

## AGE AND GENDER DIFFERENCES IN ABSOLUTE AND RELATIVE VALUES OF PALM GRIP STRENGTH IN ADOLESCENTS FROM 11 TO 14 YEARS OF AGE

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(Original scientific paper)

Liridon Berkolli<sup>1</sup>, Labinot Ramadani<sup>2</sup>, Qëndresa Ramabaja<sup>2</sup>, Naser Rashiti<sup>1</sup>

<sup>1</sup> University of Prishtina, Faculty of Physical Education and Sport, Prishtina, Kosova

<sup>2</sup>Ss. Cyril and Methodius University in Skopje Faculty of Physical Education, Sport and Health

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### Abstract

*The influence of good muscular fitness is also well known in the prevention of some chronic diseases. In this regard, the palm dynamometry test, which is an indicator of muscle fitness, is used in adults and children as an indicator of nutritional status. The aim of the research was to determine the age and gender differences in absolute and relative values of palm grip strength in adolescents aged 11 to 14 years. The research was carried out on a sample of 1863 respondents. The sample is divided into two subsamples according to gender, namely 968 male respondents and 895 female respondents. In order to achieve the goals of the research, the palm dynamometry test was applied, from which the absolute and relative values were taken as the test result. (dividing maximal handgrip strength by BMI, the grip-to- BMI ratio). Based on the obtained results, it can be concluded that boys, unlike girls, in all age categories show better results in the absolute and relative values obtained from the palm dynamometry test. With the age, there is a moderate improvement in absolute and relative values in the palm dynamometry test. 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.*

**Keywords:** handgrip strength, dynamometer, grip-to- BMI ratio, adolescent

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### Introduction

Monitoring physical fitness is a powerful indicator of health status both in childhood, adolescence and also in the adulthood (Ortega, et al. 2008). Even among children and adolescents, physical fitness is negatively correlated with cardiorespiratory diseases, high blood pressure (Sallis, et al. 1998; Ruiz, et al. 2006), abdominal adiposity (Brunet, et al. 2006), the total obesity (Ruiz, et al. 2006; Ortega, et al. 2001), impaired skeletal health (Moliner-Urdiales, et al. 2010), hyperinsulinemia (Gutin, et al. 2004), insulin resistance (Gulati, et al. 2003), atherogenic profile lipids (Mesa, et al. 2006) and a large number of metabolic risk factors (Bürgi, et al. 2011; Ruiz, et al. 2006). In addition, physical fitness is related to academic performance that includes cognitive skills and attitudes (attention, memory, comprehension), academic behavior (organization, attendance, impulse control) and achievement (better achievement in knowledge tests, higher average grades) (Kohl, et al., 2013; Grissom, 2005; Welk, et al., 2010; Rasberry, et al., 2011).

The influence of good muscular fitness is also well known in the prevention of some chronic diseases (Wolfe, 2006). In this regard, the palm dynamometry test, which is an indicator of muscle fitness, is used in adults and children as an indicator of nutritional status (Schlüssel, Anjos, & Kac, 2008). In fact, an association has been found between the deficiency of some micronutrients, a condition which is common among young people in Europe, and the palm dynamometry test (Valtueña et al., 2013; Bohannon, 2001). Also, this parameter correlates with several diseases and clinical complications and can predict mortality in both adults and adolescents (Sasaki et al., 2007; Ortega et al., 2012; Leong et al., 2015).

In parallel, an increase in the values of the palm dynamometry test also occurs with increasing age, which indicates that to a large extent the results in the test depend on an increase in the body mass index (BMI), in particular, muscle mass (De Miguel-Etayo et al. 2014; Ortega et al., 2011; Guliás-González et al., 2014). However, this may simply reflect the sexual dimorphism (Loomba-Albrecht et al., 2009), as a

result of the action of sexual steroid hormones. The palm dynamometry test is widely used in experimental and epidemiological studies. Several factors affect test results, including age, gender, different angles in the shoulder joints, forearm and palm (Richards et al. 1996). Another important factor affecting grip strength is palm size. The aim of the research is to determine age and gender differences in the absolute and relative values of palm grip strength in adolescents aged 11 to 14 years.

