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GENDER DIFFERENCES IN ABSOLUTE AND RELATIVE VALUES OF HAND DYNAMOMETER TEST WITH 9 AND 10-YEAR OLD CHILDREN FROM THE SKOPJE REGION IN R.N. MACEDONIA

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Abstract

Background. Handgrip strength test is applied both to adults and children to indicate muscular fitness as well as the nutritional and health status. It differs in adults and adolescents depending on the gender. However, it is not clear whether a difference exists also in children at 9 to 10 years of age, and what are the factors that influence it. The goal of the research was to determine the absolute and relative values of the hand dynamometer test with healthy Macedonian boys and girls aged 9 and 10 from the Skopje region as well as to determine the factors that affect the handgrip strength at that age.

Materials and methods. The research was conducted on a sample of 775 children (boys n = 386; girls n = 389), whereby the following characteristics were measured: handgrip strength, weight, height, body fat percentage, muscle mass percentage and the body mass index (BMI) was calculated. The maximum handgrip strength was measured with a digital Takei TKK 5101 dynamometer.

Results. The research found that there are statistically significant differences in the absolute values obtained in the hand dynamometer test between healthy boys and girls in Macedonia at 9 and 10 years of age. On the basis of the results obtained from the research, one can conclude that the results of the hand dynamometer test are affected by age, gender and body composition.

Conclusion. Based on the increasing predominance of children's obesity, the present study can provide clinicians and researchers with an insight how body composition influences muscular fitness, and can serve policy-makers to develop gender-specific strategies about body-weight management and promotion of muscular performance among children and adolescents.

Keywords: handgrip strength, dynamometer, nutrition, children, early phase of puberty.

Introduction

Physical fitness is used as a means to predict an individual health condition throughout a lifetime (Ortega et al., 2008; Artero et al., 2011; Cooper et al., 2011; Ortega et al., 2012). There is evidence that muscle fitness is associated with insulin sensitivity in children and adolescents (Benson, Torode & Singh, 2006) which is associated with a risk of type 2 diabetes mellitus (T2DM) later on in life (Sabin et al., 2015). The effect of muscle fitness is also well known in preventing some chronic diseases (Wolfe, 2006). In this regard, the handgrip strength (HGS), which is an indicator of muscle fitness, is

used in both adults and children, and also as an indicator of the nutritional status (Schlüssel, Anjos, & Kac, 2008). In fact, an association between some micronutrient deficiencies, which occurs in some situations in European young people (Valtueña et al., 2013), and HGS has been found (Bohannon, 2001). In addition, this parameter is also correlated with several diseases and clinical complications (Bohannon, 2001; Snow-Harter et al., 1990; Lamprinouidi et al., 2014; Webb et al., 1989) and can predict mortality in both adults and children (Sasaki et al., 2007; Ortega et al., 2012; Leong et al., 2015).

Currently, there are various studies proposing reference values for the hand dynamometer test, and some of them refer exclusively to young people in Europe. Unfortunately, there is not enough data about Macedonian students from

9 to 10 years of age (Gontarev et al., 2018). In the IDEFICS study, which was conducted on European children, the hand dynamometer test was used only for 9-year-old girls and boys (De Miguel-Etayo et al., 2014).

The HELENA study with the hand dynamometer test examined a large group of young people from several European countries, however they were older than 12 years (Ortega et al., 2011). Other researches provide values for the hand dynamometer test only for Spanish (Gulías-González et al., 2014) or Estonian (Semproul et al., 2007) children from 9 to 10 years of age. The reference values are necessary to identify children with malnutrition or at risk for other clinical complications, as well as to plan an appropriate treatment approach.

Furthermore, it is assumed that some anthropometric variables and indices could have an impact on the results, but currently their relationship is not clear enough. Some authors point out the effect of body height on the hand dynamometer test, in the early stage of puberty, especially in boys. A parallel increase of HGS has also been demonstrated with age (De Miguel-Etayo et al., 2014; Ortega et al., 2011; Gulías-González et al., 2014), that seems largely dependent on the increase in body mass index (BMI) and, particularly, muscle mass (Sartorio et al., 2002). However, this could simply reflect the sexual dimorphism (Loomba-Albrecht et al., 2009), due to the action of sex steroid hormones.

