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Reliability of Tests Assessing Balance, Coordination, and Strength among Younger Preschool Children

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Abstract

The aim of this research is to determine the psychometric properties of tests which assess balance, coordination, and strength among younger preschool children. The sample consisted of 115 children aged 4 years (+/- 6 months). The sample of variables was made up of 9 newly designed tests for assessing balance (MRUJN – standing longitudinally on one foot; MRPDN – standing transversally on both feet; MRUDN – standing longitudinally on both feet), coordination (MKTL – running with a ball; MKKČ – crawling in circles on all fours; MKTČ – running towards cones), and strength (MSČ15 – number of squats in 15 seconds; MSIM – throwing a medicine ball; MSSV – high jumps). The K-S test was used to examine the normality of distributions. The reliability of measuring instruments was determined with Cronbach's alpha (α). Homogeneity was calculated by the average correlation between particles (IIr). Sensitivity of the newly designed tests was assessed by the measures of skewness (Skew) and the level of kurtosis (Kurt) of the results, whereby factorial validity was determined by factor analysis. The obtained results indicate good metric characteristics of the tests for assessing coordination (MKTL, MKKČ, MKTČ) and strength (MSSV). Based on the results, one may conclude that it is possible to reliably measure coordination and explosive strength, such as jumping, whereas tests for assessing balance and other types of strength have to be more precisely defined, so that satisfactory metric characteristics might be obtained in a repeated study.

Key words: *motor skills, psychometric properties, 4-year-old children.*

Introduction

Proper growth and development is particularly at risk at the present moment, when more or less everyone feels the negative impact of the "modern lifestyle". This is especially true of preschool children, who are at the most sensitive age for growth and development.

New research has shown the impact of a sedentary lifestyle, dominated by sedentary activities in which the vast majority of children spend time in static positions with very little movement through space. According to the theory of integrated development, negative impact on individual abilities is most certainly reflected in the entire anthropological status (Ismail, 1976). Existing research, typically conducted throughout the world, shows that more than 50% of children spend approximately three hours a day doing sedentary activities, such as watching TV or playing on the computer. In addition, because of their living conditions, more and more children consume high-calorie food of low nutritional value. This results in a considerable increase of body weight among children, with a noticeable increase in subcutaneous adipose tissue (Horvat, Mišigoj-Duraković, & Prskalo, 2009). Moreover, children have demonstrated a decrease in the development of motor skills and the level of acquired motor learning. It is generally accepted that children with an insufficient number of motor skills and low levels of motor learning gradually avoid physical activities, and increasingly lag behind their peers in later stages (Horvat, 2010).

It is believed that children should be physically active for a minimum of one hour a day. This includes outdoor activities of higher exercise load accompanied by appropriate motor skills. Some studies (668 children) vetted the connection between improper weight measured by body mass index (BMI) and leisure time with the level of motor skills development. The negative effect that body weight has on some anthropological dimensions was determined in this way. Children with a BMI that indicates obesity displayed inferiority in all motor skills that were tested (Graf, Koch, Kretschmann-Kandel, Falkowski, Christ, Coburger, Lehmacher, Bjarnason-Wehrens, Platen, Tokarski, Predel, & Dordel, 2004). On the other hand, children who exercised and actively spent their leisure time, displayed a positive correlation with the overall development of motor skills (Agras, Hammer, Mcnicholas, & Kraemer, 2004; Datar, & Sturm, 2004; Nawalyah, & Bong, 2004).

In order to adequately determine the level of motor skills development, it is necessary to prepare a battery of tests for their assessment (Sindik, Horvat, & Hraski, 2016). These should most certainly be tests with good psychometric properties, specially designed for children (Horvat, Jenko Miholić, & Blažević, 2009; Jenko Miholić, Horvat, & Cvetković, 2009). This paper primarily wishes to analyse a few tests specifically designed to assess certain motor skills. The significance of this work lies in the fact that it examines tests designed for four-year-olds, which have so far been the subject of limited research.

Methods

The sample consisted of boys and girls, aged 4 years (± 6 months). Parental consent was obtained for all children who participated in the study, in accordance with the Code of Ethics drawn up by the Council for Children as the main advisor of the Croatian Government. During the study, the children had to be completely healthy and could decide on their own whether they wanted to participate, meaning that they could terminate their participation at any moment. A total of 115 children were included in the study.

The study was conducted by students of the Faculty of Teacher Education who underwent special training for this occasion.

