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Metric Characteristics of Tests for Assessing Coordination, Speed and Balance in Four-Year-Old Children

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Abstract

The aim of this pilot study was to determine the metric characteristics of tests for assessing coordination, speed and balance in preschool children. For the purpose of this study, a sample of 59 boys and girls was measured. The respondents were selected from three kindergartens in the city of Zagreb and their age ranged from 48 ± 6 months. The variables were composed of six motor tests of which two test were for assessing coordination (walking on all fours around the stand and eight with bending), two for assessing speed (two-leg jumping hoops and 10m running) and two for testing balance (standing on one leg and walking on the narrowed field). The collected data were analysed by statistical software Statistica 12. The reliability of the test was determined by calculating inter item correlation (r II), and Cronbach alpha (α). The basic descriptive parameters were calculated: arithmetic mean (M), standard deviation (SD), the asymmetry (SKEW) and degree of peakedness (KURT) of distribution for determining the sensitivity while the normality was tested by the K-S test. The homogeneity was estimated by univariate analysis of variance (F test and the level of significance p<0.05). Factorial validity of tests was calculated by factor analysis. The results of this research will provide the answer whether the selected tests can be used to assess motor abilities in four-year-old children. This is a pilot study and the results will be helpful for future research related to motor abilities of preschool children.

Key words: *motor abilities; preschool children; test reliability.*

Introduction

Motor abilities are responsible for the effectiveness of human movement (Malina, 2004). They are the basis for the development and improvement of certain types of movement and motor skills (Petz, 1992). The successful transformation of certain kinanthropological dimensions depends on systematic planning, programming and implementation of the educational process. The realization of the objectives of the planned process largely depends on the possibility of determining the proper level of development of some anthropological dimension. Motor abilities are one of the main factors that largely define the level of success when performing movement structures (Popeska, Georgiev, & Mitevski, 2009). In addition, the level of development of motor abilities is important for a child's overall development, both in the physical sense, but also in the cognitive, emotional and social aspect (Pišot & Planinšec, 2010).

Most motor abilities develop between the age of 3 and 10, while the particularly sensitive phase is from 4 to 7 years of age. During this period the structure of motor space based on genetic and external factors that affect the overall growth and development of children are being developed (Burton & Miller, 1998).

Monitoring of motor abilities and their objective verification is one of the major problems in working with preschool children. The main problem lies in inadequate measurement instruments and their construction. Measuring instruments used in the assessment of motor space are mostly adapted from the population of adult respondents or from the population of schoolchildren (Horvat, 1999).

Numerous studies were conducted to describe measuring instruments that defined a hypothetical model of the structure of motor abilities among the adult population (Fleishmann, 1964; Carina, Hošek, Metikoš, & Momirović, 1975; Kurelić, Momirović, Mraković, & Sturm, 1979; Viskić-Štalec & Mejovšek, 1975). There are also studies that have partially explored the classical hierarchical structure of motor abilities in children (Rajtmajer, 1993; Mraković, et al., 1996; Planinšec, 2002; Popeska et al., 2009; Horvat, 2010), and studies that indicate existence of one general motor factor, which is the most structured by dimensions of coordination and balance (Ismail & Gruber, 1971; Videmšek, 1996; Bala, 2003; Zurc, Pišot, & Strojnik, 2005).

The reason behind unsatisfactory metric characteristics of measuring instruments used to collect data of children's motor status is inappropriateness of tests and this is mostly due to problems of measurement, measurement protocols, motivation, etc. (Tomac, Hraski, & Sporiš, 2012).

Therefore, the aim of this study was to determine the metric characteristics of tests to assess the hypothetical dimensions of motor abilities such as coordination, speed and balance in four-year-old children.

Methods

For the purposes of this pilot study, a sample of 59 boys and girls was used. Participants were selected from three kindergartens in the city of Zagreb and their ages ranged from 48 ± 6 months.

The measurement was carried out by six motor tests (Table 1) from which two test aimed to assess coordination (*walking on all fours around the stand* and *eights with bending*), two for assessing speed (*two-leg jumping hoops* and *10 m running*) and two for the assessment of balance (*standing on one leg* and *walking on the narrowed field*).