## Methods

### *Participants*

The research was carried out on a sample of 1863 respondents. The sample is divided into two subsamples according to gender, namely 968 male respondents and 895 female respondents. Each of the subsamples is also divided according to chronological age into 4 age groups in a span of one calendar year. Chronological age is defined on the basis of decimal years (the difference between the date of measurement and the date of birth, which have been transformed into a size corresponding to the division of the year into ten instead of twelve months). Based on that, 4 age groups of males and 4 age groups of females were formed in the span of one calendar year, namely: 11 (11-11.9), 12 (12-12.9), 13 (13-13.9), 14 (14-14.9) years.

The sample included all students whose parents gave consent to participate in the project and who were psychophysically healthy and regularly attend physical and health education classes. In addition, all students who for some reason did not take all the measurements and tests or for some other reason were excluded from the analysis. Respondents are treated in accordance with the Helsinki Declaration (Helsinki Declaration of 1975, as revised in 2013).

### *HGS measurement*

With the use of a digital Takei TKK 5101 dynamometer (range, 1-100 kg), the maximum grip strength was measured for both hands. The respondent 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. When ready the respondent squeezes the dynamometer with maximum isometric effort, which is maintained for about 3 seconds. No other body movement is allowed. The respondent should be strongly encouraged to give a maximum effort. Then, the best value, whether from the right or left hand, was used as the maximal handgrip strength value. By dividing maximal handgrip strength by BMI, the grip-to- BMI ratio was calculated.

### *Statistical analysis*

Data are reported as mean  $\pm$  (SD). Differences in both absolute and relative values obtained from the palm dynamometry test determined by one-factor univariate analysis of variance (ANOVA). To determine which subsamples are statistically different from each other, the LSD test was applied to the variables where there is a statistically significant difference.

The data will be processed with statistical packages SPSS for Windows Version 26.0 (SPSS Inc., Chicago, IL, USA).

## Results

Table 1 shows the significance of the differences (t-tests) of the arithmetic means, in the absolute values obtained from the palm dynamometry test between boys and girls in each age category (from 11 to 14 years). From the review of table 1, it can be seen that in the absolute values obtained from the palm dynamometry test between boys and girls in all age categories there were statistically significant differences ( $p < 0.001$ ). From the values of the arithmetic means and the level of statistical significance, it can be seen that boys, unlike girls, in all age categories show better results in the absolute values obtained from the palm dynamometry test.

Table 2 shows the significance of the differences (t-tests) of the arithmetic means in the relative values obtained from the palm dynamometry test between boys and girls in each age category (from 11 to 14 years). From the review of table 2, it can be seen that in the relative values obtained from the palm dynamometry test between boys and girls in all age categories there were statistically significant differences ( $p < 0.001$ ). From the values of the arithmetic means and the level of statistical significance, it can be seen

that boys, unlike girls, in all age categories show better results in the relative values obtained from the palm dynamometry test.

Table 1. Gender differences within each age category in the absolute values obtained from the palm dynamometry test

Years	Boys		Girls		T-test	P
	Mean	SD	Mean	SD		
11 years	20,43	4,42	18,30	4,19	32,19	0,000
12 years	23,56	5,11	21,68	4,22	17,94	0,000
13 years	28,75	6,59	23,87	4,38	82,81	0,000
14 years	35,56	7,43	25,77	4,79	265,23	0,000

Table 2. Gender differences within each age category in the relative values obtained from the palm dynamometry test

Years	Boys		Girls		T-test	P
	Mean	SD	Mean	SD		
11 years	1,02	0,22	0,94	0,20	15,08	0,000
12 years	1,15	0,26	1,07	0,21	10,52	0,001
13 years	1,37	0,33	1,15	0,25	57,59	0,000
14 years	1,61	0,34	1,19	0,25	212,72	0,000

In order to determine if there were statistically significant differences in the absolute and relative values obtained from the palm dynamometry test between the different age categories in both genders, a one-factor univariate analysis of variance was calculated. From the review of table 3, it can be seen that there were statistically significant differences in the absolute values obtained from the palm dynamometry test between boys aged 11 to 14 years ( $F=302,74$ ;  $p=0,000$ ).

Table 3. Differences in the absolute values obtained from the palm dynamometry test between boys of different age categories

	Mean	SD	F	P
11 years	20,43	4,42	302,74	0,000
12 years	23,56	5,11		
13 years	28,75	6,59		
14 years	35,56	7,43		

From the review of table 4, it can be seen that there were statistically significant differences in the relative values obtained from the palm dynamometry test among boys from 11 to 14 years of age ( $F=197,27$ ;  $p=0,000$ ).

