risks and provide an alternative to using body mass index. Various methods exist for evaluating body composition, such as body adiposity index (BAI), relative fat mass (RFM), waist-to-height ratio (WHtR), muscle-to-fat ratio (MFR), waist–BMI ratio, and handgrip strength-to-BMI ratio.

These methods have the ability to provide more insight into a person's physical health status and could improve the traditional techniques for evaluating body composition. Handgrip strength-to-BMI ratio is a key factor in evaluating an individual's general health and physical fitness. In field tests, it is advisable and efficient to assess the handgrip strength-to-BMI ratio, in addition to the standard BMI measurement. This approach provides valuable insights into the physical health and muscular strength of individuals, enhancing the overall understanding of their fitness levels. This enables a thorough evaluation of not only physical fitness but also overall health. Furthermore, multiple research studies have indicated the potential benefits of using alternative metrics, like the muscle-fat ratio (MFR), that are currently underutilized in clinical practice. The muscle-to-fat ratio (MFR), is a measurement that compares the amount of skeletal muscle mass to the percentage of fat in the body. This method is based on accurate body composition assessments and is commonly viewed as the primary marker of reduced muscle mass.

The aim of this research is to examine how body mass index, muscle-to-fat ratio (MFR), handgrip strength-to-BMI ratio, and physical fitness components are related in young individuals from Macedonia, particularly looking at differences between males and females. This research aims to contribute to our understanding of how these factors influence physical fitness levels in this specific demographic group.

METHODS

PARTICIPANTS

The study included 2197 children from 9 primary schools in the Skopje region of North Macedonia. The sample was split into two groups based on gender: 1096 boys and 1101 girls (average age 8.1 ± 1.3 years). The research involved students who had parental consent, were physically healthy, and consistently attended physical and health education classes. The participants were cared for following the guidelines of the Helsinki Declaration. The protocols received approval from the Ethics Committee at the University of Ss Cyril and Methodius in Skopje.

OUTCOME MEASURES

The anthropometric measurements were carried out according to the methodology of the International Biological Program (IBP). The Tanita BC/418MA model digital scale was used to measure weight under standard conditions, with a measurement precision of 0.10 kg. The measurements were taken in the morning prior to eating, with the participants wearing light clothing.

The students' heights were measured in a standing position without shoes using a stadiometer with a measurement precision of 0.1 cm. The body mass index was calculated by dividing each child's weight in kilograms by the square of their height in meters.

The body composition components are determined by the bioelectrical impedance method (the measurement is carried out using the Body Composition Monitor, model "Tanita BC-418MA",

single frequency [50 Hz]). Before starting the measurement, the following parameters are entered in the Body Composition Monitor: gender, age and body height of the participant. The instrument used in this study has been compared with the DXA method (which is the gold standard) in mixed populations of children and adults and it has shown satisfactory measurement characteristics (7) MFR was calculated as the ratio of skeletal muscle mass (SMM) to the fat component (MFR = SMM [kg] / fat mass [kg]).

The study utilized the national battery "MAKFIT" (8) to evaluate physical fitness levels. This battery is an adapted version of the ALPHA fitness battery, specifically designed for assessing the physical fitness related to health in children and adolescents (9). All fitness tests were administered by researchers, and the order in which they were administered is as follows:

Sit and reach test

With the subject seated on the floor and using a standardized support, the maximum distance reached with the tip of the fingers by forward flexion of the trunk is measured. Test indicative of amplitude of movement or flexibility.

Test for hand grip strength

The maximum grip strength for both hands was measured using a digital Takei TKK 5101 dynamometer, which has a range of 1-100 kg.

Long jump standing test

The maximum horizontal distance achieved with feet together was measured. This evaluation assesses the explosive power of the legs.

Sit-ups for 30 seconds

The highest number of sit ups completed within a 30 second time frame. This assessment evaluates the strength of the muscles in the abdomen.

Shuttle run: 4 × 10 meters

This test provides an integral evaluation of the speed of movement, agility and coordination. The subject does four shuttle runs as fast as possible between 2 lines 10 meters apart. At each end the subject places or picks up an object (a sponge) beside the line on the floor.

