# PSYCHOMETRIC PROPERTIES OF STANDARDIZED AND MODIFIED TESTS FOR THE ESTIMATION OF STATIC STRENGTH OF PRESCHOOL CHILDREN

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***Abstract***
*The aim of this study was to examine the psychometric characteristics of the bent arm hang test which is performed in three different positions: at the vertical angle under 90°, angle of the body of 45° and 20° in relation to the ground. Some studies point out the poor psychometric characteristics of the classic bent arm hang test. Therefore, it will be examined in this paper which of the three proposed tests is appropriate, reliable and valid for checking the static strength of arms and shoulders among children of preschool age on the same sample of children. 70 children participated in the study (34 girls and 36 boys), aged 5.5 to 6.5. In addition to the standardized bent arm hang test under 90°, two more tests were constructed: bent arm hang test under 45°, with leg support at an angle of 45° in relation to the ground and the bent arm hang test under 20° with leg support at an angle of 20° in relation to the ground. Each test was repeated three times with 7 days between repetitions in order to determine their reliability, validity and applicability in working with preschool children. Based on the obtained results it was determined that test of 90° is the only reliable and suitable test for the work with preschool children, but only after the children have been well acquainted with the position required for the measurement. Furthermore, it was concluded that the test under 45° and test under 20° are inapplicable in work until the systematic error has been eliminated. Also, it was determined that there is no gender difference in performance except in the test under 90°. For quality assessment of muscle strength of preschoolers it is necessary to continue to research the psychometric properties of the measurement instruments.*

***Keywords****: bent arm hang, static strength, muscular endurance, preschool children*

## Introduction and study problem

The contemporary lifestyle along with the intensive development of technology lead to reduced levels of physical activity which can be defined as the movement of the body in space with increased energy consumption. Such a sedentary lifestyle leads to the development of excess body weight, which is determined by discrepancies between an increased energy intake and a reduced energy consumption whereby the positive energy balance results in storing excess energy in the adipose tissue (Kumanyika et al., 2002). Numerous studies have shown that besides genetic and metabolic causes obesity may arise as a result of a sedentary lifestyle and bad habits (Whitaker, RC, 2004, Stettler et al., 2002, Gillman, WM et al., 2001, Faith, MS et al., 2003). Such a negative way of life is reflected on children who increasingly spend their free time indoors, watching TV and playing video – games which limit the proper physical development, and which is indicated by the data by Kim et al. (2005) that in the U.S. the emergence of obesity in children and adolescents has tripled in the last three decades. The same authors suggest that obesity in childhood can have health consequences such as cardio - vascular disease, diabetes, asthma during childhood, but also the risk of obesity during the aging process which causes social and economic consequences. These bad habits have a negative impact on fitness which refers to the ability of performance of strenuous daily physical activities with reduced risk of hypokinetic diseases.

Physical fitness consists of three components: muscular strength and endurance, cardio-respiratory endurance and motor ability, and is part of the health-related fitness which also consists of the metabolic and morphological components, particularly body composition and fatness (Malina and Katzmarzyk, 2006). This subcutaneous fat is a significant component of the health-related fitness because it is negatively associated with the cardio-respiratory endurance and strength (Malina et al., 1995). It is therefore recommended to apply the development of strength from the early age. With an increase in strength in children and adolescents, the impact on other components of health-related fitness, cardio- respiratory fitness, body composition, blood lipids etc. is enabled, as well as on the improvement of motor skills and minimization of injuries during physical activities (Faigenbaum, 2000). Also, Mišigoj-Duraković (1999) argues that the development of strength enables the reduction of the workload of the articular surfaces through an increase in their stability, greater muscle blood flow at same levels of force that allow a delay in fatigue and an increase in endurance. In addition to these benefits, Faigenbaum (2000) also states that the strength and power are essential in most sports which enable the children of more developed abilities to more easily engage in sport and to achieve success. All this suggests that it is necessary to study the children's strength as early as in childhood.

