

REGRESSIVE RELATIONSHIP OF ANTHROPOMETRIC MEASURES, BODY COMPOSITION AND AGE ON THE RESULTS OF THE PALM DYNAMOMETRY TEST IN ADOLESCENTS

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(Original scientific paper)

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Abstract

Background: Handgrip strength is an index of nutritional status which correlates to morbidity and mortality in young. It differs in adults and adolescents between gender. However, it is not clear whether a difference exists also in children aged 11 to 14 years, and which are the factors influencing it. Furthermore, data of Handgrip strength of Macedonian children are lacking. The aim of the research was to determine how anthropometric measures, body composition assessment measures and age affect the results of the palm dynamometry test in male and female respondents aged 11 to 14 years. **Methods:** The research was conducted on a sample of 1863 children (boys n = 968; girls n = 895), 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:** Based on the obtained results, it can be concluded from the research that in adolescents, the results of the palm dynamometry test are influenced by age 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 adolescents.

Keywords: handgrip strength, dynamometer, nutrition, children, puberty

Introduction

Physical fitness can be objectively and accurately measured through laboratory methods, but due to the high cost, the necessity of sophisticated equipment, qualified professional staff, time constraints, laboratory tests cannot yet be used at the population level. In contrast, field fitness tests are easy to administer, they involve minimal equipment, can test a large number of respondents simultaneously, and can be evaluated in a short period of time. (Paineau, 2008; Rodriguez, 2005; Ruiz, 2009). In the school environment, field tests are an economical and practical option for assessing the level of physical fitness of students.

Currently, there are various studies, with a proposal of reference values, for the palm dynamometry test, and some of them refer exclusively to young people in Europe. In the IDEFICS study, which was carried out in European children, the palm dynamometry test was investigated in girls and boys aged 6 to 9 years (De Miguel-Etayo et al., 2014).

In the HELANA study, the palm dynamometry test was applied to a large group of young people from several European countries, but they were older than 12 years (Ortega et al., 2011). Other surveys provide palm dynamometry test values only for Spanish (Gulías-González et al., 2014) or Estonian (Semproli et al., 2007) children aged 9 to 10 years. Reference values are necessary to identify children with malnutrition or which are at risk of other clinical complications, as well as to plan an appropriate treatment approach.

Some authors highlight the influence of body height on the palm dynamometry test, in the early stage of puberty, especially in boys. 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;

Gulías-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 purpose of the research is to determine how anthropometric measures, measures for assessing body composition and age affect the results of the palm dynamometry test in male and female respondents 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.

The study included all the students whose parents gave consent to participate in the research, who were psychophysically healthy and who regularly attended physical and health education classes. The respondents were treated in accordance with the Helsinki Declaration.

The measurements were carried out in the months of March, April and May 2019, within standard school conditions during regular physical and health education classes.

Anthropometric measures and body composition

Anthropometric measurements were taken according to standard methodology of International Biological Program (IBP) and according to the recommendations of World Health Organization (WHO) and Weiner & Lurie (1981). Weight was measured in underwear and without shoes with an 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 was calculated as body 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 body weight, fat tissue percent and muscular mass percent. Prior to commencing the measurement we had entered the parameters of gender, years and body 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 measuring, we ensured that the preconditions recommended by ACSM (2005) and Heyward (2006) had been fulfilled.

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 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. When ready the subject squeezes the dynamometer with maximum isometric effort, which is maintained for about 3 seconds. No other body movement is allowed. The subject 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). The Multivariate linear regression analysis was used to determine the independent contributions of age, weight, height, BMI, fat tissue 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

The system of predictor variables (table 1) statistically significantly affects the criterion variable, the absolute values obtained from the palm dynamometry test at the .00 level. The multiple correlation is .86 and explains the common variability between the system and the criterion variable of about 73%. From the entire predictor system, the age variables have a statistically significant influence ($\beta=0.22$, $p<0.000$), body

weight ($\beta=0.51$, $p<0.000$), percentage of adipose tissue ($\beta=-0,41$, $p<0.000$), percentage of muscle mass ($\beta=0.14$, $p=0.001$) and body mass index ($\beta=0.23$, $p<0,000$).