20 meters shuttle-run test

Cardiorespiratory fitness (CRF) was measured using the 20-mSRT. Children had to run back and forth between two lines that were 20 meters apart for this exam. A pre-recorded tape was used to emit a sound signal to control the speed of running. The rate at which the sound signals were emitted was raised in a way that the running speed increased by 0.5 km/hour every minute from the initial speed of 8.5 km/hour.

Handgrip strength-to-BMI ratio

It was estimated with the handgrip strength (kg) and BMI (kg/m^2).

DEFINITION OF WEIGHT STATUS

This study categorized participants into three groups based on their weight status: normal weight, overweight, and obesity. Participants were grouped based on the BMI (kg/m^2) cut-off points specific to age and gender on a global scale (10). These guidelines have been specifically developed for children and teenagers between the ages of 2 and 18, broken down by gender and age groups. Groups of individuals who are 0.5 years apart in age. The cut-off values are determined by the percentiles achieved at 18 years of age with a BMI of 18.5 kg/m^2 for those who are underweight, 25 kg/m^2 for those who are overweight, and 30 kg/m^2 for those who are considered obese (10).

STATISTICAL ANALYSIS

The data were depicted in the form of frequencies with corresponding percentages for categorical variables, and in terms of the mean with the standard deviation for continuous variables. A Kolmogorov-Smirnov test was employed to validate the assumption of normal distribution for the variables under study. Gender disparities in physical fitness and body measurements were examined using a one-way analysis of variance (ANOVA). The χ^2 test was employed to analyze categorical data pertaining to weight status.

Adjustment for age was performed using analysis of covariance (ANCOVA) to examine differences in fitness level among weight status groups. Because a significant interaction was found for weight status and gender in relation to all fitness tests ($p < 0.05$), all the analyses were performed separately for girls and boys. Bonferroni's corrections were employed for comparing pairs.

Pearson's partial correlation was used to analyze the relationship between physical fitness tests and anthropometric indicators MFR and handgrip strength-to-BMI, while controlling for age.The analysis was conducted using the Statistical Package for Social Sciences software (SPSS, Version 26.0 of Windows) significance was determined by values of $p < 0.05$

RESULTS

Table I displays the characteristics of the participants in the study separated by gender. From the table review, it can be seen

that boys have a higher percentage of muscle mass, a higher muscle mass expressed in kilograms and handgrip strength-to-BMI ratio ($p < 0.001$). Also, boys show better results in all physical fitness tests ($p < 0.001$), except for the sit and reach test ($p < 0.001$), compared to girls. The distribution of the normal state, overweight and obesity in children, assessed by BMI, in relation to gender is also shown in table I. The values of the χ^2 test ($\chi^2 = 6.62$; $p = 0.037$) indicate that there are statistically significant differences in the degree of nutrition among boys and girls of this age. The percentage values show that a higher percentage of girls are classified as overweight (21.5 % boys vs. 25.1 % girls), while a higher percentage of boys are classified as obese (15.7 % boys vs. 12.6 % girls).

For the purposes of further analysis, the participants were classified into three distinct groups, based on the percentile values of the body mass index, according to the IOTF standard, and the differences in status between the three groups were tested with a one-factor age-controlling univariate analysis of covariance (age was treated as fixed covariance) in order to neutralize its potential impact on the analysis. The results are shown in tables II and III. In both sexes, statistically significant differences were established in all the tests for assessing the fitness components between the groups of participants formed on the basis of BMI classification, except for the sit and reach fitness test. From the values of the arithmetic properties and the level of statistical significance in table II, it can be seen that boys with normal body weight achieve lower results in the handgrip dynamometry test compared to overweight and obese subjects ($p < 0.00$), and better results in the standing long jump, shuttle run 4 x 10 m and 20 meters shuttle-run test (20-mSRT) ($p < 0.00$) tests. In the sit-ups 30 sec test, no statistically significant differences between boys with normal and overweight body weight were established. Overweight boys scored better in all fitness tests (except the handgrip test) than boys classified as obese. The review of table III, shows that girls with normal body weight achieve lower results in the handgrip test compared to overweight and obese girls ($p < 0.00$), and better results in all other fitness tests ($p < 0.000$). Overweight girls achieve better results in fitness sit-ups 30 sec, and shuttle run 4 x 10 m. tests, compared to girls classified as obese.

