

TEST-RETEST RELIABILITY OF THE HAND GRIP DYNAMOMETRY TEST IN MACEDONIAN ADOLESCENTS

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(Original scientific paper)

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Abstract

The strength of hand grip can be non-invasively measured easily and quickly using portable hand dynamometers. The wrist dynamometry fitness test is widely applicable in many areas of medicine and sports science to assess isometric muscle strength of the wrist and forearm. The aim of this study was to determine the test-retest reliability of the wrist dynamometry test in Macedonian adolescents. The study included a sample of 20 male participants aged 14 years. Each participant performed three maximal voluntary contractions for each hand, always starting with the dominant hand. The measurement of hand grip strength was repeated the following week under the same conditions and at the same time of day and location. The intraclass correlation coefficient (ICC), standard error of measurement (SEM), and 95% limits of agreement (LOA) were calculated. The relative reliability between the first and second (test-retest) measurements is very high, ranging from 0.98 to 0.998 (ICC) for dominant hand wrist dynamometry, from 0.928 to 0.991 (ICC) for non-dominant hand wrist dynamometry, and from 0.971 to 0.996 (ICC) for wrist dynamometry averaged across the right and left hands. The current results indicate that maximum hand grip strength can be reliably measured using the Camry hand dynamometer in Macedonian adolescents.

Key Words: *Test-Retest, Isometric Strength, Handedness, Adolescents*

Introduction

Hand grip strength can be non-invasively measured easily and quickly using portable hand dynamometers (Peolsson, Hedlund, & Öberg, 2001). The wrist dynamometry fitness test is widely applied in many areas of medicine and sports science to assess isometric muscle strength of the wrist and forearm (Roberts, et al., 2011). As the hand dynamometry test correlates positively with overall muscle strength in healthy young individuals, it can serve as an indicator of total body strength in adolescents (Wind et al., 2010). From the perspective of sports coaches and healthcare professionals, it is important to assess the quality of physical fitness using reliable, valid, and objective measuring instruments that provide accuracy, tracking capabilities, and the ability to compare results (Lachin, 2004; Schreuders et al., 2003). In comparison to adults, the reliability of hand grip strength tests with different dynamometers is less explored in children and adolescents [Clerke et al., 2005; Espana-Romero et al., 2008; España-Romero et al., 2010]. Some studies suggest that children and adolescents may be influenced by certain factors that could affect the results in hand dynamometry tests, impacting the measurement reliability. Factors such as age (Zuidam et al., 2008; Svensson, Waling & Häger-Ross, 2008), hand shape related to gender (Clerke, et al., 2005), handedness (Molenaar et al., 2009), testing procedures (España-Romero et al., 2010; España-Romero et al., 2010), and fitness level (Gerodimos, 2012) could play a role.

Several studies have investigated the test-retest reliability of the hand dynamometry test in children (Espana-Romero et al., 2008), adolescents (Clerke et al., 2005; Espana Romero et al., 2010b; Ortega et al., 2008; Ruiz et al., 2006), and adults (Peolsson et al., 2001; Ruiz-Ruiz et al., 2002; Shechtman et al., 2005). Espana-Romero et al. (2008) and Clerke et al. (2005) found high reliability of the hand grip strength assessment test in children and adolescents. Additionally, Peolsson et al. (2001) and Ruiz-Ruiz et al. (2002) found high reliability of the hand grip strength assessment test in healthy adults using Jamar and Takey dynamometers.

In North Macedonia, there is no research investigating the test-retest reliability of the hand dynamometry test in an adolescent population with its socio-cultural, economic, and geographical specificities, which may influence measurement outcomes. Based on these considerations and the awareness that this issue has not been addressed in the Republic of North Macedonia to date, this study was conducted with the main goal of determining the test-retest reliability of the hand dynamometry test in Macedonian adolescents.



Figure 1. Camry Digital Hand Dynamometer

Methods

Participants

The study included a sample of 20 male participants aged 14 years. All students for whom parents gave consent to participate in the project and were psychophysically healthy, regularly attending physical and health education classes, were included in the sample. The treatment of participants adhered to the principles outlined in the Helsinki Declaration.