The goal of the research was to determine the absolute and relative values of the hand dynamometer test with healthy boys and girls at the age of 9 and 10 years from Skopje region, in R.N. Macedonia. Furthermore, in this study we wanted to determine how anthropometric measures, body composition assessment measures, age and gender affect the results of the hand dynamometer test at this age.

Materials and methods

Study Participants

The sample included 775 children from the Skopje region in North Macedonia, at 9 and 10 years of age. The sample was divided into two subsamples according to gender, with 386 male and 389 female respondents. Each of the subsamples is divided according to the chronological age into 2 age groups within a calendar year, 179 male respondents at 9 years of age and 207 male respondents at 10 years of age, 216 female respondents at 10 years of age and 173 female respondents at 9 years of age.

The study included all students whose parents agreed to participate in the study, who were psychophysically healthy and who regularly attended Physical and Health Education classes. The respondents were treated in accordance with the Helsinki Declaration (revision of Edinburgh 2013). The protocols were approved by the Ethics Committee at the Ss. Cyril and Methodius University of Skopje.

The measurements were realized in March, April and May 2019, in standard school conditions at the regular classes in Physical and Health Education.

Anthropometric measures and body composition

The anthropometric measurements were taken according to the standard methodology of the International Biological Program (IBP) and according to the recommendations of

the World Health Organization (WHO) and Weiner & Lurie (1981). Weight was measured in underwear and without shoes with a medical decimal weight scales, to the nearest 0.1 kg, and height was measured barefoot in the Frankfurt horizontal plane with a telescopic height measuring instrument (Martin's anthropometry) to the nearest 0.1 cm. Body mass index (BMI kg/m²) was calculated as weight in kilograms divided by the square of height in meters.

Components of the body composition have been determined by the method of bioelectrical impedance (measuring of the electric conductivity – Bioelectrical Impedance Analysis - BIA). The measuring was realized by a Body Composition Monitor, model "OMRON – BF511", by means of which we have measured the weight (kg), body fat percentage (BFP %) and muscular mass percent (MM %). Prior to commencing the measurement we had entered the parameters of gender, years and height of the respondent in the Body Composition Monitor. In order to provide better precision of the results obtained from the estimation of the body composition, prior to each measurement, we ensured that the preconditions recommended by ACSM (2005) and Heyward (2006) had been fulfilled.

HGS measurement

With the use of a digital Takei TTK 5101 dynamometer (range, 1-100 kg), the maximum grip strength was measured for both hands. The subject holds the dynamometer in the hand to be tested, with the arm at right angles and the elbow by the side of the body. The handle of the dynamometer is adjusted if required – the base should rest on the first metacarpal (heel of palm), while the handle should rest on middle of the four fingers. The children were instructed to squeeze the dynamometer three consecutive times with each hand as tight as possible, and the highest value (maximal value in kilograms) was used for the analyses (Haidar et al., 2004). By dividing maximal handgrip strength by BMI, the grip-to-BMI ratio was calculated.

Statistical Analysis

Data are reported as mean $\pm$ (SD). A t-test was performed to compare the means between the genders. The Pearson correlation was used to identify the variables correlated to the HGS and grip-to-BMI ratio given that the continuous variables were normally distributed according to the Kolmogorov-Smirnov test (age, weight, height, BMI, body fat percentage and muscle mass percentage). The Multivariate hierarchical linear regression analysis was used to determine the independent contributions of age, weight, height, BMI, body fat percentage percent and muscular mass percent on predicting the HGS and grip-to-BMI ratio. Significant differences were assumed to be present at $p < 0.05$ (two-tailed). All comparisons were performed using SPSS 22.0 for Windows (IBM Corporation, New York, NY, United States).