Table IV illustrates the association between anthropometric indices and physical fitness parameters in consideration of gender. The analysis of the data presented in the table reveals a statistically significant positive association between MFR and the standing long jump test, sit-ups for 30 seconds, and shuttle run for 4 x 10 meters, 20 meters shuttle-run test (20-mSRT) laps and 20 meters shuttle-run test (20-mSRT) meters in both males and females. The analysis revealed that there was no statistically significant correlation observed between the muscle-to-fat ratio (MFR) and the sit and reach test. Moreover, a study found a significant negative correlation between muscle-to-fat ratio (MFR) and performance on the handgrip test. On the other hand, a positive and statistically significant correlation was discovered between grip strength-to-BMI and all components used to assess physical fitness in both males and females.

Table I. Characteristics of the study sample by gender

	Boys		Girls		*p**
	Mean	**SD**	**Mean**	**SD**	
Height (cm)	133.52	9.64	133.18	10.07	0.207
Weight (kg)	34.02	10.29	33.10	9.56	0.014
Body fat (%)	23.61	7.79	22.76	8.15	0.015
Fat mass (kg)	8.58	5.24	8.10	4.97	0.021
Fat-free mass (kg)	25.44	5.79	25.00	5.33	0.026
Muscular mass (%)	30.41	3.26	29.97	2.63	*0.000*
Muscular mass (kg)	10.48	3.66	9.99	3.15	*0.000*
Muscle-fat-ratio	1.48	0.68	1.55	0.76	0.021
BMI (kg/m^2)	18.76	3.64	18.36	3.30	0.006
Grip-to-BMI	0.75	0.18	0.69	0.18	*0.000*
Sit and reach (cm)	14.37	6.33	17.63	6.02	*0.000*
Handgrip (kg)	13.84	3.60	12.55	3.53	*0.000*
Standing long jump (cm)	114.23	23.94	100.98	22.04	*0.000*
Sit-ups 30 sec. (*n*)	13.88	5.38	11.27	5.36	*0.000*
Shuttle run 4 x 10 m	14.80	1.97	15.70	1.95	*0.000*
20-mSRT (stg)	3.81	1.58	3.13	1.13	*0.000*
20-mSRT (meters)	543.42	278.00	420.20	187.86	*0.000*
Normal weight†	688	62.80 %	686	62.30 %	
Overweight	236	21.50 %	276	25.10 %	
Obese	172	15.70 %	139	12.60 %	*0.037*

**p < 0.001 for difference between boys and girls (ANKOVA); †p < 0.05 for difference between boys and girls (chi-square tests); ns: non-significant.*

Table II. Significance of differences in physical fitness components in the various BMI categories in the boys

	Normal weight		Overweight		Obese		F	Sig.	*Post hoc* pairwise
	M	SD	M	SD	M	SD			
Sit and reach (cm)	14.5	6.3	15.0	6.5	13.3	6.2	3.1	0.045	ns
Handgrip (kg)	12.9	3.4	14.5	3.7	15.5	3.9	49.0	*0.000*	1 & 2; 1 & 3; 2 & 3
Standing long jump (cm)	116.8	24.5	112.1	21.9	100.0	21.5	51.6	*0.000*	1 & 2; 1 & 3; 2 & 3
Sit-ups 30 sec. (*n*)	14.3	5.3	13.9	5.3	11.0	5.9	37.2	*0.000*	1 & 3; 2 & 3
Shuttle run 4 x 10 (m)	14.6	2.0	15.0	2.0	15.6	1.8	33.1	*0.000*	1 & 2; 1 & 3; 2 & 3
20-mSRT (stg)	4.2	1.6	3.4	1.3	2.6	0.9	115.4	*0.000*	1 & 2; 1 & 3; 2 & 3
20-mSRT (meters)	608.7	289.8	472.7	217.0	328.4	148.1	121.8	*0.000*	1 & 2; 1 & 3; 2 & 3

1 = normal weight; 2 = overweight; 3 = obese.