Measurement Procedure

All measurements were conducted in a hall from 8 to 12 o'clock. Firstly, participants were informed about the measurement procedures. Secondly, anthropometric characteristics (body weight and height) were measured, and the dominant hand was identified. Before conducting the hand dynamometry test, all participants were warmed up and familiarized with the dynamometer. Familiarization included gripping the handle, adjusting the grip strength, and performing 2-3 practice tests. The actual testing began 5 minutes after the familiarization procedure.

Each participant performed three maximal voluntary contractions for each hand, always starting with the dominant hand. The average of the three tests (trials) was calculated to two decimal places and used in further analysis. Verbal instructions before each test were as follows: "This task will measure the strength of your hand grip," followed by a verbal command for participants to "Squeeze as hard as you can for 3 seconds!". Children were instructed to stop squeezing if they felt pain or discomfort during the measurement. Participants were verbally encouraged by the researcher to give their best effort during testing. The dynamometer display was always turned towards the examiner.

During testing, the hand and wrist holding the dynamometer were not allowed to touch the body. The instrument was held in line with the forearm alongside the body, adjusting the handle so that the two handles of the dynamometer corresponded to the size of the first phalanx of the middle finger. Measurements were conducted using a CAMRY dynamometer.

All measurements were conducted by the same researcher. Hand grip strength measurement was repeated the following week under the same conditions, at the same time of day, and location.

Statistical Analysis

All values are presented as mean \pm SD unless otherwise stated. The normality of the data was assessed using the Kolmogorov-Smirnov test. Relative and absolute reliability were calculated (Baumgartner, 1989). To assess relative reliability, the intraclass correlation coefficient (ICC) based on a two-way random effects

model (absolute reliability, ICC2.1) was used (Weir 2005). The reliability of test-retest testing is considered good when ICC values range from 0.61 to 0.80 and excellent when values range between 0.81 and 1.00 (Shrout, 1998).

Before calculating absolute reliability, heteroscedasticity (unequal variance) was assessed by checking Pearson correlation coefficients of the absolute difference between the test and retest and the mean value of the test and retest (Bland & Altman, 1986; Bland & Altman, 1999). If the correlation coefficient (r) was between 0 and 0.1, the data were considered homoscedastic. In such cases, absolute reliability was recommended to be assessed using the standard error of measurement (SEM) (Atkinson & Nevill, A. 1998). If r was greater than 0.1, the data were considered heteroscedastic, and consequently, the log-transformed coefficient of variation (CV) should be used to estimate absolute reliability (Bland & Altman, 1999). SEM was used to estimate the smallest detectable difference (SDD), also known as "minimal detectable change (MDC)" or "minimal detectable difference (SDC)." To compare the credibility of the hand dynamometry test with most studies conducted with pediatric participants, the percentage value of SEM (SEM%) and normalized smallest detectable difference (nSDD) were also calculated. SEM was calculated using the following formula $SEM = SD \times (1 - ICC) 0.5$, where SD = the pooled standard deviation of the test and retest results, and ICC = calculated intraclass correlation within interclass correlation. SEM was divided by the mean value of measurements from test 1 and test 2 and multiplied by 100 to obtain a percentage value (SEM%). CV was calculated as standard deviation \sqrt{d} divided by the mean value and multiplied by 100. SDD is a linear transformation of SEM, i.e., $1.96 \times 2 \times SEM$ (Weir, 2005; Schreuders, et al. 2003). nSDD is SDD expressed as a percentage of the average maximal voluntary contraction (Molenaar et al., 2008). ICC2.1 was calculated using MedCalc for Windows, version 15.2.2 (MedCalc Software, Inc, Mariakerke, Belgium) (Schoonjans et al., 1995).

Results

To determine whether there are differences between the first and second measurements of the three variables assessing hand grip strength (hand dynamometry of the dominant hand, hand dynamometry of the non-dominant hand, average value of hand dynamometry of the left and right hand), paired t-tests for small dependent samples were conducted. The results of the analysis are presented in Table 1. From the examination of the table, it can be observed that no statistically significant differences were found between the first and second measurements in any variable assessing hand grip strength.