Jones and Stratton (2000) argue that the study of the muscle function has its application in rehabilitation, physical education, training and scientific research, but the measurement procedure depends on the reason for testing, population, available equipment and other factors. Although there are laboratory and field tests, the battery of tests for the assessment of physical fitness are most widespread in the field of physical education (Woods, Pate and Burges, 1992; Tsigilis, Douda and Tokmakidis, 2002). In relevant battery tests such as EUROFIT in Europe and AAPHERD batteries in North America, except for assessment tests of other skills for assessing muscular strength and endurance, the bent arm hang (flexed arm hang) test is applied. However, gender, body weight and body composition play a significant role on the test results (Woods, Pate and Burges, 1992; Kim et al., 2005), and in addition, there are substantial objections to field fitness tests which require performance skills. Jones and Stratton (2000) note that frequent objections to these tests are that they require quality motor performance. For quality assessment of muscle strength is necessary to use reliable measuring instruments with high psychometric characteristics. While the reliability in composite measuring instruments is calculated by the method of internal consistency, when testing muscle strength due to the volume of load that occurs during power endurance tests it is not possible to construct a composite instrument that determines the reliability of the same test-retest method. Kemper and van Mechelen (1996) suggest that it is necessary to constantly explore the reliability of the tests in order to obtain real results, and Hopkins (2000) states that it takes a minimum of three measurements with the number of participants bigger than 50 to accurately determine the level of reliability. As to the effect of morphological characteristics of the results in the bent arm hang test which can distort the metric characteristics of the measuring instrument (Trajkovski, 2004), this study sought to modify the same test, in order to relieve the grip and relativize the influence of body weight on the test results. Therefore, the aim of the study was to evaluate the arm and shoulder static strength in three different positions of preschool children (±6 yrs.): in first position the classic test was performed, in the bent arm hang position perpendicular to the surface (90), in the second test at the body angle of 45° in relation to the ground and in the third test at a body angle of 20° in relation to the ground. Another aim was to check which of the three modes of the test are reliable and appropriate to be carry out in the work with preschool children.

## Methods

*The sample*

The sample in this study consisted of preschool children (±6 years) in kindergarten. 70 children participated in the study, 34 girls and 36 boys, aged 5.5 to 6.5.

All the children during the study were healthy and fully aware of the content tests (measurements) and the parent/guardian signed a written consent for each child to participate in the study, which is in accordance with the Code of Ethics prepared by the Council for Children as an advisory body of the Croatian Government.

*The sample of variables*

The measuring instruments in this study consisted of three motor tests: the standardized test of endurance in the bent arm hang test under 90° in relation to the ground, in the supine hands position (palms facing the face) and two newly constructed tests: bent arm hang test under 45°, with the leg support at an angle of 45° in relation to the ground and bent arm hang test under 20°, with the leg support at an angle of 20° in relation to the ground with the same hand position.

1. Bent arm hang test under 90°

2. Bent arm hang test under 45°

3. Bent arm hang test under 20°

The measurements were performed in the same building at the same time. During the course of one day only one test was performed once so as to avoid unnecessary negative consequences for the results. Each of the three tests (bent arm under 90°, 45° and 20°) was repeated 3 times, with intervals of one week between each series of measurements in order to determine the validity and reliability of the tests. The measurement were carried out every other day (Monday, Wednesday, Friday with rest days between tests) in the morning, following the given schedule: bent arm hang test under 90°, bent arm hang test under 45 ° and bent arm hang test under 20°.

*Methods of data processing*

For all three tests basic descriptive parameters (mean, standard deviation and measures of curvature and flattening distribution) were calculated in all three measurements. Normality of distribution was tested by the Kolmogorov - Smirnov test, and the reliability between the sets of measurements was calculated with the Interclass correlation coefficient (ICC). The validity of the newly constructed tests was determined with the Pearson correlation coefficient. In order to determine the systematic error of measurement and gender differences, the two-factor analysis of variance for repeated measures (ANOVA) was used. If the level of F was significant, then the Fisher LSD post hoc test was applied. Random error was measured by the coefficient of variation (CV).