The collected data were analysed using the statistical software package Statistica 12. The reliability of tests was calculated by inter item correlation (r II) and Cronbach alpha (α). The basic descriptive parameters were calculated: arithmetic mean (M), standard deviation (SD), the asymmetry (SKEW) and the degree of peakedness (KURT) of distribution to determine the sensitivity, and the normality of distribution was tested by the K-S test. The homogeneity was estimated by univariate analysis of variance (F test and the level of significance $p<0.05$). Factorial validity of constructed instruments was calculated by factor analysis.

Table 1
Tests Description

Test	Walking on all fours around the stand (WFAS)
Equipment	Duct tape 50 cm in length, 1 stand
Execution	At the signal, a child, on all fours, goes around the stand located at a distance of 3 m and comes back. The test is finished when the child passes the starting line
Recording	Children perform the task three times, measuring in seconds
Test	Eight with bending (EWB)
Equipment	Duct tape 50 cm in length, 2 stands, 4 m elastic ribbon
Execution	At the signal, a child passing by the stand, bends under the elastic ribbon located at the height of his/her hips, continues to run and circumvents the stand located at a distance of 4 m, comes back, once again bends and runs across the starting line
Recording	Children perform the task three times, measuring in seconds
Test	Two-leg jumping hoops (TLJH)
Equipment	Duct tape 50 cm in length, 5 hoops
Execution	At the signal, a child jumps into hoops with both feet, upon passing all five hoops turns and jumps back with both feet until he/she passes the starting line with both feet
Recording	Children perform the task three times, measuring in seconds
Test	10 m running (R10M)
Equipment	Two duct tapes 50 cm in length
Execution	At the signal, a child runs the distance of 10 m as quickly as possible
Recording	Children perform the task three times, measuring in seconds
Test	Standing on one leg (SOL)
Equipment	A cube 10 cm high
Execution	A child tries to stand on one leg on the cube as long as possible, and in doing so does not touch the other foot or ground. In that case the task is completed successfully
Recording	Children perform the task three times, measuring in seconds
Test	Walking on the plank (WOP)
Equipment	Plank 2 m long, 5 cm wide and 1 cm high. Duct tape.
Execution	At the signal, a child has to walk on the plank from the beginning to end and in doing so, does not touch the floor
Recording	Each child performs the task three times, measuring in seconds

Results and Discussion

In accordance with the aim of the research, Tables 2 to 7 present the results of metric characteristics of tests constructed for the assessment of coordination, speed and balance of children at the age of 4 (+/- 6 months). From the results of the K-S test, it is evident that there are significant differences between the calculated and the expected distribution of the results in five of the six tests of motor abilities. Although the results of the tests *eight with bending* (EWB) and *two-leg jumping hoops* (TLJH) are at the limit value of normal distribution, the only test where the respondents' results were not normally distributed is the test for assessing balance - *standing on one leg* (SOL) (d=0.22). Based on the results of the K-S test, we can state that all tests except *standing on one leg* (SOL) are sensitive, and successfully differentiate the respondents.

However, examining the results of asymmetry of distribution (skewness - SKEW) and results of the peakedness of distribution (kurtosis - KURT) it can be concluded that the distribution of the tests *walking on all fours around the stand* (WFAS), *eight with bending* (EWB) and *two-leg jumping hoops* (TLJH) are positively asymmetric and leptokurtic. That may suggest that these tests are too demanding for four-year-old children. Evidence for that conclusion comes from the clustering results in the area of lower values. In tests *10m running* (R10M) and *walking on the plank* (WOP) frequencies of results are evenly distributed left and right of the average value making it a symmetrical distribution. The exception is the test *standing on one leg* (SOL) where skewness and kurtosis measures indicate no symmetrical distribution. The value of K-S test also shows that the results are not normally distributed, and the test is not sensitive enough due to the grouping of results in the area of lower values.

The homogeneity of tests was calculated by analysis of variance. The results of tests *10m running* (R10M), *standing on one leg* (SOL) and *walking on the plank* (WOP) show their homogeneity. In other tests, the results of the respondents in all of the items do not depend on the same object of measurement ($p<0.05$), therefore their diagnostic significance is not satisfactory.

From observing the parameters of reliability (II r and α) in the constructed tests for assessing coordination, speed and balance in four-year-old children (Tables 2 to 7) a relatively large range of results is present depending on the observed test. Values of inter item correlations ranged from a low 0.57 and 0.64 for the tests *10m running* (R10M) and *standing on one leg* (SOL) to a high 0.84 for tests *eight with bending* (EWB) and *two-leg jumping hoops* (TLJH).