Table 1. Differences between the first and second measurements in hand dynamometry test among adolescents

	Measurement 1		Measurement 2		Mean difference [95% CI]			t	P
	Mean	SD	Mean	SD					
HG (D) kg	41,55	7,23	41,42	6,87	0,13	-0,41	0,67	0,52	0,611
HG (ND) kg	39,09	4,30	38,74	4,30	0,34	-0,38	1,06	1,02	0,325
HG (D/L) kg	40,32	5,46	40,08	5,32	0,24	-0,34	0,81	0,88	0,394

Table 2. Statistical reliability coefficients for the dominant hand, non-dominant hand, and average value from both hands

	Inter-rater reliability			SEM (kg)	SEM (%)	SDD (kg)	CV
	ICC _{2.1}	95% CI					
		Low	High				
HG (D) kg	0,995	0,985	0,998	0,50	1,20	1,96	1,53
HG (ND) kg	0,975	0,928	0,991	0,68	1,75	2,29	2,45
HG (D/L) kg	0,990	0,971	0,996	0,54	1,34	2,04	1,80

ICC-intraclass correlation coefficient, SEM-standard error of measurement, SDD-smallest detectable change, CV-coefficient of variatione

The data for relative and absolute reliability from the first and second measurements are presented in Tables 1 and 2. The relative reliability between the first and second (test-retest) measurements is very high, ranging from 0.98 to 0.998 (ICC) for hand dynamometry of the dominant hand, from 0.928 to 0.991 (ICC) for hand dynamometry of the non-dominant hand, and from 0.971 to 0.996 (ICC) for hand dynamometry

of the average value from the right and left hand. The absolute reliability of the three variables (SEM and LOA) is good. The average absolute differences between the first and second measurements were 0.13 kg for hand dynamometry of the dominant hand, 0.34 kg for hand dynamometry of the non-dominant hand, and 0.24 kg for hand dynamometry of the average value from the right and left hand. The 95% limits of agreement (LOA) ranged from -0.41 to 0.67 kg for hand dynamometry of the dominant hand, from -0.38 to 1.06 kg for hand dynamometry of the non-dominant hand, and from -0.34 to 0.81 kg for hand dynamometry of the average value from the right and left hand. The standard error of measurement (SEM) ranged from 0.50 kg for hand dynamometry of the dominant hand, 0.68 kg for hand dynamometry of the non-dominant hand, and 0.54 kg for hand dynamometry of the average value from the right and left hand.