**Results**

In tables 1, 2 and 3 three coefficients of correlation are shown between all three used tests in all three series of measurements. From the correlation matrix, it is evident that all Pearson correlation coefficients are statistically significant at p = 0.05 and it can be stated that all tests assess the same measurement object i.e. muscular endurance.

Table 1. Correlation matrix between the three tests in the first series of measurements

| | 90° 1 | 45° 1 | 20° 1 |
|---|---|---|---|
| 90° 1 | 1,000 | 0,590* | 0,548* |
| 45° 1 | 0,590* | 1,000 | 0,583* |
| 20° 1 | 0,548* | 0,583* | 1,000 |

*Statistically significant at p=0,05

Table 2. Correlation matrix between the three tests in the second series of measurements

| | 90° 2 | 45° 2 | 20° 2 |
|---|---|---|---|
| 90° 2 | 1,000 | 0,622* | 0,637* |
| 45° 2 | 0,622* | 1,000 | 0,612* |
| 20° 2 | 0,637* | 0,612* | 1,000 |

*Statistically significant at p=0,05

Table 3. Correlation matrix between the three tests in the third series of measurements

| | 90° 3 | 45° 3 | 20° 3 |
|---|---|---|---|
| 90° 3 | 1,000 | 0,518* | 0,636* |
| 45° 3 | 0,518* | 1,000 | 0,559* |
| 20° 3 | 0,636* | 0,559* | 1,000 |

*Statistically significant at p=0,05

**Results in the 90° TEST**

Results of descriptive statistics for the bent arm hang test under 90° (90° TEST) are shown in Table 4.

Table 4. Descriptive indicators of results in the test 90° on the entire sample

| | Mean | Min | Max | SD | Skew. | Kurt. | CV | K-S d |
|---|---|---|---|---|---|---|---|---|
| 90° 1 | 14,74 | 2,00 | 60,30 | 11,67 | 2,07 | 4,90 | 79,16 | 0,197* |
| 90° 2 | 16,83 | 2,10 | 43,30 | 8,92 | 1,00 | 0,70 | 53,00 | 0,130 |
| 90° 3 | 17,83 | 3,10 | 50,50 | 9,64 | 1,15 | 1,31 | 54,05 | 0,150 |

Mean-arithmetic mean; MIN-lowest score; MAX-highest score; SD-standard deviation, Skeweness; Kurtosis; CV-coefficient of variation; K-Sd- Kolmogorov – Smirnov test, * Distribution deviates significantly from normal

Results indicate that in the test 90° there appears a significant deviation from the normal distribution (KSd, Skewness, Kurtosis) in the first series of measurements, and which impairs the sensitivity as an important metric characteristic of the measuring instrument. A high variability coefficient is also expressed. However, in subsequent measurements a significant reduction of these coefficients and their stabilization has been noticed. The deviation from the normal distribution to poorer results was observed in some other studies in this test (Trajkovski, 2004, 2011), whereby the author concluded that this test is too difficult and not suitable for children of preschool age. Results of the test-retest reliability of the endurance in the bent arm hang test on the entire sample indicate that there was no statistically significant effect of repeated measurements on the test results (F=2.97, p=0.06). Subsequent post - hoc test (Fisher LSD) showed that there are still significant differences between the first and third series of measurements (p = 0.01), while between the second and third series there were no significant differences (p = 0.40). During the analysis of the reliability of the test separately by gender, it was observed that neither in boys (F = 0.75, p = 0.48) nor in girls (F = 2.79, p = 0.07) was there a statistically significant difference in the results of repeated measurements. Also, the Interclass correlation coefficient was at a satisfactory level in both genders, in boys it was ICC = 0.706 (95% CI 0.466 to 0.848), and in girls ICC = 0.814 (95% CI 0.669-0.902). Some authors have already noted that in some tests of strength (body lifting - repetitive strength of the body) there are no differences by gender in children of preschool age, while the apparent differences are observable in school-aged children (Trajkovski, 2011).

