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Towards the Construction of Test for Assessing Motor Abilities in Four-aged Pre-school Children*

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ABSTRACT The objective of this study is to determine the basic metrical properties of the tests for the assessment latent dimensions of motor abilities at four-year children. Sample included 50 children aged 4 years (± 6 months) from three kindergartens in Zagreb, during the first half of 2015. Battery of tests that assess the hypothetical motor abilities (coordination, speed, balance, and strength) was applied. Reliabilities of the tests varied in the range from 0.45 to 0.96 (Cronbach's alpha). Already satisfactory discriminability is not found only for tests two-leg jumping through hoops and standing on one leg. Homogeneity of the tests varies in range from 0.22 to 0.89 (average inter-item correlation). Analysis of the construct validity revealed two-component structure which has very low reliability of the second component. Results indicate the potential for constructing new instruments for measuring motor abilities in four-aged children, on a larger sample of participants.

INTRODUCTION

Monitoring the motor abilities in preschool children is important from the aspect of ensuring stimulatory environment for their healthy growth and development. However, the main problem during the monitoring of these motor abilities of young children is the inadequate measuring instruments for their assessment (Hraski et al. 2015). Therefore, the main scope of this article is to construct the battery of measuring instruments, to measure the motor abilities in four-aged preschool children.

Motor Abilities in Children

Studies of motor abilities of preschool children started relatively early. Hicks (1930) study on 60 younger children investigated a development of motor skills of shooting the ball in both moving and stationary targets. A few years later, Cowan and Pratt (1934) tested the possibility of applying a jump over the obstacles as a diagnostic test to assess coordination. However, motor abilities are responsible for the efficiency of human motion (Malina 2004; Popeska et al. 2015).

Problem of Dimensionality

Various studies on adults have shown that motor skills cannot be effectively described by a single general dimension. On the other hand, describing the humans motion capability is a necessary articulation on more quantitative (strength, speed, endurance, and flexibility) and qualitative (coordination, agility, balance, precision) motor abilities (Gredelj et al. 1975; Metikoš et al. 1979; Gallahue and Donnely 2005). However, in children, there are several studies that have partially explored classical hierarchical structure motoric abilities (Rajtmajer 1993; Pišot and Planinšec 2010; Popescu et al. 2009). Other studies indicate the existence of general motor factors, which are mostly defined by the dimensions of coordination and balance (Ismail and Gruber 1971; Videmšek 1996; Bala 2003; Zurc et al. 2005).

Practical Problems in Determining the Structure of Motor Space

The differences in determining the structure of motor space in young children results from a series of problems that researcher meet in practice. The reasons for practical problems include special conditions, and space and time during the measurement (Petz 1992; Prskalo et al. 2006), measurement protocol and familiarization (Hayes et al. 2007; Glaister et al. 2010; Tomac et al. 2012), the motivation of children (Sanders 2002; Labiadh et al. 2010; Weimer et al. 2011), and the inadequacy of tests to the age and stage of development (Burton and Miller 1998; Jurak et al. 2003; Malina 2004). Therefore, there is a pressing need

to construct age-adjusted motor ability tests for preschool children, which are short and which have easy understandable instructions to the children and good metric characteristics.

Objective of the Study

Consequently, the main goal of the study is to determine the basic kinesiometric properties of the tests for the assessment of certain hypothetical latent dimensions of motor abilities at four-year children. More specifically, the first goal of the study was to estimate the validity, homogeneity, discriminability, and reliability of the tests for the assessment of motor abilities. Second goal was to determine the correlations between the scores in the motor tests, as well as the correlations between age and factor scores in certain hypothetical latent dimensions of motor abilities. The third goal is to determine the gender differences in the scores of motor tests and in hypothetical latent dimensions of motor abilities.

METHODOLOGY

Subjects

The study was conducted in three kindergartens in the city of Zagreb during the first half of 2015. The research participants were healthy 50 children, among which are 24 boys and 26 girls, aged 4 years (± 6 months). The sample of participants was randomly selected.