In accordance with the values of inter item correlation coefficient Cronbach alpha ranges from limit values of 0.80 to a high correlative value of 0.93. The results of Cronbach alpha coefficients indicate a satisfactory correlation between items in all of the analysed variables for assessing the measured motor abilities.

Table 2

Metric characteristics of the test for assessing coordination - walking on all fours around the stand

	M	SD	KS	SKEW	KURT	F	P	IIr	α
WFAS1	8.83	3.34							
WFAS2	8.08	1.87	0.12	2.42	10.12	5.01	0.00	0.77	0.88
WFAS3	8.12	2.64							

Table 3

Metric characteristics of the test for assessing coordination - eight with bending

	M	SD	KS	SKEW	KURT	F	P	IIr	α
EWB1	10.88	2.95							
EWB2	10.26	2.19	0.17	2.08	7.04	6.61	0.00	0.84	0.93
EWB3	10.27	2.43							

Table 4

Metric characteristics of the test for assessing speed – two-leg jumping hoops

	M	SD	KS	SKEW	KURT	F	P	IIr	α
TLJH1	8.54	1.96							
TLJH2	8.57	2.53	0.17	2.08	7.04	6.61	0.00	0.84	0.93
TLJH3	8.43	2.41							

Table 5

Metric characteristics of the test for assessing speed –10m running

	M	SD	KS	SKEW	KURT	F	P	IIr	α
R10M1	3.57	0.37							
R10M2	3.57	0.35	0.07	-0.17	-0.68	0.67	0.51	0.57	0.80
R10M3	3.53	0.38							

Table 6

Metric characteristics of the test for assessing balance – standing on one leg

	M	SD	KS	SKEW	KURT	F	P	IIr	α
SOL1	4.67	4.03							
SOL2	4.74	5.53	0.22	1.76	2.81	0.04	0.96	0.64	0.82
SOL3	4.59	4.56							

Table 7

Metric characteristics of the test for assessing balance – walking on a plank

	M	SD	KS	SKEW	KURT	F	P	IIr	α
WOP1	5.84	4.44							
WOP2	5.28	3.28	0.16	1.66	3.16	2.26	0.11	0.78	0.90
WOP3	5.16	3.33							

Factorial validity of the measuring instrument answers the question whether a measuring instrument truly measures what it was intended to measure, or with how much variance the factor is explained. This characteristic is determined by factor analysis (Petz, 1992). In this study, factor analysis of six manifest variables for assessing three dimensions, extract two latent dimensions - latent dimension of coordination and balance. Table 7 shows that WFAS, EWB and TLJH tests have the greatest projection on the first factor. From isolating tests *walking on all fours around the stand* (WFAS) and *eight with bending* (EWB), which are constructed to assess the coordination, it can be said that they are valid for assessing the required motor abilities and the first factor can be called factor of coordination. In addition, Table 8 shows that the greatest projection of the second factor comes from the test for assessing balance - *walking on the plank* (WOP) so this factor can be called factor of balance and the test WOP is valid for estimating this dimension. Tests *two-leg jumping hoops* (TLJH), and *10 meters running* (R10M) are constructed to estimate speed but this latent dimension is not extracted so these tests are not valid for assessing speed. Also, the test *standing on one leg* (SOL) was not projected as the factor of balance and thus is not valid for assessing balance.

Table 8

Factorial validity of constructed tests

	FACTOR 1	FACTOR 2
WFAS	**0.88**	0.03
EWB	**0.89**	0.11
TLJH	**0.81**	0.06
R10M	0.42	0.40
SOL	-0.51	-0.53
WOP	-0.02	**0.90**
Expl.Var	2.67	1.26
Prp.Total	0.44	0.21

Similar issues in constructing tests and determining the metric characteristics of tests recommended for the assessing strength, coordination and flexibility in four-year-old children, were studied by Trajkovski Višić, Berlot, and Kinkela (2007). The authors, based on research results, verified discrimination, reliability and validity of the constructed tests. They concluded that the tests: *shuttle run*, *walking back on all fours*, *crunches*, *standing long jump* and *sit and reach* can be used for monitoring the motor efficiency of preschool children, while tests *hopscotch*, *endurance in pull-ups*, *lateral split* and *lying down with hands backwards* have good reliability (0.85) but poor discrimination.