Figure 1. Result curve of the overall sample in the test 90°

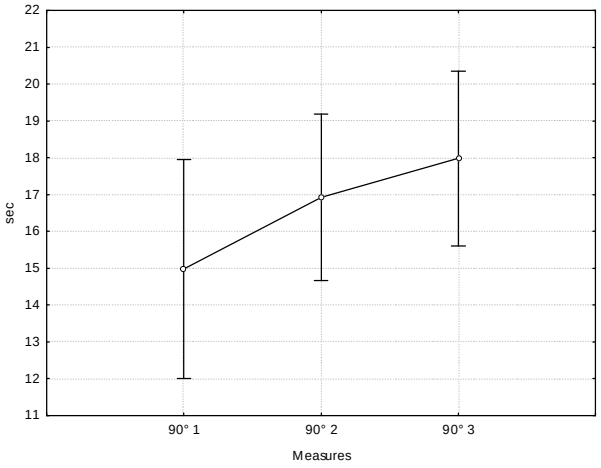


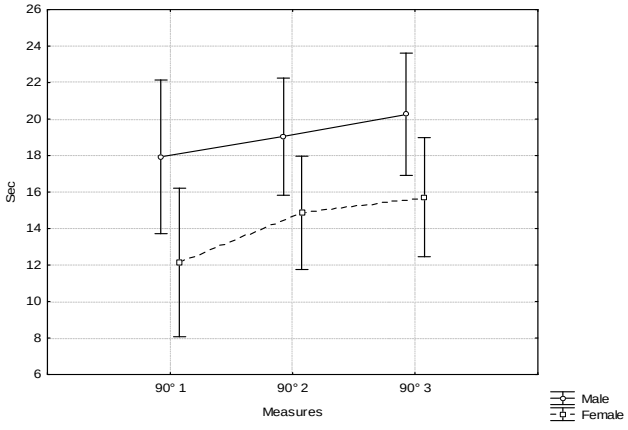

Table 5. Differences in results during repeated measurements in the test 90°

| | SS | Degr. of freedom | MS | F | p |
|---|---|---|---|---|---|
| Intercept | 53224,23 | 1,00 | 53224,23 | 257,42 | 0,00 |
| GENDER | 1126,02 | 1,00 | 1126,02 | 5,45 | 0,02* |
| MEASUREMENT | 286,29 | 2,00 | 143,14 | 2,97 | 0,06 |
| MEASUREMENT *GENDER | 22,98 | 2,00 | 11,49 | 0,24 | 0,79 |

* Statistically significant at p = 0.05

Although generally speaking, there are significant differences by gender (in all three measurements in total) in the 90° test, however, there was no statistically significant interaction between gender and repeated measurements. Furthermore, neither a statistically significant effect of measurements, nor an interactive effect of measurements and gender were obtained.

Figure 2. Result curve by gender during the series of measurements in the test 90°




**Results in the TEST 45 °**

Results of the descriptive statistics for the bent arm hang test at an angle of 45° (45° TEST), are shown in Table 6. In this test, it is evident that the results are significantly higher than in the 90° test, measured in seconds, which indicates that this way and in these body positions the conditions for the performance test are made easier.

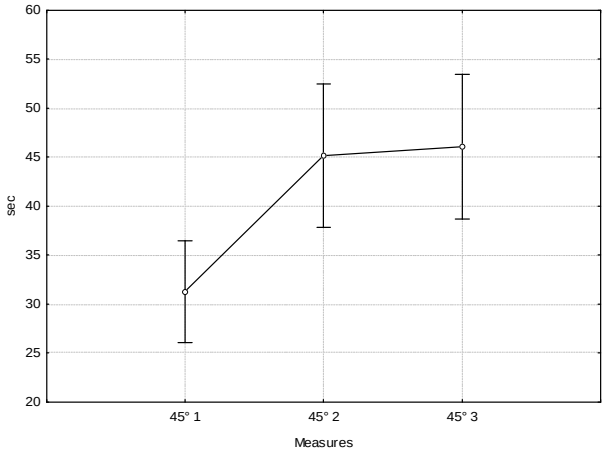
Table 6. Descriptive indicators of results of the test 45°on the entire sample