The variables used in the study were designed to evaluate certain hypothetical, latent proportions of this age group. Hypothetical proportions of motor skills for assessing balance, coordination, and strength were evaluated. Three tests were created for each latent proportion. Each test was measured three times and the best results from all three measurements obtained during data processing were used. Thus, the balance was evaluated by the following three tests: MRUJN – standing longitudinally on one foot, MRPDN – standing transversally on two feet, and MRUDN – standing longitudinally on two feet. A device was constructed for the purpose of conducting these tests, and the tests were carried out on it. The device was a 5-centimetre-wide raised ledge. The children would climb the ledge barefoot and proceed to stand on it longitudinally on one foot, transversally on both feet, and longitudinally on both feet. Coordination was evaluated with the following tests: MKTL – running with a ball (children rolled the ball on the floor between cones), MKKČ – crawling in circles on all fours (children crawled forward around four cones), and MKTČ – running toward cones (children had to touch the cones). The hypothetical latent proportion of motor skill strength was evaluated with the following three tests: MSČ15 – the number of squats made in 15 seconds (children were supposed to squat as many times as they could in the course of 15 seconds by touching a bat that was set at a height that matched the height every child reached when squatted at a 90°-angle between the upper and lower leg), MSIM – throwing a medicine ball (throwing a 1-kilo medicine ball from their chest using both hands), and MSSV – high jumps (jumping into the air with both feet).

Considering the objectives and tasks of the study, basic and descriptive parameters of each test were determined: the arithmetic mean, standard deviation, minimum and maximum scores, skewness, and kurtosis. Cronbach's alpha, the average correlation between the particles, and the Kolmogorov-Smirnov (K-S) test were calculated in order to assess the psychometric properties of tests. The data were processed by the SPSS 23 program.

Results

Basic descriptive indicators for all the tests were created to assess hypothetical proportions of motor skills, which included balance, coordination, and strength. All are charted in Table 1.

Table 1

Basic and descriptive parameters, Cronbach's alpha, Kolmogorov-Smirnov test

	N	Min	Max	M	SD	Skew	Kurt	C alph	K-S
MRUJN	115	0.00	31.32	6.38	6.45	1.88	3.32	.83	.00
MRPDN	115	1.24	39.00	25.15	8.40	-1.36	0.55	.87	.00
MRUDN	115	2.38	30.45	20.27	9.58	-0.34	-1.42	.84	.00
MKTL	115	3.63	7.50	5.10	0.68	0.63	0.96	.74	.20*
MKKČ	115	1.66	19.99	10.15	3.30	0.72	0.89	.93	.17
MKTČ	115	4.04	12.28	6.91	1.74	0.58	0.06	.91	.20*
MSČ15	115	4.00	16.00	11.42	2.41	-0.17	-0.38	.93	.00
MSIM	115	0.40	4.90	1.56	0.62	1.78	6.99	.92	.00
MSSV	115	5.00	32.00	16.03	5.11	0.23	0.46	.89	.20*

Legend: N – number of examinees; Min – minimum score; Max – maximum score; M – arithmetic mean; SD – standard deviation; Skew – asymmetry; Kurt – curvature; C alph – Cronbach's alpha; K-S – Kolmogorov-Smirnov test

The best result of all three measurements was the main criteria for interpreting the test as part of data processing. It seems that, when it comes to children of this age, it is better to use the best result from all three measurements than the average result, as is common procedure. The primary reason is the rapid loss of concentration among children. This resulted in great differences in the results during the measurement, because children eventually lost focus and interest, and the results of the same test deviated significantly from measurement to measurement. The cause was, first of all, the loss of intrinsic motivation. This is especially evident in the results of balance tests.

The table shows good curvature and dispersion on the balancing test. Cronbach's alpha determined that all tests used in this study have a high reliability. One test (MKTL) has a slightly lower value, but is still on a satisfactory level. The Kolmogorov-Smirnov test for normality distribution of the results shows that four tests have a normal distribution, including all three tests of coordination and one test of strength. Other tests do not feature normal distribution.

Table 2 shows correlations between tests in order to determine the amount of connectivity between individual tests construed for particular hypothetic parameters.

Table 2

Correlation coefficients between results of individual tests

	MRUJN	MRPDN	MRUDN	MKTL	MKKČ	MKTČ	MSČ15	MSIM	MSSV
MRUJN	1.00	0.26	0.22	-0.37	-0.29	-0.41	0.26	0.17	0.17
MRPDN		1.00	0.55	-0.16	-0.17	-0.03	0.26	-0.20	0.13
MRUDN			1.00	-0.09	-0.17	-0.08	0.26	-0.16	0.05
MKTL				1.00	0.52	0.53	-0.41	-0.29	-0.42
MKKČ					1.00	0.62	-0.30	-0.35	-0.38
MKTČ						1.00	-0.34	-0.43	-0.36
MSČ15							1.00	0.02	0.20
MSIM								1.00	0.32
MSSV									1.00

The correlation matrix between the tests indicates relatively low values. Moderate correlations appear between balance tests, and especially between coordination tests. It seems that these tests are well developed and measure the same latent parameters.