Results

Table 1 shows the significance of the differences (t-test) of the arithmetic means of the anthropometric measures, the body composition assessment measures, and the absolute and relative value obtained from the hand dynamometer fit-

Table 1. Differences in anthropometric measures. body composition assessment measures and hand dynamometer test between boys and girls at 9 years of age

Indicator	Boys (n = 179)		Girls (n = 173)		t	df	P-values	C' d
	Mean	Std.Dev.	Mean	Std.Dev.				
Age	9.42	0.29	9.46	0.30	-1.38	393.00	0.17	-0.1
Height (cm)	138.07	7.01	137.67	6.93	0.57	393.00	0.57	0.1
Weight (kg)	38.39	9.63	35.74	8.80	2.86	393.00	0.01	0.3
BMI (kg/m ²)	19.98	3.80	18.69	3.46	3.52	391.00	0.00	0.4
BFP (%)	25.62	7.86	23.09	8.62	3.02	391.00	0.00	0.3
MM (%)	31.44	2.41	30.95	2.04	2.21	391.00	0.03	0.2
Handgrip (kg)	15.08	2.90	13.84	2.59	4.50	393.00	0.00	0.5
Grip-to-BMI (kg/kg/m ²)	0.77	0.17	0.75	0.15	1.09	391.00	0.28	0.1

Table 2. Differences in anthropometric measures. body composition assessment measures and hand dynamometer test between 10-years-old boys and girls

Indicator	Boys (n = 207)		Girls (n = 216)		t	df	P-values	C' d
	Mean	Std.Dev.	Mean	Std.Dev.				
Age	10.48	0.28	10.46	0.29	0.44	378.00	0.66	0.0
Height (cm)	143.89	6.49	144.04	7.32	-0.20	378.00	0.84	0.0
Weight (kg)	42.67	11.39	40.79	10.07	1.69	378.00	0.09	0.2
BMI (kg/m ²)	20.39	4.32	19.47	3.71	2.18	376.00	0.03	0.2
BFP (%)	24.93	8.62	24.03	8.77	0.99	376.00	0.32	0.1
MM (%)	32.68	2.26	31.95	2.28	3.13	376.00	0.00	0.3
Handgrip (kg)	16.94	3.25	16.16	3.13	2.39	378.00	0.02	0.2
Grip-to-BMI (kg/kg/m ²)	0.85	0.19	0.85	0.17	0.34	376.00	0.73	0.0

ness test in boys and girls at 9 years of age. From the review of Table 1, it can be seen that there are statistically significant differences between boys and girls at 9 years of age in 5 out of 8 variables. Intergroup differences were found in the following variables: weight ($t = 2.86$; $p = .01$), body mass index ($t = 3.52$; $p = .000$), body fat percentage ($t = 3.02$; $p = .000$), muscle mass percentage ($t = 2.21$; $p = .030$) and the absolute values obtained in the hand dynamometer test ($t = 4.50$; $p = .000$). The partial effect of the determinants C' d is ranked between 0.2 and 0.5 and shows a small to medium effect. The greatest effect in determining the differences is shown by the variables of the absolute values obtained in the hand dynamometer test (C' d = 0.5).

Table 2 shows the significance of the differences (t-test) of the arithmetic means of the anthropometric measures, the body composition assessment measures, and the absolute and relative value obtained from the hand dynamometer fitness test in boys and girls at 10 years of age. The overview of Table 2 shows that there are statistically significant differences between boys and girls at 10 years of age in 3 out of 8 variables. Intergroup differences were found in the variables: body mass index ($t = 2.18$; $p = .030$), muscle mass percentage ($t = 3.13$; $p = .000$) and the absolute values obtained in the hand dynamometer test ($t = 2.39$; $p = .020$). The partial effect of the C'd determinants is ranked between 0.2 and 0.3 and shows little effect.

Table 3 shows the correlation coefficients between the absolute and the relative value obtained from the hand dynamometer fitness test and the anthropometric measures, the body composition assessment measures, age and gender.