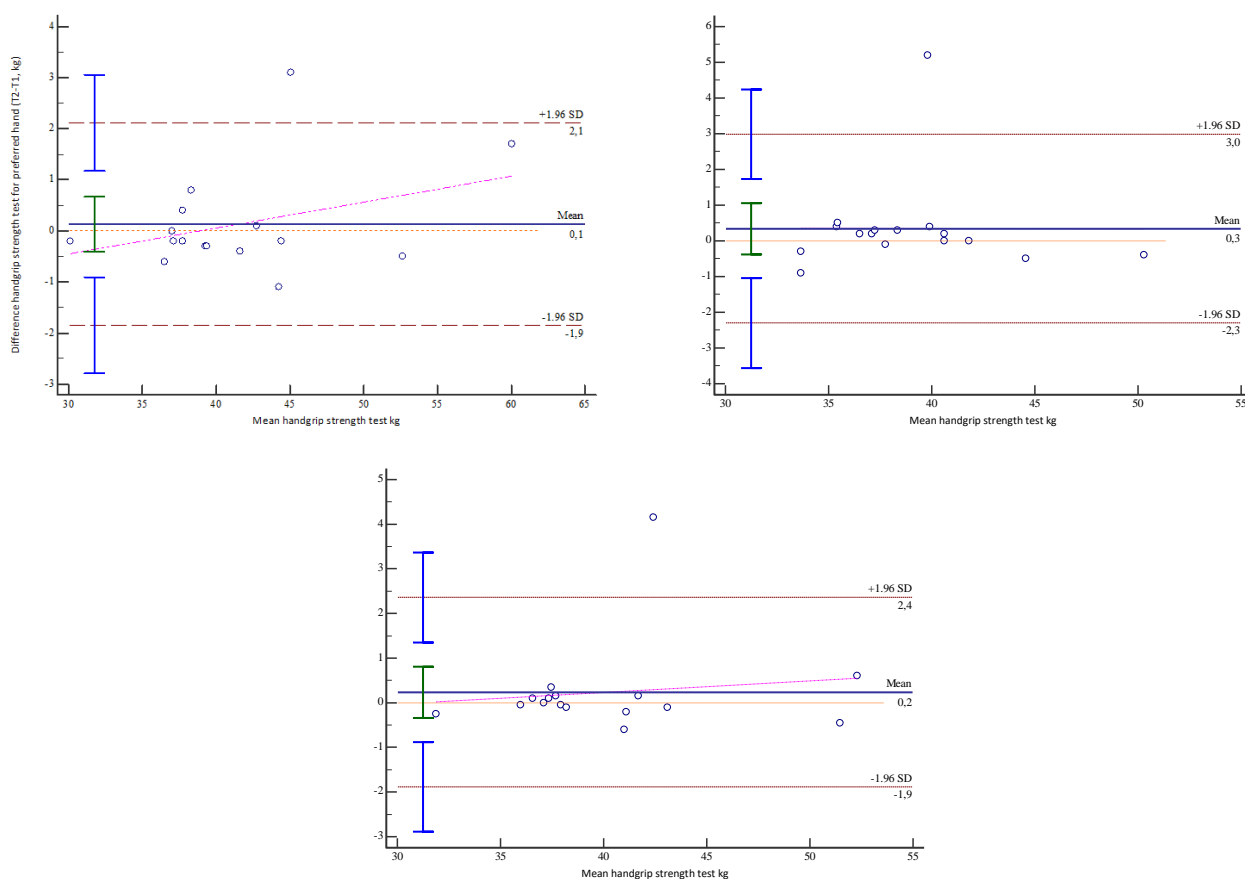


Figure 1. Bland-Altman plots of the handgrip strength test for preferred, non-preferred hand and mean of preferred, non-preferred hand. The central line characterizes the mean difference between test and retest values; the upper and lower lines characterize the upper and lower 95 % limits of agreement (LOA = inter-trials mean difference \pm 1.96 SD the inter-trials difference), respectively.

Discussion

Based on the obtained results, it can be stated that the wrist dynamometry test demonstrates very high relative and absolute reliability in this sample of participants. The findings of this study are consistent with previous research that reported high reliability of handgrip strength in children (España-Romero et al., 2008), adolescents (España-Romero et al., 2010b; Ruiz et al., 2010b; al., 2006), and adults (Langerstrom et al., 1998; Peolsson et al., 2001; Ruiz-Ruiz et al., 2002; Shechtman et al., 2005) using various types of hand dynamometers.

España-Romero et al. (2008) reported high reliability (ICC = 0.97 - 0.98) for the wrist strength assessment test in children aged 6-12 years, using the Takey dynamometer. Ruiz et al. (2006) found high reliability between the first and second measurements (test-retest measurement) ($r = 0.96 - 0.98$) for the handgrip strength test in adolescents aged 14 to 17 years. Similarly, Langerstrom et al. (1998) and Ruiz-Ruiz et al. (2002) established high reliability ($r = 0.91 - 0.97$) for the handgrip strength test in adults using the Grippit and Takei hand dynamometers.

The results of this study are also in line with those of Coelho e Silva et al. (2008; 2010), who conducted research on young basketball players (aged 14-15.9 years and 12-13.9 years) and found high reliability ($r = 0.99$) for the handgrip strength test assessed with a Lafayette hand dynamometer.

Our results support previous studies that showed insignificant differences in handgrip strength between values from the first and second measurements (test-retest measurements) (España-Romero et al., 2008; 2010). In contrast, Clerke et al. (2005) found small but statistically significant differences in handgrip strength between the first and second measurements in adolescents aged 13 to 17 years. The absence of warm-up or familiarization with the test before testing in the latter study may explain the differences in handgrip strength between the first and second measurements. Specifically, Svensson et al. (2008), who also found differences in handgrip strength between the first and second measurements, suggest that children and adolescents should be familiarized with the dynamometer and learn the technique of its use before the test. Therefore, the authors recommend one familiarization trial and three repetitions during testing.