Tables 3 to 11 show correlations between the same tests in all three measurements.

Table 3
Correlation coefficients MRUJN

	MRUJN1	MRUJN2	MRUJN3
MRUJN1	1.00	.61	.63
MRUJN2		1.00	.63
MRUJN3			1.00

Table *4*
Correlation coefficients MRPDN

	MRPDN1	MRPDN2	MRPDN3
MRPDN1	1.00	.65	.64
MRPDN2		1.00	.81
MRPDN3			1.00

Table 5
Correlation coefficients MRUDN

	MRUDN1	MRUDN2	MRUDN3
MRUDN1	1.00	.62	.61
MRUDN2		1.00	.69
MRUDN3			1.00

Tables 3, 4, and 5 show moderate correlations between the first, second, and third measurement in the tests for assessing balance. Correlation between the second and third measurement for the test that involves standing transversally on a balance board with both feet is somewhat more significant.

Table 6
Correlation coefficients MKTL

	MKTL1	MKTL2	MKTL3
MKTL1	1.00	.58	.44
MKTL2		1.00	.53
MKTL3			1.00

Table 7
Correlation coefficients MKKČ

	MKKČ1	MKKČ2	MKKČ3
MKKČ1	1.00	.82	.76
MKKČ2		1.00	.89
MKKČ3			1.00

Table 8
Correlation coefficients MKTČ

	MKTČ1	MKTČ2	MKTČ3
MKTČ1	1.00	.76	.79
MKTČ2		1.00	.81
MKTČ3			1.00

Tables 6, 7, and 8 show correlations between the first, second, and third measurement of tests for assessing coordination. Correlations between certain items in MKKČ and MKTČ are the largest among all the measured tests. It is evident that these tests were

well construed and that there are no great differences between results within certain measurements.

Table 9

Correlation coefficients MSČ15

	MSČ151	MSČ152	MSČ153
MSČ151	1.00	.80	.79
MSČ152		1.00	.82
MSČ153			1.00

Table 10

Correlation coefficients MSIM

	MSIM1	MSIM2	MSIM3
MSIM1	1.00	.85	.77
MSIM2		1.00	.77
MSIM3			1.00

Table 11

Correlation coefficients MSSV

	MSSV1	MSSV2	MSSV3
MSSV1	1.00	.74	.73
MSSV2		1.00	.71
MSSV3			1.00

Tables 9, 10, and 11 show correlations between the first, second, and third measurement of tests for assessing strength. Correlations between certain items in all tests are significant. It is evident that these tests were well construed and that there is a significant connection between certain measurements.

Discussion

The research conducted on 4-year-old children who attended kindergartens in the City of Zagreb emerged from the need to create a battery of appropriate, scientifically validated tests for assessing certain hypothetical motor skills parameters for preschool children. We do not yet possess a sufficient number of quality tests.

This study developed a battery of nine tests (three for each of the hypothetical latent parameters for motor skills, such as balance, coordination, and strength). All tests were primarily designed to precisely measure the exact ability we wanted to test. So far, research studies have proven that balance, coordination, and strength are in a sensitive stage at this age, which means that this is the most appropriate moment for a positive impact on precisely these motor skills. The impact of the level of balance, coordination, and strength development on the development of the anthropological status of children, especially during the acquisition of new or practicing modified biotic motor learnings, as well as simple kinesiology motor learnings, is well known. This is particularly evident in light of the negative influence today's lifestyle has on the anthropological status of humans. In order to downplay its influence, it is essential to implement organised kinesiology activities through which the transformation of the anthropological status of children would be influenced, with special emphasis on kinesiology-anthropological parameters.

Three tests were constructed for each of the hypothetical latent parameters, all specifically adapted to this particular age.