From the overview of Table 3 it is observable that a moderately positive statistically significant correlation was found (within the range of .34 to .57) between the absolute value

obtained from the hand dynamometer fitness test and age, height, weight, body mass index, the body fat percentage and the muscle mass percentage. A statistically significant negative low correlation was established between the absolute value obtained from the hand dynamometer fitness test and gender (-.19). Moderately negative statistically significant correlation (within the range from -.29 to .38) was found between the relative value obtained from the hand dynamometer test and weight, the body mass index and the body fat percentage. Low positive statistically significant correlation (within the range from .19 to .29) was found between the relative value obtained from the hand dynamometer test and height and age. Moderately positive statistically significant correlation (.66) was found between the relative value obtained from the hand dynamometer fitness test and the muscle mass percentage. A statistically significant correlation

Table 3. Correlation between the absolute and the relative value obtained from the hand dynamometer test and the anthropometric measures, the body composition measurement measures, age and gender

Indicator	Handgrip (kg)		Grip-to-BMI (kg/kg/m ²)	
Gender	-0.19	p=.000	-0.06	p=.109
Age	0.39	p=0.00	0.29	p=.000
Height (cm)	0.57	p=0.00	0.20	p=.000
Weight (kg)	0.53	p=0.00	-0.28	p=.000
BMI (kg/m ²)	0.39	p=0.00	-0.48	p=0.00
BFP (%)	0.23	p=.000	-0.58	p=0.00
MM (%)	0.34	p=0.00	0.66	p=0.00

Table 4. Hierarchical regression analysis of the hand dynamometer test expressed in absolute values and the anthropometric measures. the body composition assessment measures. age and gender

Indicator	β	Sig	Partial r	β_1	Sig ₁
R = 0.540 R ² = 0.292***					
Age	.347	.000	.379	.169	.000
Body mass index	.343	.000	.373	.536	.001
Gender	-.116	.000	-.134	-.031	.274
R = 0.635 R ² = 0.403***					
Age	.178	.000	.200	.169	.000
Body mass index	-.007	.964	-.002	.536	.001
Gender	-.130	.000	-.163	-.031	.274
Height (cm)	.293	.000	.128	.007	.934
Weight (kg)	.272	.154	.052	.214	.000
R = 0.699 R ² = 0.488***					
Age	.169	.000	.204	.169	.000
Body mass index	.536	.001	.115	.536	.001
Gender	-.031	.274	-.040	-.031	.274
Height (cm)	.007	.934	.003	.007	.934
Weight (kg)	.214	.233	.043	.214	.233
Body fat percentage	-.220	.007	-.097	-.220	.007
Muscle mass percentage	.406	.000	.301	.406	.000

Note. Partial r – partial correlation coefficient; β – standardized partial regression coefficient; β_1 – value of β – coefficient in the last equation analysis; R – Multiple correlation coefficient; R² – change the coefficient of determination; Significance. * P < 0.05. ** P < 0.01. *** P < 0.001.

Table 5. Hierarchical regression analysis of the hand dynamometer test expressed in relative values and the anthropometric measures. the body composition assessment measures. age and gender

Indicator	β	Sig	Partial r	β_1	Sig ₁
R = 0.289 R ² = 0.083***					
Age	.284	.000	.283	.163	.000
Gender	-.038	.271	-.040	-.031	.240
R = 0.651 R ² = 0.424***					
Age	.191	.000	.219	.163	.000
Gender	-.119	.000	-.153	-.031	.240
Height (cm)	.674	.000	.506	.078	.172
Weight (kg)	-.817	.000	-.606	-.021	.792
R = 0.733 R ² = 0.538***					
Age	.163	.000	.208	.163	.000
Gender	-.031	.240	-.043	-.031	.240
Height (cm)	.078	.172	.049	.078	.172
Weight (kg)	-.021	.792	-.010	-.021	.792
Body fat percentage	-.399	.000	-.215	-.399	.000
Muscle mass percentage	.357	.000	.282	.357	.000

Note. Partial r – partial correlation coefficient; β – standardized partial regression coefficient; β_1 – value of β – coefficient in the last equation analysis; R – Multiple correlation coefficient; R² – change the coefficient of determination; Significance. * P < 0.05. ** P < 0.01. *** P < 0.001.

has not been found between the relative value obtained from the hand dynamometer fitness test and gender.