Table 1. Regressive analysis of the palm dynamometry test expressed in absolute values and anthropometric measures, measures for assessing body composition and age in male respondents

	R	Part-R	BETA	T-TEST	Q
YEARS	0,69	0,29	0,22	9,18	0,000
ATELVIS	0,79	0,03	0,05	0,86	0,390
AELMAS	0,65	0,20	0,51	6,34	0,000
PROMAS	-0,16	-0,25	-0,41	-7,98	0,000
PROMUS	0,48	0,10	0,14	3,22	0,001
BMI	0,35	0,12	0,23	3,76	0,000
DELTA .86 RO . 73 DF1 6 DF2 956 Q 0.000					

The system of predictor variables (table 2) has a statistically significant effect on the criterion variable, relative values obtained from the palm dynamometry test at the .00 level. The multiple correlation is .85 and explains the common variability between the system and the criterion variable with about 72%. From the entire predictor system, the age variables have a statistically significant influence ($\beta=0.21$, $p<0.001$), body weight ($\beta=0.29$, $p<0.001$), percentage of adipose tissue ($\beta=-0,42$, $p<0.001$) and percentage of muscle mass ($\beta=0.18$, $p<0.001$).

Table 2. Regressive analysis of the palm dynamometry test expressed in relative values and anthropometric measures, measures for assessing body composition and age in male respondents

	R	Part-R	BETA	T-TEST	Q
YEARS	0,61	0,27	0,21	8,54	0,000
ATELVIS	0,63	0,18	0,29	5,69	0,000
AELMAS	0,14	0,03	0,05	0,90	0,369
PROMAS	-0,64	-0,28	-0,42	-8,97	0,000
PROMUS	0,78	0,13	0,18	4,17	0,000
DELTA .85 RO . 72 DF1 5 DF2 957 Q 0.000					

In order to determine how multivariate, anthropometric measures, measures for assessing body composition and age affect the absolute and relative values obtained from the palm dynamometry test in female respondents, a multivariate linear regressive analysis was applied. The results of the regressive analysis are shown in Tables 3 and 4.

The system of predictor variables (table 3) statistically significantly affects the criterion variable, the absolute values obtained from the palm dynamometry test at the .00 level. The multiple correlation is 72 and explains the common variability between the system and the criterion variable with about 53%. From the overall predictor system, the age variables have a statistically significant influence ($\beta=0.29$, $p<0.000$), body height ($\beta=0.22$, $p<0.000$), body weight ($\beta=0.22$, $p<0.001$), percentage of adipose tissue ($\beta=-0,18$, $p=0.021$), percentage of muscle mass ($\beta=0.22$, $p<0.001$) and body mass index ($\beta=0.42$, $p<0,000$).

Table 3. Regressive analysis of the palm dynamometry test expressed in absolute values and anthropometric measures, measures for assessing body composition and age in female respondents

	R	Part-R	BETA	T-TEST	Q
YEARS	0,54	0,34	0,29	10,56	0,000
ATELVIS	0,60	0,14	0,22	4,14	0,000
AELMAS	0,58	0,07	0,22	2,18	0,029
PROMAS	0,27	-0,08	-0,18	-2,30	0,021
PROMUS	-0,03	0,12	0,22	3,67	0,000
BMI	0,40	0,14	0,42	4,25	0,000
DELTA .72 RO .53 DF1 6 DF2 880 Q 0.000					

The system of predictor variables (table 3) has a statistically significant effect on the criterion variable, relative values obtained from the palm dynamometry test at the .00 level. The multiple correlation is .73 and explains the common variability between the system and the criterion variable with about 53%. From the overall predictor system, the age variables have a statistically significant influence ($\beta=0.30$, $p<0.001$), body height ($\beta=0.35$, $p<0.001$), percentage of adipose tissue ($\beta=-0.34$, $p<0.000$) and percentage of muscle mass ($\beta=0.19$, $p=0.001$).