| | AS | Min | Max | SD | Skew. | Kurt. | CV | K-S d |
|---|---|---|---|---|---|---|---|---|
| 45°1 | 32,16 | 4,00 | 96,80 | 21,12 | 1,24 | 1,28 | 65,68 | 0,157 |
| 45°2 | 45,34 | 4,60 | 143,20 | 29,43 | 1,12 | 1,06 | 64,91 | 0,142 |
| 45°3 | 46,06 | 3,10 | 145,30 | 30,12 | 1,17 | 0,82 | 65,38 | 0,161 |

Mean-arithmetic mean; MIN-lowest score; MAX-highest score; SD-standard deviation; Skeweness; Kurtosis; CV-coefficient of variation; K-S d- Kolmogorov – Smirnov test

Variability coefficients thereby remain at the same high level or are even slightly increased during the series of measurements, and the measures of sensitivity are at a higher level than in the test 90°. Except in the first series of measurements the variability coefficients are higher than in the test 90°. In this test at the angle of 45° it is observable that there is a systematic error of measurement whereby there is a significant influence of repeated measurements on the results of the test ($F = 13.22$, $p = 0.00$), and with Fisher's LSD post - hoc test it was determined that there is a statistically significant difference between the first and second measurement ($p = 0.00$), first and third measurement ($p = 0.00$), while there was no difference between the second and third measurement ($p = 0.77$). The Interclass correlation coefficient in this test was ICC = 0.778 and ranged in the 95% confidence interval (0.664 to 0.858).

Figure 3. Curve results of the entire sample in the test 45°




Unlike the test 90°, in this test statistically significant differences in repeated measurements were obtained both in boys ($F = 7.87$, $p = 0.00$) and in girls ($F = 6.26$, $p = 0.00$), indicating a significant systematic measurement error in the assessment of strength.

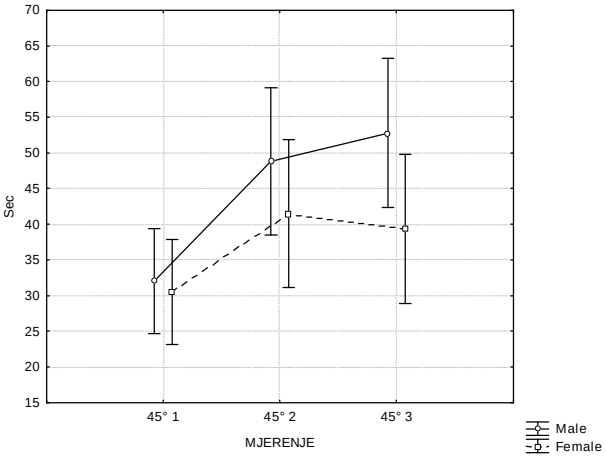
Also, although in girls a satisfactory level of retest reliability ICC = 0.905 (95% CI 0.830-0.951) was obtained, in boys the Interclass correlation coefficient is still below a satisfactory level ICC = 0.576 (95% CI 0.238 to 0.779). By studying the influence of gender on repeated measurements, a significant interaction between these two factors was found, although no gender differences in the results were determined.

Table 7. Differences in the results during repeated measurements in the test 45°

| | SS | Degr. of freedom | MS | F | p |
|---|---|---|---|---|---|
| Intercept | 319929,20 | 1,00 | 319929,20 | 213,42 | 0,00 |
| GENDER | 2658,91 | 1,00 | 2658,91 | 1,77 | 0,19 |
| MEASUREMENT | 8793,73 | 2,00 | 4396,87 | 13,22 | 0,00* |
| MEASUREMENT * GENDER | 1117,24 | 2,00 | 558,62 | 1,68 | 0,19 |

* Statistically significant at p = 0.05

Figure 4. Result curve by gender during a series of measurements in the test 45°




**Results in the TEST 20°**

Results of descriptive statistics for the bent arm hang test at an angle of 20° are shown in Table 8.