In order to determine the multivariate effects of the anthropometric measures, the body composition assessment measures, age and gender on the absolute value obtained from the hand dynamometer fitness test, a hierarchical regression analysis has been applied. The results of the regression analysis are presented in Table 4.

The first regression equation explains 29.2% (p < 0.001) of the total variability of the criterion variable, with statistically significant influence on the predictive variables years, body mass index and gender. By including both anthropometric

variables (height and weight) in the second step, the amount of the explained variance increases to 40.3% (P < 0.001), and the coefficients of the linear correlation in the equation for this system of 5 predictors with the absolute value obtained from the hand dynamometer fitness test is R = 0.635 (F = 103.11, p < 0.001). Age (β = 0.178, p < 0.001), gender (β = -0.130, p < 0.001) and height (β = 0.293, p < 0.001) are important determinants that have a significant statistical effect on the criterion variable. By including the third block of variables, the amount of the explained variance increases to 48.8% (p < 0.001). The variables age (β = 0.169, p < 0.001), body mass index (β = 0.536, p < 0.01), body fat percentage

($\beta = -0.220$, $p < 0.01$) and muscle mass percentage ($\beta = 0.406$, $p < 0.001$) have statistically significant influence on the overall predictive system. After including the third block of variables for body composition assessment, it can be seen that the variables gender, height and weight in the final regression equation become statistically insignificant.

In order to determine the multivariate effect of the anthropometric measures, the body composition assessment measures, age and gender of the relative value obtained from the hand dynamometer fitness test, a hierarchical regression analysis was applied. The results of the regression analysis are shown in Table 5. The first regression equation explains 8.3% ($p < 0.001$) of the total variability of the criterion variance, with a statistically significant effect on the predictive variable age. By including both anthropometric variables (height and weight) in the second step, the amount of the explained variance increases to 42.4% ($p < 0.001$), and the coefficients of the linear correlation in the equation for this system of 4 predictors with the relative value obtained from the hand dynamometer fitness test are $R = 0.651$, ($F = 140.90$, $p < 0.001$). Age ($\beta = 0.191$, $p < 0.001$), gender ($\beta = -0.119$, $p < 0.001$), height ($\beta = 0.674$, $p < 0.001$) and weight ($\beta = -0.817$, $p < 0.001$) are significant determinants that statistically significantly affect the criterion variable. By including the third block of variables, the amount of the explained variance increases to 53.8% ($p < 0.001$). The variables age ($\beta = 0.163$, $p < 0.001$), body fat percentage ($\beta = -0.399$, $p < 0.001$) and muscle mass percentage ($\beta = 0.357$, $p < 0.001$) have a statistically significant influence on the overall predictive system. After including the third block of variables for body composition assessment, it can be seen that the variables gender, height, and weight in the final regression equation become statistically insignificant.

Discussion

Recent scientific research suggests that physical fitness is a powerful indicator of the health status in childhood and adolescence, as well as in adulthood (Ortega et al., 2008; Cooper et al., 2011; Ortega et al., 2012). Even in children and adolescents, physical fitness is negatively correlated with cardiorespiratory diseases, high blood pressure, abdominal adiposity, total obesity, impaired skeletal health, hyperinsulinemia, insulin resistance, impaired lipid profile and metabolic risk factors (Ortega, et. al. 2008).

In this research, we give the maximum and relative HGS value of apparently healthy Macedonia school girls and boys aged from 9 to 10, from Skopje region. Furthermore, as expected, we demonstrated a significant difference in HGS performance between the genders. We also found a relation between maximum and relative HGS with the age, gender, weight, height, BMI, body fat percentage and muscle mass percentage.