Table 4. Regressive analysis of the palm dynamometry test expressed in relative values and anthropometric measures, measures for assessing body composition and age in female respondents

	R	Part-R	BETA	T-TEST	Q
YEARS	0,38	0,35	0,30	10,92	0,000
ADELVIS	0,45	0,27	0,35	8,42	0,000
ADELMAS	-0,08	-0,03	-0,04	-0,73	0,463
PROMAS	-0,41	-0,16	-0,34	-4,85	0,000
PROMUS	0,55	0,11	0,19	3,25	0,001
	DELTA .73	RO .53	DF1 5	DF2 881	Q 0.000

Discussion

The latest scientific researches indicate that physical fitness is a powerful indicator of health status both in childhood and adolescence, as well as in adulthood. Even in children and adolescents the 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).

During the individual growth and development of the child, there are greater or lesser differences in fitness (motoric) abilities in relation not only to age, but also to gender. The determined quantity, quality and tendency of those differences, characterize the appropriate age and gender in children.

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 research aimed to determine how anthropometric measures, body composition assessment measures, age affect on the absolute and relative values of the palm dynamometry test results in adolescents aged 11 to 14 years.

The previous researches indicate that the palm dynamometry test is positively related to weight, height and body surface area and that in puberty, body height may be a key factor influencing the palm dynamometry test. Our results are somewhat consistent with these studies. The results of our research indicate that the predictor variables body weight, percentage of fat tissue and body mass index show the greatest influence on the absolute values obtained from the palm dynamometry test among male respondents. Male respondents who have a higher body weight, a lower percentage of fat tissue, a higher body mass index, a higher percentage of muscle mass and who are older at age achieve better absolute results obtained from the palm dynamometry test. Similar results were obtained when the relative value from the palm dynamometry test (in relation to the test result and the body mass index- BMI) was used as a criterion. Male respondents who have a higher body weight, a lower percentage of fat tissue, a higher percentage of muscle mass and more years achieve better relative results obtained from the palm dynamometry test. In male respondents, the relative test result is determined to the greatest extent by the variable percentage of fat tissue.

The results of our research further indicate that the predictor variables body mass index and age show the greatest impact on the absolute values obtained from the palm dynamometry test among female respondents. Female respondents who have a higher body mass index, age, body height, body weight, lower percentage of fat tissue and higher percentage of muscle mass achieve better absolute results obtained from the palm dynamometry test. Female respondents who have a lower percentage of fat tissue, higher body height, higher percentage of muscle mass and age achieve better relative results obtained from the palm

dynamometry test. As with the male respondents, among the female respondents the test result is largely determined by the variable percentage of adipose tissue.

Also, the improvement of the result in the palm dynamometry test with increasing age can be prescribed in addition to hormonal changes over time and the influence of sociological factors. Boys during this period have more spontaneous physical and organized extracurricular physical activity, which contributes to the manifestation of strength based on the harmonization of movement, that is, improved coordination. During development, motor tasks are accomplished with the participation of different mechanisms, so that the successful performance of a task implies a complementary interaction of different abilities, and is not only a consequence of one ability.

Based on the results obtained from this research and from the previous research, it can be concluded that the palm dynamometry test, which is an indicator of muscle fitness, can be used both in adults, adolescents and children, and 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 common among young people in Europe, and of the palm dynamometry test (Valtueña et al., 2013; Bohannon, 2001). Also, this parameter correlates with several diseases and clinical complications and can predict the mortality in both adults and children (Sasaki et al., 2007; Ortega et al., 2012; Leong et al., 2015).

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 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 policy-makers to develop gender-specific strategies about body-weight management and promotion of muscular performance among children and adolescents.

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