Table 8. Descriptive indicators of the results in the test 20° on the entire sample

| | AS | Min | Max | SD | Skew. | Kurt. | CV | K-S d |
|---|---|---|---|---|---|---|---|---|
| 20°1 | 19,28 | 3,10 | 50,70 | 9,41 | 1,01 | 1,40 | 48,82 | 0,103 |
| 20° 2 | 22,04 | 3,40 | 47,60 | 10,62 | 0,51 | -0,42 | 48,19 | 0,107 |
| 20° 3 | 25,87 | 4,50 | 80,40 | 14,38 | 1,41 | 2,66 | 55,59 | 0,152 |

Mean-arithmetic mean; MIN-lowest score; MAX-highest score; SD-standard deviation; Skeweness; Kurtosis; CV-coefficient of variation; K-S d- Kolmogorov – Smirnov test

Results of the nominal value in all three measurements are lower in relation to the test45°, but more than the results in the test 90°, which again suggests eased conditions of the test performance. In this test, it is obvious that the coefficients of flatness and curvature distribution are on the rise during the series of measurements. The same occurs with variability coefficients. Although they are on the rise, they are still at a lower level than in previous tests, 90° and 45°. As in the test 45°, a significant systematic measurement error in both genders was noticed in this test, whereby there are significant differences in repeated measurements in boys (F = 5.28, p = 0.01) and in girls (F = 7, 53, p = 0.00), although the Interclass coefficients are satisfying for both genders, ICC = 0.749 (95% CI 0.535 to 0.874) in boys, and ICC = 0.882 (95% CI 0.789 to 0.939) in girls. Table 9 shows the results of the two-factor analysis of the variance for repeated measures (ANOVA) for determining the systematic error of measurement and gender differences.

Figure 5. Results curve of the entire sample in the test 20°

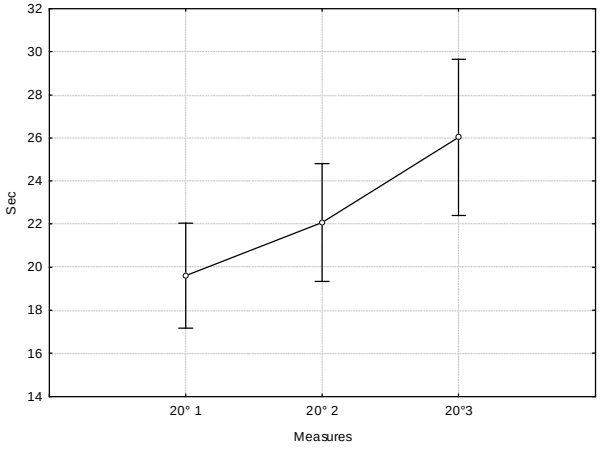


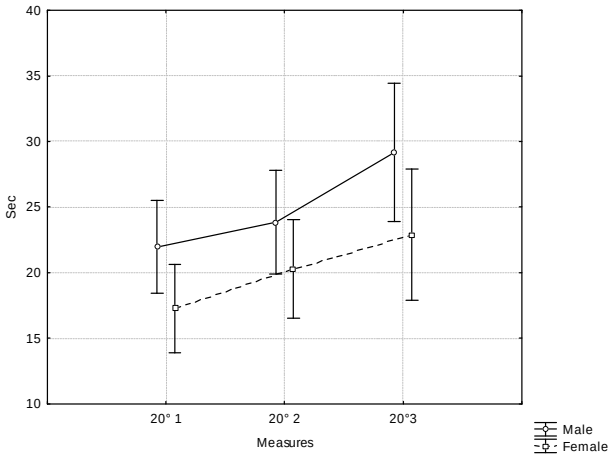

Table 9. Differences in results during repeated measurements in the test 45°

| | SS | Degr. of freedom | MS | F | p |
|---|---|---|---|---|---|
| Intercept | 92974,52 | 1,00 | 92974,52 | 314,16 | 0,00 |
| GENDER | 1075,16 | 1,00 | 1075,16 | 3,63 | 0,06 |
| MEASUREMENT | 1276,43 | 2,00 | 638,22 | 11,77 | 0,00* |
| MEASUREMENT *GENDER | 57,64 | 2,00 | 28,82 | 0,53 | 0,59 |