Furthermore, Horvat, Jenko Miholić, and Blažević (2008) determined the metric characteristics of tests for assessing balance as one of the hypothetical latent dimensions of motor abilities among preschool children. The authors concluded that two tests have satisfactory metric characteristics while the third one had somewhat lower metric characteristics. Also, the authors believe that it would be reasonable to make certain changes in test construction (e.g. to increase the standing area) in order to improve the metric characteristics, as is the case in this study. Namely, from the six tests provided, the only acceptable one for assessing balance is *walking on the plank*

(WOP), while the other tests need to be modified to be appropriate for children aged four years.

Stanišić (2012) also dealt with determining metric characteristics of tests for the assessment of speed in preschool children. The results obtained indicate that the tests for the evaluation of speed frequency jumping have a solid discrimination, very high reliability, and belong to a hypothetical factor responsible for preschool children's evaluation of speed frequency jumping.

In this study an attempt was made to construct a test for the assessment of speed, *two-leg jumping hoops* (TLJH), so the authors recommend constructing a test that would be appropriate for four-year-old children, following the example of research results by Stanišić (2012) obtained on six-year-old children.

Conclusion

The objective of this pilot study was to construct a number of tests for assessing the hypothetical dimensions of motor abilities in children of younger kindergarten age. For that purpose determining the metric characteristics of tests to assess the coordination, speed and balance on a sample of 59 four-year-old children was provided. The results indicate good reliability (α) of all the measured tests. However, the results of the homogeneity and sensitivity of tests show that WFAS, EWB, TLJH and SOL are not appropriate to the selected age of the respondents because the achieved results were grouped in the zone of poorer outcomes. That suggests that these tests were too difficult for four-year-old children. Furthermore, the factor analysis revealed that the test *10m running* (R10M) has a poor construct validity, meaning that it is not appropriate for use in assessing speed among four-year-old children. With regard to the satisfactory metric characteristics of the WOP test, the authors propose its further use in determining the level of development of hypothetical motor abilities of balance with four-year-olds. In further studies, the authors also suggest modifying certain tests that have not had satisfactory metric characteristics and their implementation on a larger sample.

References

Bala, G. (2003). Quantitive differences in motor abilities of pre-school boys and girls. *Kinesiologia Slovenica, 9*(2), 5-16.

Fleishmann, E. A. (1964). *The structure and measurment of physical fitness.* New York: Prentice-Hall, Engelwood Cliffs.

Gredelj, M., Metikoš, D., Hošek, A., & Momirović, K. (1975). Model hijerarhijske strukture motoričkih sposobnosti. 1. rezultati dobiveni primjenom jednog neoklasičnog postupka za procjenu latentnih dimenzija. *Kineziologija, 5*(1-2), 7-81.

Horvat, V. (1999). *Motorička znanja djece predškolske dobi*. (Master's thesis, University of Zagreb). Zagreb: Fakultet za fizičku kulturu.

Horvat, V. (2010). *Relacije između morfoloških i motoričkih dimenzija te spremnosti za školu djece predškolske dobi.* (Doctoral thesis, University of Zagreb). Zagreb: Kineziološki fakultet Sveučilišta u Zagrebu.

Horvat, V., Jenko Miholić, S., & Blažević, K. (2009). Metric characteristics of tests for assessing balance in preschool children. In I. Prskalo, V. Findak, & J. Strel (Eds.), *3rd Special Focus Symposium: Kinesiological education – heading towards the future* (pp. 75-82). Zadar: Faculty of Teacher Education, University of Zagreb.

Ismail, A. H., & Gruber, J. J. (1971). *Integrated development - Motor aptitude and intellectual performance*. Columbus: Charles E. Merrill Books.

Kurelić, N., Momirović, K., Mraković, M., & Šturm, J. (1979). Struktura motoričkih sposobnosti i njihove relacije sa ostalim dimenzijama ličnosti. *Kineziologija, 9*(1-2), 5-20.

Malina, R. M. (2004). Motor Development during Infancy and Early Childhood: Overview and Suggested Directions for Research. *International Journal for Sport and Health Science*, *2*, 50-66. http://dx.doi.org/10.5432/ijshs.2.50

Mraković, M., Findak, V., Metikoš, D., & Neljak, B. (1996). Developmental characteristics of motor and functional abilities in primary and secondary school pupils. *Kineziologija, 28*(2), 62-70.