Conclusion

Based on the obtained results, it can be concluded that the reliability of the wrist dynamometry test using a hand dynamometer from the CAMRY brand is very high in Macedonian male adolescents, and it can be used in practical and scientific work. This study provides valuable information indicating that sports and health professionals assessing handgrip strength can use this type of dynamometer as a reliable measurement tool to assess isometric grip strength in adolescents. Information about the smallest detectable change can help inform researchers and clinicians when interpreting data in relation to pediatric participants with chronic medical conditions, as well as in calculating the sample size for randomized controlled trial studies.

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Introduction

Concept of physical fitness is as old as humankind. Through out the history of mankind physical fitness has been considered an essential element of every day life. The ancient people were mainly dependent upon their individual strength, vigor and vitality for physical survival. This involved mastery of some basic skill like strength, speed, endurance, agility for running, jumping, climbing and other skills employed in hunting for their livings.

The physical fitness is connected to the health condition during the childhood and adolescence (Myers J, et.al. 2002; Andersen LB, et.al 2006). Even among children, fitness is inversely associated with cardiovascular risk factors for chronic disease such as high blood pressure (Sallis JF, et al. 1998; Ruiz JR, et. al. 2006), total fatness (Ruiz JR, et al. 2006), hyperinsulinemia (Gutin B, et al. 2004), abdominal adiposity (Brunet M, et.al. 2006), atherogenic lipid profile (Mesa, J.L, et al. 2006) insulin resistance (Gulati M, et. al. 2003), and clustering of metabolic risk factors (Brage S., et al. 2004; Ruiz J.R, et. 2007). Unfortunately, in the last two decades we have witnessed more evident tendency of decreasing of the physical activity among children, that happens not only in our state, but also in the countries nearby (Šiljeg, Zečić, Mrgan and Kević, 2008; Strel, Bizjak, Starc and Kovač, 2009), as well as in the developed countries (Janz, Dawson & Mahoney, 2000; Tomkinson, Olds & Gulbin, 2003; Wedderkopp, Froberg, Hansen & Andersen, 2004).

Huge number of the environmental factors such as: socio-economic status, cultural influence, life style, health condition and many others factors have influence upon the level of physical activity among children and at the same time there is also an indirect influence upon the anthropological characteristics of the children. Both, children and youngsters differ at the level of physical fitness regarding the socio-economic characteristics, as well as the living environment and that's because they depend on the economic and cultural potentials of their family.

The parents and the environment have great influence on the development of the abilities and characteristics at most of the adolescent, whereby they have big responsibility for their proper psycho-physical development, education and development of the total abilities, which influence is especially important for the sport results that are achieved by the children.

The first assumption of this research is that the students from different residential status have different level of the physical fitness. In our state, there are no researches for the physical fitness among the students, regarding different residential status, whereas many foreign authors dealt with this matter during the last few years (Loucaides, Chedzoy, & Bennett, 2004; Eiben, Barabás, & Németh, 2005; Badrić i Petračić, 2007; Bathrellou et al., 2007; Petrić, 2009; Tinazci & Emiroğlu, 2010).

Methods

The research is conducted on a sample of 2199 participants, which is 97% from the total population of students at the researched age, at the primary schools in the Municipality of Strumica, Republic of Macedonia. In the Municipality there are 9 primary schools from which are in rural environment and 4 are in urban environment. The sample is divided into two subsamples according the gender as it: 1124 participants are male (684 from urban and 371 from rural) and 1075 participants are female (665 from urban and 363 from rural). The average age of the participants from both genders is 12,31 years.

In the sample all the students who participated, obtained consent from their parents that they allow them to participate in the project and were psycho-physically healthy and regularly attended classes of physical and health education. The participants were treated pursuant to the Helsinki Declaration.

The measuring was realised in March, April and May, 2012, in standard school conditions during the regular classes of physical and health education. The measuring was conducted by professionals from the area of kinesiology and medicine, which were previously trained for measuring of the determined tests and measurements.

Anthropometric measurements

Anthropometric measurements were taken according to standard methodology of International Biological Program (IBP) and according to the recommendations of World Health Organisation (WHO) and Weiner-Lurie (Weiner JS, Lourie JA., 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 Frankfort horizontal plane with a telescopic height measuring instrument (Martin's anthropometer) to the nearest 0.1 cm. Body mass index was calculated as body weight in kilograms divided by the square of height in meters.