The research results are significant with regard to more than one aspect. The hand dynamometer test is used as an index of physical fitness related to children's health. (Ortega et al., 2008; Vicente-Rodriguez et al., 2008; Artero et al. 2011; Ortega et al., 2012). Physical activity plays a key role in normal growth during the first phase of life and it also affects the psychosocial maturation of young people. The hand dynamometer test is also an index of the nutritional status (Schlüssel et al., 2008; Valtueña et al., 2013; Flood et al., 2014; White et al., 2012) and it is useful for examining patients with neuromuscular diseases (Wiles et al., 1990). In addition, the

test is an indicator of mortality in young people (Ortega et al., 2012). Therefore, the availability of normative data about the test may help identify children who need special dietary or pharmacological treatments or children at high risk for clinical complications (Bohannon, 2001; Snow-Harter et al., 1990; Lamprinouidi et al., 2014; Webb et al., 1989).

In a certain number of studies, such as EUROFIT and CHMS, the test result that is taken into consideration is the best result obtained from the left and the right hand, while in the studies IDEFICS and HELENA, the authors used as a test result the average value obtained from the better result of both trials with the right and the left hand. However, both methods have been shown to be very consistent, without a statistically significant difference. In this research, the methodology used in the IDEFICS and HELENA studies was applied. As it was expected, our results are very different from the results obtained in the CHMS study, conducted on Canadian children in which the hand dynamometer test was applied and where the test results were obtained between 24 and 27 kg in boys and between 21 and 24 kg in girls from 8 to 10 years of age (Tremblay et al., 2010). This data emphasizes the importance of having a reference value for different populations, which have different lifestyles, eating habits, opportunities to engage in different physical activities, as well as differences in education and training systems.

The results of our research showed that boys at 9 and 10 years of age achieve better results in absolute values obtained in the hand dynamometer test compared to girls, however when the test result is divided by the body mass index, there are no statistically significant differences between boys and girls at 9 and 10 years of age. In this regard, we found that at 9 years of age, the absolute values obtained in the hand dynamometer test were 13.8 ± 2.6 in girls and 15.1 ± 3.0 kg in boys. At 10 years of age, the absolute values obtained in the hand dynamometer test were 16.2 ± 3.1 in girls and 17.0 ± 3.2 kg in boys. At the age of 9, the relative values obtained in the hand dynamometer test were 0.75 ± 0.1 in girls and 0.77 ± 0.2 kg/kg/m² in boys. At the age of 10, the relative values obtained in the hand dynamometer test were 0.85 ± 0.2 in girls and 0.85 ± 0.2 kg/kg/m² in boys. Our results were similar to those obtained in the EUROFIT study, in which the maximum handgrip strength was 14.1 ± 2 in girls and 15.7 ± 3 kg in boys at 9 years of age and 17.1 ± 3 in boys and 16 ± 3 kg in girls at 10 years of age (Gulías-González et al., 2014). Gender differences were also identified in the in CHMS, HELENA and IDEFICS studies (Tremblay et al., 2010; Ortega et al., 2011; De Miguel-Etayo et al., 2014). The results of the research showed that the differences in the test in terms of gender disappear when the test result is expressed in relative values (the absolute result of the test divided by the body mass index - BMI), and the biggest factor that affects the differences in terms of gender are sex hormones. In fact, muscle mass is related to sex hormones and is more common in boys than in girls. In this regard, it is well known that sexual dimorphism in the body is largely due to the action of sex steroid hormones. Recent research has shown that sexual differences in body composition are manifested ever since fetal life, and the differences in estrogen and testosterone are evident before external signs of puberty appear, leading to differences in the absolute values obtained in the hand dynamometer test. However, if we look at the results, it is observable that the muscle mass percentage is the main determinant that leads to differences between boys and girls. Interestingly, at 9 years of age, boys have a higher per-

centage of adipose component than girls, and at the age of 10, differences have not been found in the percentage of adipose component between boys and girls. This suggests that in addition to sex hormones, diet and physical activity also affect body composition (Sartorio et al., 2002).