Table III. Significance of differences in physical fitness components in the various BMI categories in the girls

	Normal weight		Overweight		Obese		F	Sig.	*Post hoc* pairwaise
	M	SD	M	SD	M	SD			
Sit and reach (cm)	17.7	5.9	17.5	6.2	17.4	6.3	0.1	0.875	ns
Handgrip (kg)	11.7	3.2	13.2	3.8	13.6	3.7	28.0	*0.000*	1 & 2; 1 & 3; 2 & 3
Standing long jump (cm)	104.0	22.1	95.3	20.8	90.9	19.5	33.1	*0.000*	1 & 2; 1 & 3
Sit-ups 30 sec. (*n*)	11.9	4.9	10.6	5.5	8.3	5.8	32.5	*0.000*	1 & 2; 1 & 3; 2 & 3
Shuttle run 4 x 10 (m)	15.5	1.9	16.0	1.9	16.6	2.1	21.8	*0.000*	1 & 2; 1 & 3; 2 & 3
20-mSRT (stg)	3.4	1.2	2.7	0.9	2.5	0.8	58.9	*0.000*	1 & 2; 1 & 3
20-mSRT (meters)	457.0	195.9	352.0	145.1	317.1	129.4	60.6	*0.000*	1 & 2; 1 & 3

1 = normal weight; 2 = overweight; 3 = obese.

Table IV. Relationship between physical fitness parameters and anthropometric status based on muscle-fat-ratio, handgrip strength-to-BMI and body mass index

Boys*	**Muscle-fat ratio**		**Grip strength-to-BMI**		**Body mass index**	
	R	***p***	**R**	***p***	**R**	***p***
Sit and reach (cm)	-0.042	0.181	0.138	0.000	-0.021	0.468
Handgrip (kg)	-0.086	0.007	0.663	0.000	0.353	0.000
Standing long jump (cm)	0.293	0.000	0.509	0.000	-0.291	0.000
Sit-ups 30 sec. (*n*)	0.237	0.000	0.444	0.000	-0.237	0.000
Shuttle run 4 x 10 m	-0.242	0.000	-0.440	0.000	0.256	0.000
20-mSRT (stg)	0.346	0.000	0.435	0.000	-0.445	0.000
20-mSRT (meters)	0.362	0.000	0.447	0.000	-0.457	0.000
Girls*	**R**	**p**	**R**	**p**	**R**	**p**
Sit and reach (cm)	0.023	0.469	0.086	0.005	-0.009	0.777
Handgrip (kg)	-0.150	0.000	0.668	0.000	0.354	0.000
Standing long jump (cm)	0.294	0.000	0.438	0.000	-0.264	0.000
Sit-ups 30 sec. (*n*)	0.215	0.000	0.373	0.000	-0.262	0.000
Shuttle run 4 x 10 m	-0.161	0.000	-0.367	0.000	0.192	0.000
20-mSRT (stg)	0.319	0.000	0.382	0.000	-0.342	0.000
20-mSRT (meters)	0.333	0.000	0.406	0.000	-0.358	0.000

**Pearson's partial correlation, controlling for age.*

DISCUSSION

The findings of the study indicate that the weight status determined by the body mass index, as well as the muscle-to-fat ratio (MFR), and the handgrip strength-to-BMI ratio, are linked to aspects of physical fitness and can serve as health markers for this particular group. Additionally, the relation between the handgrip strength-to-BMI ratio and the muscle-to-fat ratio (MFR), indicated statistically important correlations with the cardio-respiratory fitness, the explosive force of the lower limbs the force of the abdominal musculature and the speed, agility and coordination in both sexes. There is a positive correlation between the handgrip strength-to-BMI ratio, as indicated by the absolute values obtained from the handgrip dynamometry test. Even though prior studies suggested that body mass index could help in identifying weight status, the findings of this study show that using other body composition indices such as muscle-to-fat ratio (MFR), and the relationship handgrip strength-to-BMI ratio, can also be useful indicators for assessing physical fitness in children. The research results revealed that the normal weight children, regardless of their sex, have a higher level of cardio-respiratory, muscular and motor fitness compared to the children classified as overweight. Contrary to this, the overweight children exhibit better results in the absolute values obtained from the handgrip dynamometry test in comparison to the normal weight children. The percentage of normal-weight children in this study amounted 62 %, while 23 % and 14 % of the children were overweight or obese. This indicated that although children have compulsory three school classes of physical education per week, 38 % of the respondents exhibited high level of the body mass index (BMI). The results of this research confirm the previous researches of the correlation between the weight status classified on the basis of the body mass index (BMI) and the physical fitness (11-15). Further, the results indicate a correlation of the higher level of absolute muscle force assessed by the handgrip dynamometry test with the overweight or obesity status, which was more prominent among boys. These findings are consistent with the study of Fernandez et al. (16) and Elezi et al. (17), where it is concluded that the handgrip force is in positive correlation with the body mass index (BMI).