Table 1, therefore, displays basic and dispersive parameters for each test. When calculating and processing each test, it is recommended to take the best result from the three measurements. While determining psychometric properties of tests for assessing balance, we must conclude that their basic and dispersive parameters are satisfactory. In all three tests, the value of Cronbach's alpha is above .80. On the other hand, correlations between individual tests are low. The Kolmogorov-Smirnov test shows abnormality in the distribution of the results. This is somewhat understandable since the measured balance is sensitive to external influences; moreover, 4-year-old children lose motivation relatively quickly. The results show that it would be unwise to make certain changes within the structure of these tests in order to improve their psychometric properties. Considering that there is a limited number of tests assessing balance among children of such a young age, the authors suggest that these tests be used in practice until tests with better psychometric properties are discovered.

The group of tests which were designed to determine the level of development of hypothetical latent parameters of coordination showed the best psychometric properties. Basic and dispersive parameters were satisfactory. Cronbach's alpha was very high in two tests and satisfactory in one. The K-S test was used to check the normality of distribution, which proved to be normal in two tests, and bordering on normality in one test. In the correlation matrix between all tests, these tests show maximum correlation among themselves. The table of correlations between particular measurements within the same test shows they are high in two tests, and moderate in one. All of this shows that the group of tests for assessing the hypothetical parameters for motor skills coordination is well designed, which is supported by their good psychometric properties. The authors believe that these tests can and should be applied in practice.

Insight into the basic and dispersive parameters of tests for assessing the hypothetical latent parameters of strength in 4-year-old children supports their satisfactory validity. Cronbach's alpha shows that these tests are highly reliable. The test measuring high jumps with both feet from one spot displays the normal distribution of results. Other tests do not have a normal distribution, which indicates a need for corrections and modifications of the tests. The table featuring correlations between the tests indicates very low levels of correlation. It is obvious that certain tests of strength, such as throwing the medicine ball, do not measure the same space. Results of the medicine ball throwing test are probably more affected by the throwing technique than the level of development of explosive strength in the arms. Additionally, the 15-second squat test also displays an abnormal distribution of results. The test evaluating jumps with both feet from one spot obviously contains good psychometric properties, which is why the authors recommend it for further use.

Conclusion

By reviewing the results of psychometric properties of the tests for assessing the hypothetical latent parameters of motor skills and balance, coordination and strength,

it can be determined that we have identified four tests which have good psychometric properties and are recommended for use in practice. These are the three tests of coordination (MKTL, MKKČ, MKTČ) and the test of strength (MSSV). Other tests should be subjected to a certain level of correction and adjustment in order to improve their psychometric properties. Given that only a limited number of tests for assessing the level of development of certain motor skills in preschool children is available at the moment, the authors believe that the proposed tests can be applied in practice. The proposed tests will certainly enable better diagnostics, better planning, and programming of kinesiology activities for preschool children.

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Pouzdanost testova za procjenu ravnoteže, koordinacije i snage kod djece mlađe vrtićke dobi

Sažetak

Cilj je ovog istraživanja utvrditi metrijske karakteristike testova za procjenu ravnoteže, koordinacije i snage kod djece mlađe vrtićke dobi. Uzorak ispitanika sastojao se od 115 djece u dobi od četiri godine (+-6 mjeseci). Uzorak varijabli činilo je 9 novokonstruiranih testova za procjenu ravnoteže (MRUJN – stajanje uzdužno jednom nogom, MRPDN – stajanje poprečno s dvije noge, MRUDN – stajanje uzdužno s dvije noge), koordinacije (MKTL – trčanje s loptom, MKKČ – krug četveronoške, MKTČ – trčanje do čunjeva) i snage (MSČ15 – čučnjevi u 15 sekundi, MSIM – izbačaj medicinke, MSSV – skok uvis). Za provjeru normalnosti distribucija koristio se KS test. Pouzdanost mjernih instrumenata utvrđena je Cronbach alfom (α). Homogenost je izračunata putem prosječne korelacije između čestica (IIr). Osjetljivost novokonstruiranih testova, procijenjena je s pomoću mjera asimetričnosti (Skew) i stupnja zakrivljenosti (Kurt) rezultata, a faktorska je valjanost dobivena s pomoću faktorske analize. Dobiveni rezultati ukazuju na dobre metrijske karakteristike testova za procjenu koordinacije (MKTL, MKKČ, MKTČ) i snage (MSSV). Na osnovi dobivenog može se zaključiti da se kod četverogodišnjaka može pouzdano mjeriti koordinacija i eksplozivna snaga tipa skočnosti, a da se testovi za provjeru ravnoteže i ostalih tipova snage moraju preciznije definirati, kako bi se u ponovljenoj studiji dobile zadovoljavajuće metrijske karakteristike.

Ključne riječi: *četverogodišnjaci; metrijske karakteristike; motoričke sposobnosti.*