*statistically significant at p = 0.05

In this test as in the test 45° it is observable that there is a systematic error of measurement, i.e. an increase in the results of repeated measurements, in which there is a significant influence on the results of repeated measurements (F = 11.77, p = 0.00). Fisher's LSD post - hoc test determined a statistically significant difference between the first, second and third measurement (p = 0.00), and between the second and third measurements there are no significant differences (p = 0.06). The Interclass correlation coefficient in this test was ICC = 0.826 and ranges in the 95% confidence interval (0.734 to 0.890). The two-factor analysis of the variance for repeated measurements identified neither the differences by gender nor a significant interaction between gender and repeated measurements.

Figure 6. The result curve by gender during the series of measurements in the test 20°



## Discussion

The study was conducted with the aim to investigate the psychometric characteristics of the famous bent arm hang test and two newly constructed modified tests, with different angles of the body in relation to the ground and grip. Research results have shown that the values of standard deviations and variability coefficients in all three tests during the series of measurements are at high levels, ranging between 53.00% and 79.26% in the test 90°; in the test 45° between 64.91% and 65.68% and in the test 20° between 48.19% and 55.59%.

High reliability coefficients indicate the difficulty of the test, and the results of significant deviations from the normal distribution (KSd, Skewness, Kurtosis) in the test 90° lead to the same conclusion, which impairs the sensitivity as an important metric characteristic of the measuring instrument. Similar results were obtained by Tisgilis, Douda and Tokmakidis (2002) on an older population, whereby the CV was 18.6% and they state that the test is too demanding for this population as well and that it depends on the body weight, which is also found in the study by Kim et al. (2005) who found that 40% of overweight respondents fail to meet the standards of the test. Although in this study a modification of the test attempts to relativize the impact of weight and relieve the grip, it is evident that the body weight alone does not have sufficient impact on the results of the bent arm hang test, but the body composition, i.e. the adipose tissue has a significant impact. Woods, Pate and Burges (1992) have determined a significantly negative impact of fatness on the results of the test, as well as Malin et al. (1995) whereby slimmer children achieve significantly better results than plumper children. By analyzing the effect of repeated measurements on the results of the tests, it is observable that in the test 90° no significant differences between the sets of measurements ($F = 2.97$, $p = 0.06$) were determined. Unlike the traditional test 90°, in the test 45° ($F = 13.08$, $p = 0.00$) and 20° ($F = 11.77$, $p = 0.00$) a systematic measurement error was observed whereby there are differences between the sets of measurements.

However, a significant difference between the first and third series of measurements in the test 90° was determined with the post - hoc test, and at least one series of measurements before using the results is recommended, as is suggested by Marković et al. (2004) in some tests of explosive strength. While in the test 90° a familiarization attempt is needed before using the results in the tests 45° and 20°, it can be assumed that more of them are necessary. The results obtained in this study can be attributed to the insufficiently developed and adopted motor knowledge and skills at this age and which are required to perform the test 45° and test 20°, because the children are not familiar with such a position in comparison to a classic elevated position.

Usually there are big objections to field fitness tests that require a performance skill (Jones and Stratton, 2000), and they recommend raising of motivation, process of familiarization, adequate test duration and the standardization of the measurement process in order to increase the reliability. Although some authors believe that the ICC value below 0.70 is at an unsatisfactory level (Suni et al., 1996), in this study the values of the ICC in all three tests are above that level. In the test 90° ICC = 0.706; in the test 45° ICC = 0.778; and in the test 20° ICC 0,826. Nevertheless, these results should be taken with caution and may be considered as limiting to the research because Artero et al. (2010) noted that the ICC values from 0.7 to 0.8 are of questionable significance, while values above 0.9 are considered relevant. Furthermore, from the obtained results it is noticeable that the test 90° is reliable and applicable to the assessment of muscle strength in arms and shoulders in preschool children after the children are well acquainted with the test prior to the measurement.