Thus, besides the positive relation between the handgrip force with the high body mass index (BMI), as well as the good cardio-respiratory, muscular and motor fitness with the optimal value of the body mass index (BMI), the data referring to the body composition should also be taken into consideratio when the relations between the physical fitness and the health-related results are researched.

Although the body mass index (BMI) is the most frequently used indicator of the assessment of the weight status in children and adolescents (10,18), this indicator does not make any difference between the fat and non-fat component (19) and cannot determine the amount of fats in the body (20). Therefore, the muscle-to-fat ratio (MFR), and the handgrip strength-to-BMI ratio,can be good alternative indices, able to solve some limitations of the body mass index (BMI).

In one of the first studies in which the relation between the body mass index (BMI), the muscle-to-fat ratio (MFR), and the relation between the handgrip strength-to-BMI ratio, with the components of the physical fitness in Spanish children and adolescents was researched, it was concluded that the muscle-to-fat ratio (MFR) was in direct correlation with the cardiorespiratory fitness (CRF) and the vertical jump test, but not with the handgrip grip force in both boys and girls. The correlation between the handgrip strength-to-BMI ratio, were positive with the components of physical fitness in both sexes observed in the course of three years (21). Also, some researches indicated that the muscle fat ratio can be a potential indicator of type 2 diabetes, a metabolic syndrome and hypertension in adults (22-24). Steffl et al., Gontarev et al., and Bekolli et al. indicate that the handgrip strength-to-BMI ratio can be used in the identification of children exposed to the development of sarcopenic obesity (25-27). Zadarko-Domaradzka et al. (28) researched the influence of six indicators (relative fat mass, the relation of waist and the body mass index (BMI), triponderal mass index, the relation between the waist and the height, the waist, the ratio between the hips and the body mass index) in predicting cardio-respiratory fitness (CRF) in school aged children. Considering the children's sex and age, regression models indicated that the relative fat mass pediatric (RFMp) was in its highest relation with the cardiorespiratory fitness.

The outcomes of the studies conducted by Manzano-Carrasco (21) and Zadarko-Domaradzka et al. (28), and the results of this study indicate that the body mass index (BMI) and some other anthropometric indices can be taken into consideration upon the assessment of the physical fitness and health in children and adolescents. Therefore, more studies carried out on large number of children and adolescents are necessary, as they will provide additional proofs about whether the weight status is to be considered only through the body mass index (BMI) or if some other anthropometric indicators as muscle-to-fat ratio (MFR), and the handgrip strength-to-BMI ratio, and maybe some other indices can be used as well.

In our opinion, the strength of this study is the inclusion of other anthropometric indices in the context of determination of their connection with some components of physical fitness. The relatively large sample of respondents and the use of a standardized measuring procedure. However, the study has some methodological limitations, all participants originate from the same region in the country; therefore the forthcoming researches have to include data collected from other regions and other age groups, in order to confirm the results. Also, the study is of transversal character, which makes it impossible to determine the causal connection. The research did not take into account certain variables (the socio-economic status, the ethnicity, the physical activity and the nutrition habits), which can have some impact on the obtained results. Although the bioelectrical impendance method can be a good tool in the evaluation of the body composition, the forthcoming researches should possibly include the use of more sophisticated and more precise instruments (DEXA, MIR and CT) in order to confirm the results obtained in this research.

CONCLUSIONS

The findings of this study suggest that weight status, taken from the percentile values of the body mass index (BMI), as well as the muscle-to-fat ratio (MFR), and the handgrip strength-to-BMI ratio, are significantly correlated with various aspects of physical fitness and health status in children These conclusions were drawn based on the percentile values of body mass index and their relationship to these factors.

Children who have a healthy body weight demonstrate greater fitness component outcomes in comparison to children who are overweight and obese. Moreover, there was a positive correlation between the muscle-to-fat ratio (MFR), handgrip strength-to-BMI ratio, and different components of physical fitness. While numerous studies have shown that body composition analysis and determining weight status can be done using body mass index (BMI), the findings of this study suggest that utilizing additional indicators like muscle-to-fat ratio (MFR), and the handgrip strength-to-BMI ratio,can also help in identifying correlations between children's body composition and physical fitness.

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