The components of the body composition are determined by the method of bioelectrical impedance (measuring of electrical conductivity - Bioelektrical Impedance Analysis - BIA). The measuring was realised by the Body Composition Monitor, model "OMRON - BF511", by which the body weight, the percentage of body fat, percentage of muscular mass and the index of body mass were measured (BMI).

Before the measuring in the Body Composition Monitor the following parameters were being entered: gender, ages and height of the participant.

In order to achieve maximally precise results during the measuring i.e. evaluation of the body composition, preconditions which are recommended by ACSM (2005) and Heyward (2006) were fulfilled before every measuring.

Evaluation of Physical Fitness

Prior to starting the study, the researchers involved in the project undertook training sessions in order to guarantee the standardization, validation, and reliability of the measurements (Moreno LA, et. al. 2003). Seven tests, forming part of the EUROFIT battery, validated and standardized by the European Council, were applied in the following order:

1. 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.
2. Falamingo. Balancing on one leg as long as possible while standing on the preferred foot. This test measures general balance.
3. Plate Tapping. Test Rapid tapping of 2 plates alternately with the preferred hand. The subject performed 25 cycles for 2 times, and the better result was the score.
4. Hand Grip test. With the use of a digital Takei TKK 5101 dynamometer (range, 1-100 kg), the maximum grip strength was measured for both hands.
5. Standing broad jump test. The maximum horizontal distance attained, with feet together, was measured. This test evaluates lower limb explosive-strength.
6. Bent Arm Hang test. A standardized test was used to measure the maximum time hanging from a fixed bar. This test estimates the upper limb endurance- strength.
7. Sit-ups 30 sek. Maximum number of sit ups achieved in 30 seconds. This test measures the endurance of the abdominal muscles
8. 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.
9. The three-minute step test. The aerobic capacity has been estimated by means of a 3-minute step test. The respondent had a task, for 3 minutes, to get up and get down of a bench 30,5 cm high, in four cycles (up, up, down, down), with standardized rhythm of 96 beats in a minute (bmp), which was dictated by the metronome. Before beginning of the test we have measured the heart frequency, whereas the adolescent, even in the stand-by state had sub maximal value in terms of the age, were not exposed to burdening. The heart rate was measured by means of the monitor Polar RS800 for registration of the heart frequency. The average of the heart rates measured immediately after taking the test and a minute after that make up the test result.

Blood Pressure

Measuring of blood pressure (systolic and diastolic) and heart rate were realised by professionals in the area of medicine, doctor- specialist in sport's medicine. The measurements were performed in special premise with optimal ambiental conditions in relaxed condition of the participant, where the relaxation

was performed at least one minute before the measuring. The measuring was realised on the forearm above the wrist of the palm, with a clinically tested electronical digit device for measuring of the blood pressure by the firm „Omron”. The measuring was performed on the left hand and before it was taken into consideration for the cuff to be properly set, the hand to be on the same height as the heart and the participant to sit upright, not to move or talk. The blood pressure was measured for three times in the interval of 60 seconds and as a result was considered the average value of the three measuring.

Statistical analysis

The data are presented mean (SD) for continuous variables. The differences in the variables between the participants from different residential status are analyzed with the multivariable and univariable analysis of variant (MANOVA and ANOVA). The normality of the distribution of changed variables is tested with Kolmogorov-Smirnov's method. All the analyses were performed using the Statistical Package for Social Sciences software (SPSS, v.16.0 for WINDOWS; SPSS Inc., Chicago, IL, USA) and values of $p < 0.05$ were considered statistically significant.

Results

The testing of the normality of the distribution with Kolmogorov-Smirnov's procedure showed that most of the variables among the participants from both genders do not deviate from the normal distribution (податоците не се прикажани).

In the Table 1 and 2 are shown the average values, standard deviations and the values of the multivariate and univariate analysis of the covariate of the parameters for evaluation of the blood pressure, anthropometrical measurements, body composition and tests for evaluation of the level of physical fitness after the partition of the ages among the participants from both genders.

From the analysis of Table 1. we can see that are determined statistically significant differences on multivariate level in the system variables for assessing blood pressure, anthropometric measures, body composition and physical fitness levels among boys who are studying in urban and rural environment. The value of the F test for the whole system analyzed variables is statistically significant at the level of