Table 4. Differences in the relative values obtained from the palm dynamometry test between boys of different age categories

	Mean	SD	F	P
11 years	1,02	0,22	197,27	0,000
12 years	1,15	0,26		
13 years	1,37	0,33		
14 years	1,61	0,34		

Table 5. Differences in the absolute values obtained from the palm dynamometry test between girls of different age categories

	Mean	SD	F	P
11 years	18,30	4,19	124,45	0,000
12 years	21,68	4,22		
13 years	23,87	4,38		
14 years	25,77	4,79		

From the review of table 5 it can be seen that there were statistically significant differences in the absolute values obtained from the palm dynamometry test between girls from 11 to 14 years of age ( $F=124,45$ ;  $p=0,000$ ).

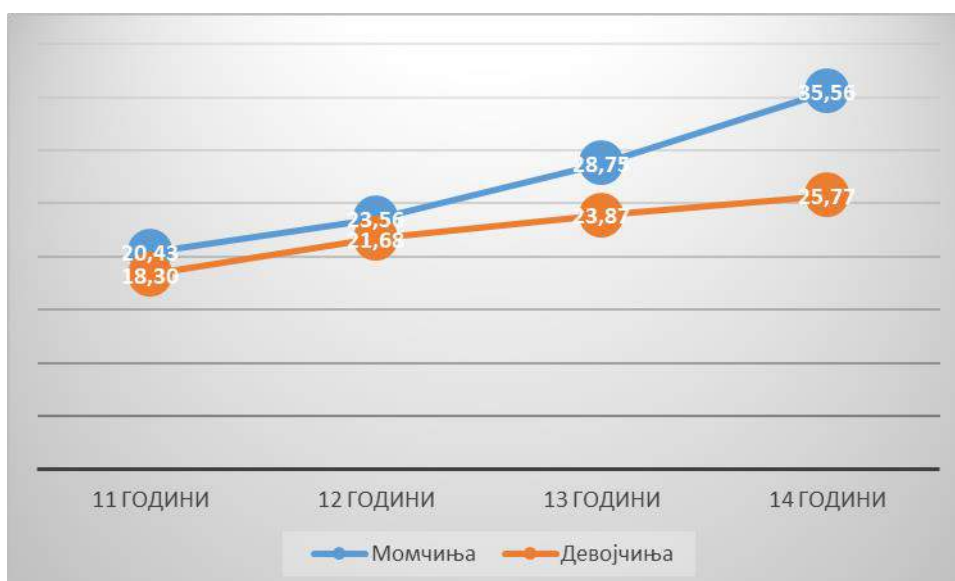
From the review of table 6, it can be seen that there were statistically significant differences in the relative values obtained from the palm dynamometry test between the girls from 11 to 14 years of age ( $F=54,82$ ;  $p=0,000$ ).

Table 6. Differences in the relative values obtained from the palm dynamometry test between girls of different age categories

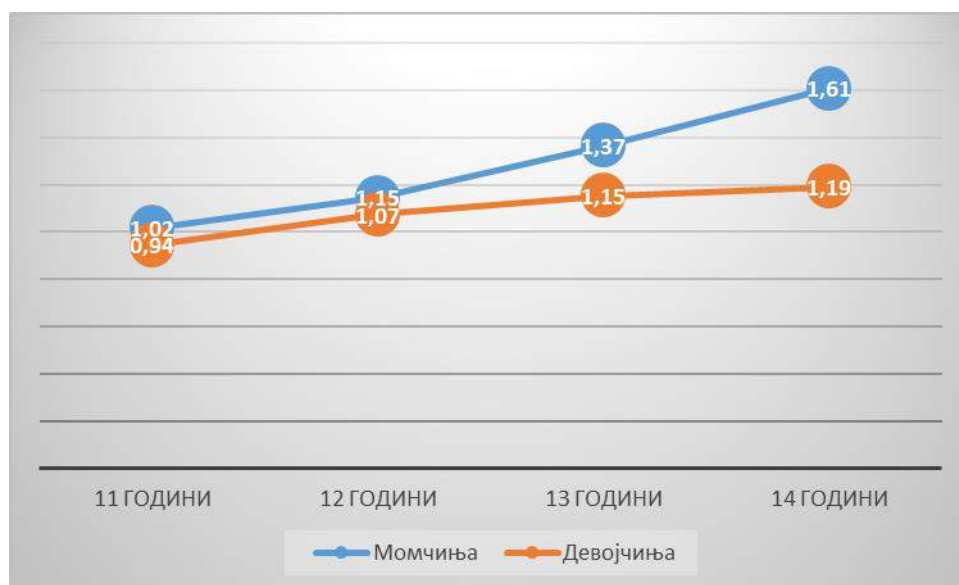
	Mean	SD	F	P
11 years	0,94	0,20	54,82	0,000
12 years	1,07	0,21		
13 years	1,15	0,25		
14 years	1,19	0,25		