Petz, B. (1992). *Psihologijski rječnik.* Zagreb: Prosvjeta.

Pišot, R., & Planinšec, J. (2010). Motor structure and basic movement competences in early child development. *Annales Kinesiologiae, 1*(2), 145-165.

Planinšec, J. (2002). Relations between the motor and cognitive dimensions of preschool girls and boys. *Perceptual and Motor Skills*, *94*, 415–423. http://dx.doi.org/10.2466/pms.2002.94.2.415

Popeska, B., Georgiev, G., & Mitevski, O. (2009). Structure of motor space in children at 7 year age. *Physical Education and Sport, 48*(8), 19-24.

Rajtmajer, D. (1993). Komparativna analiza psihomotorične strukture dečkov i deklic, starih 5-5.5 let. *Šport, 41*(1-2), 36-40.

Sanders, S. W. (2002). *Active for Life: Developmentally Appropriate Movement Programs for Young Children*. Washington, DC: NAEYC.

Stanišić, I. (2012). Metric characteristics of speed frequency jumping tests for preschool children. *Activities in Physical Education* & *Sport, 2*(2), 167-172.

Tomac, Z., Hraski, Ž., & Sporiš, G. (2012). The assessment of preschool children's motor skills after the familirization with motor test. *Journal of Strenght and Conditioning Research, 26*(7), 1792-1798. http://dx.doi.org/10.1519/JSC.0b013e318237ea3b

Trajkovski Višić, B., Berlot, S., & Kinkela, D. (2007). Metrijske karakteristike testova namijenjenih za procjenu snage, koordinacije i fleksibilnosti kod četverogodišnjaka. In V. Findak (Ed.), *Zbornik radova, 16. ljetna škola kineziologa Republike Hrvatske*, *Poreč* (pp. 257-262). Zagreb: Hrvatski kineziološki savez.

Videmšek, M. (1996). *Motorične sposobnosti triletnih otrok*. (Doctoral dissertation, University of Ljubljana). Ljubljana: Univerza v Ljubljani, Fakulteta za šport.

Viskić-Štalec, N., & Mejovšek, M. (1975). Kanoničke relacije prostora koordinacije i prostora motorike. *Kineziologija, 5*(1-2), 83-112.

Zurc, J., Pišot, R., & Strojnik, V. (2005). Gender differences in motor performance in 6.5 – year-old children. *Kinesiologia Slovenica, 11*(1), 90-104.

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Metrijske karakteristike testova za procjenu koordinacije, brzine i ravnoteže kod četverogodišnjaka

Sažetak

Cilj ovog pilot-istraživanja bilo je utvrđivanje metrijskih karakteristika testova za procjenu hipotetskih latentnih dimenzija motoričkih sposobnosti kod djece predškolske dobi i to: koordinacije, brzine i ravnoteže. Uzorak je činilo 59 dječaka i djevojčica starosti od 48 ± 6 mjeseci. Ispitanici su bili iz tri vrtića grada Zagreba. Mjerenje je provedeno sa šest varijabli od kojih su dva testa bila za procjenu koordinacije (hodanje četveronoške oko stalka i osmica sa sagibanjem), dva za procjenu brzine (sunožni skokovi u obruče i trčanje na 10 m) i dva za procjenu ravnoteže (stajanje na jednoj nozi i hodanje po suženoj površini). Prikupljeni podaci analizirani su statističkim paketom Statistica 12. Pouzdanost testa izračunata je korelacijom između čestica (IIr) i Cronbach alfom (α). Izračunati su osnovni deskriptivni parametri: aritmetička sredina (AS), standardna devijacija (SD), raspršenost (SKEW) i stupanj zakrivljenosti (Kurt) distribucije. Za procjenu osjetljivosti i normalnost distribucije koristio se KS test. Homogenost je procijenjena univarijatnom analizom varijance (F test i razina značajnosti - p <0,05). Faktorska valjanost mjernog instrumenta izračunata je faktorskom analizom. Rezultati ovog istraživanja ukazat će na mogućnost primjene odabranih testova za procjenu motoričkih sposobnosti kod četverogodišnjaka. Kako je ovo pilot-istraživanje, rezultati će nam poslužiti u daljnjim opsežnijim istraživanjima.

Ključne riječi: *motoričke sposobnosti; pouzdanost testova; predškolska dob.*