The past research has shown that the hand dynamometer test is positively related to weight, height, and body surface and that in the early stages of puberty, height may be a key factor that affects the handgrip strength (Chatterjee & Chowdhuri, 1991; Jürimäe et al., 2009; Montalcini et al., 2016). Our results are consistent with this research. However, when the multivariate hierarchical regression analysis included the body fat percentage and the muscle mass percentage as independent variables, the influence of the gender factor, height and weight disappeared. Similar results were obtained when the relative value of the hand dynamometer test (ratio of the test result and the body mass index – BMI) was used as a criterion. The result of the test is mostly determined by the variables for body composition assessment (body fat percentage and muscle mass percentage) and age.

In addition, the improvement of the result in the hand dynamometer test by increasing age can be attributed to hormonal changes over time. However, in boys, the growth hormone and testosterone have greater effects on test scores than in girls (Neu et al., 2002).

This research confirmed the need of the hand dynamometer test that will help in planning interventions aimed at improving muscle fitness, especially in children who have achieved low results in this regard. The components of prenatal, prepubertal, and pubertal growth have long-term consequences for the values in the hand dynamometer test in the middle years of life. Early interventions may help build muscle mass, which will prevent morbidity and mortality later on in life (Rudolph et al., 2013; Kulkarni et al., 2014; Battjes-Fries et al., 2015).

Unfortunately, the hand dynamometer test is not practiced in the pediatric population despite the low cost and portability of the device, hence our research suggests that in the future the hand dynamometer test will be used more often in experimental, epidemiological studies and in schools as one of the tests for assessing physical fitness related to health.

Conclusions

According to the finding in the research, there are significant differences in the absolute values obtained in the hand dynamometer test between healthy boys and girls in Macedonia at 9 and 10 years of age, from the Skopje region. Based on the results of the research, it can be concluded that the results of the hand dynamometer test are influenced by age, gender and body composition. Based on the increasing predominance of children's obesity, the present study can provide for clinicians and researcher an insight how body composition influences muscular fitness, and can also serve for police-makers to develop gender-specific strategies about body-weight management and promotion of muscular performance among children and adolescents.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article

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ГЕНДЕРНІ ВІДМІННОСТІ В АБСОЛЮТНИХ ТА ВІДНОСНИХ ЗНАЧЕННЯХ ТЕСТУ КИСТЬОВОЇ ДИНАМОМЕТРІЇ У ДІТЕЙ 9 ТА 10 РОКІВ ІЗ РЕГІОНУ СКОП'Є РЕСПУБЛІКИ ПІВНІЧНА МАКЕДОНІЯ

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 5 табл., 38 джерел.

Метою дослідження було визначити абсолютні та відносні значення тесту кистьової динамометрії у здорових македонських хлопчиків та дівчаток 9 та 10 років із регіону Скоп'є, а також визначити фактори, що впливають на силу кисті у цьому віці.

Матеріали і методи. Дослідження було проведено на вибірці з 775 дітей (хлопчиків n = 386; дівчаток n = 389), у результаті чого були виміряні такі характеристики: сила кисті, маса тіла, зріст, відсоток жиру в організмі, відсоток м'язової маси та індекс маси тіла (ІМТ). Максимальну силу кисті вимірювали цифровим динамометром Takei TKK 5101.

Результати. Дослідження показало, що існують статистично значущі відмінності в абсолютних значеннях,

отриманих під час тесту на кистьовому динамометрі, між здоровими хлопцями та дівчатами в Македонії у віці 9 та 10 років. На підставі отриманих результатів дослідження можна зробити висновок, що на результати тесту кистьової динамометрії впливають вік, стать та склад тіла.

Висновки. Дослідження може надати клініцистам та дослідникам уявлення про те, як склад тіла впливає на м'язову систему, а також може допомогти розробити гендерні стратегії щодо управління масою тіла та обсягом м'язової діяльності дітей та підлітків.

Ключові слова: сила кисті, динамометр, харчування, діти, рання фаза статевого дозрівання.

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