In order to determine which age categories among male and female respondents there are statistically significant differences in the absolute and relative values obtained from the palm dynamometry test, post hoc tests (LSD - least significant difference test) were also applied. From the values of the LSD tests (tables 7 and 8) it can be seen that significant statistical differences in the absolute and relative values obtained from the palm dynamometry test were determined in both genders in all adjacent age groups, except between the 13th and 14th year, among girls in the relative values obtained from the palm dynamometry test.

Graph 1. Developmental trend in the absolute values obtained from the palm dynamometry test among students from 11 to 14 years old



Graph 2. Developmental trend in the relative values obtained from the palm dynamometry test among students from 11 to 14 years old



## Discussion

The palm dynamometry test is simple, economical and provides information about muscles, nerves, bones or their joint disorders. The results of the AVENA study show a negative association between hand grip strength and total cholesterol levels, LDL cholesterol levels and other metabolic risk factors. (Ortega et al., 2005).

The palm dynamometry test is also an index of nutritional status and is useful for examining patients with neuromuscular diseases. In addition to that, the test is an indicator of mortality in young people. (Sasaki et al., 2007; Ortega et al., 2012; Leong et al., 2015). Therefore, the availability of normative data for the test may help identify children who need special dietary or pharmacological treatments or children who are at high risk of clinical complications.

Based on the results obtained from our research, it can be concluded that boys, unlike girls, in all age categories show better results in the absolute and relative values obtained from the palm dynamometry test, and these differences are most pronounced at the age of 14 (boys on average they achieve better results in absolute values by 9.79 kg, and in relative values by 0.42 kg in contrast to girls), the smallest differences in absolute values from the test are determined at the age of 12 (boys achieve better results on average by 1.88 kg, compared to girls). The smallest differences in the relative values obtained from the palm dynamometry test were determined at the age of 11 and 12 years (boys achieve better results by 0.07 kg on average, compared to girls). Gender differences in adolescence combined with the effects of endocrine adaptation (influence of gonadal steroid hormones and growth hormone) typical of sexual maturation, morphological difference, initially in body composition (in boys it increases the content of minerals in bones and muscle mass and reduces fat deposition around the hips), functional differences and physical activity are the main factors for differences in strength abilities during adolescence in boys and girls (Bonjour et al., 1991; Rogol et al., 2002). From the trend of the curve (Graph 1) it can be seen a constant moderate improvement of the absolute and relative values of the palm dynamometry test with increasing age in both genders. The average increase in the absolute values obtained from the palm dynamometry test in boys between the ages of 11 and 14 is 5.04 kg, while the relative values are 0.20 kg. The average increase in the absolute values obtained from the palm dynamometry test in girls between the ages of 11 and 14 is 2.49 kg, while the relative values are 0.08 kg. In boys, the greatest acceleration of the absolute and relative values obtained from the palm dynamometry test is shown between the ages of 13 and 14, when the boys improve the result in the absolute values obtained from the test by 6.81 kg on average, while in the relative values obtained in the test, on average improve the result by 0.24 kg. Among girls, the greatest acceleration of the absolute and relative values obtained from the palm dynamometry test is shown between the 11th and 12th years, when girls improve the result in the absolute values obtained from the test by 3.38 kg on average, while in the relative values obtained in the test, on average improve the result of 0.213 kg.

Unfortunately, the palm dynamometry test is not practiced in the pediatric population despite the low cost and portability of the device, so our research suggests that in the future the palm dynamometry test should be more frequently applied in experimental, epidemiological studies and in schools as one of the tests for assessing health-related physical fitness.

## Conclusion

Based on the research results, it can be concluded that the results of the palm dynamometry test in adolescents are influenced by age and gender. Boys, unlike girls, in all age categories show better results in the absolute and relative values obtained from the palm dynamometry test. With age there is a moderate improvement in absolute and relative values in the palm dynamometry test. 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.

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