Accordingly, we can completely reject the hypothesis 2 in which it was assumed that the test 90° would be too demanding and inappropriate for children of preschool age. Results have indicated the inapplicability of the test 45° and test 20° until the systematic measurement error has been removed, which allows us to reject the hypothesis 1 according to which it was assumed that children would demonstrate the best psychometric characteristics in the position of 45°. This result can be explained by an unnatural position of the body when performing the test. Also, the results showed that the hypothesis 3 can be fully accepted because the expectations that the test 20° for preschoolers would be the most difficult and completely inapplicable one were confirmed. In this study, gender differences in the test 90° were also determined, while in tests 45° and 20° there was no difference by gender. Gender differences have been observed in some tests of explosive strength (Morris et al. 1982; Bala, 2003; Zurc, Pišot, Strojník, 2005; Bala and Katić, 2009), and the differences are particularly apparent among school-aged children (Trajkovski, 2011). This was confirmed by Orjan, Kristjan and Bjorn (2005), who found gender differences at the age of 10-13, also suggest that the increase in strength is apparent while growing up, so that at 16 years of age 50% of boys are better than 5% of the best girls. However, research in the bent arm hang test conducted by Krombholz (2006) and Bala and Katić (2009) no significant differences were found.

## Conclusion

Given the significant influence of strength on physical and health related fitness it is necessary to provide the children with conditions for a proper development of motor skills, and especially of strength from an early age.

In order to follow the development of strength, not just under the influence of the biological development, but also for the control and evaluation of planned and programmed kinesiological activities, it is necessary to use appropriate instruments. Without a doubt, it is necessary to use appropriate measuring instruments for a quality evaluation. In this study it was shown that standardized and modified tests for assessing muscular endurance have a certain weaknesses in the field of psychometric features, so it is necessary to further research their reliability and applicability.

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## METRIJSKE KARAKTERISTIKE STANDARDIZIRANIH I MODIFICIRANIH TESTOVA ZA PROCJENU STATIČKE SNAGE PREDŠKOLSKE DJECE

**Sažetak**

*Cilj ovog istraživanja bio je istražiti metrijske karakteristike testa izdržaj u visu, koji je izveden u tri različita položaja: pod okomitim kutem od 90°, tjelesnim kutom od 45° i 20° u odnosu na tlo. Neka istraživanja su ukazivala na slabe metrijske karakteristike klasičnog testa izdržaja u visu. Dakle, u ovom istraživanju je istraženo koji od tri navedena položaja je odgovarajući, pouzdan i valjan za provjeru statičke snage ruku i ramenog pojasa kod djece predškolskog uzrasta. Ukupno je obrađeno 70 djece (34 djevojčice i 36 dječaka) uzrsta 5.5 do 6.5 godina. Dodatno u odnsou na standardizirani test pod 90° konstruirana su dva testa: izdržaj s nogama prema tlu pod 45° i pod 20°. Svaki je test ponovljen tri puta sa 7 dana između ponavljanja kako bi se odredila valjanost, pouzdanost i primjenjivost u radu s predškolskom djecom. Na temelju dobivenih rezultata utvrđeno je da je jedino 90° test pouzdan i pogodan za rad s predškolskom djecom, ali samo nakon što su djeca upoznata s položajem zahtijevanim za mjerenje. Nadalje, zaključeno je da test pod kutem od 45° i pod 20° su neprimjenjivi za rad dok se ne eliminira sistematska greška. Također je utvrđeno da nema spolnih razlika u izvođenju testa osim kod testa pod 90°. Za kvalitetnu procjenu snage musculature kod predškolske djece potrebno je nastaviti istraživanja metrijskih karakteristika mjernih instrumenata.*

***Ključne riječi**: izdržaj u visu, statička snaga, mišićna izdržljivost, predškolska djeca*

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