Procedure

Children's parents were informed about the protocol of measurement, signing an informed consent document, and giving permission that their children participate in the investigation. Parental consent was obtained for all participants. The study was conducted in adherence to the standards of Code of Ethics for research with children published by The Council for Children of the Croatian Government (Ajdukovic and Kolesaric 2003). Testing was performed in the first half of 2015, in the sport gyms of belonging kindergartens.

Tests and Measures

The main variables in the study are operationalized by the battery of tests, aimed to assess the hypothetical motor abilities: coordination (walking on all fours around the stem, that is, MRHD; walking on all fours in the back, that is, MKHCS); the speed (running at 10 meters, that is, MBT10M; two-leg jumping through hoops, that is, MBSSO); balance (standing on one leg, that is, MRSJN; walking on the plank, that is, MKHCN); and strength (raising the leg, that is, MSPN). Furthermore, the gender of the participants was used as the independent variable in this study.

Statistical Analysis

SPSS 20.0 package has been used for statistical analysis. The Principal Component Analysis (PCA) with Equamax rotation is used for determining the latent structure of hypothetical motor abilities. The number of significant main components has been obtained using the Guttman-Kaiser criteria and Scree Plot. Minimal saturation was 0.40 between each individual item and principal components. The scores in both principal components (that is, factors) have been defined using regression factor scores. In descriptive statistics, mean and standard deviation have been calculated. The Kolmogorov-Smirnov test was used to assess discriminability, that is testing if certain distribution deviates from Gauss's curve or not. Homogeneity is assessed using ANOVA, as well as mean inter-Item correlations. Reliability was assessed using Cronbach's Alpha internal consistency coefficient for standardized items and intraclass correlation coefficient. Spearman correlations was obtained between the scores in the motor tests for 4-year old children, while Pearson correlation coefficients are calculated between age and factor scores in the two principal components. Gender differences in the scores in the motor tests have been tested by the t-test. All the differences and correlations are commented on the levels of $p<0.01$ and $p<0.05$ (confidence interval of 95%).

RESULTS

The homogeneity, discriminability, and reliability of the motor tests for 4-year old children were presented in Table 1. Reliabilities, calculated by Cronbach's alpha (α) coefficients of internal consistency on standardized items, varied in range from 0.45 (MRHD) to 0.96 (MBSSO). On the other hand, intraclass correlation coefficients varied in range from 0.46 (MRHD) to 0.95 (MB-

Table 1: Homogeneity, discriminability and reliability of the motor tests for 4-year old children

	Cronbach's Alpha	*Mean inter-item correlations*	*ANOVA (F)df=49.2*	*Intraclass correlation coefficient*	*Kolmogorov Smirnov test*
MRHD	0.453	0.220	0.360	0.462	0.758
MBT10M	0.873	0.696	0.039	0.858	0.998
MBSSO	0.959	0.886	0.613	0.954	**0.014**
MRSJN	0.692	0.428	0.483	0.682	**0.019**
MKHCN	0.902	0.754	**4.638****	0.897	0.754
MKHCS	0.942	0.845	0.411	0.937	0.253
MSPN	-	-	-	-	0.145

Legend: **significant at p<0.01
coordination (walking on all fours around the stem, that is, MRHD; walking on all fours in the back, that is, MKHCS); speed (running at 10 meters, that is, MBT10M; two-leg jumping through hoops, that is, MBSSO); balance (standing on one leg, that is, MRSJN; walking on the plank, that is, MKHCN); strength (raising the leg, that is, MSPN)

SSO). To assess the discriminability, the Kolmogorov Smirnov test was used. This test reveals that already satisfactory discriminability is not found for the tests MBSSO and MRSJN. The homogeneity of the tests is assessed by average inter-item correlation, ranging from 0.22 (MRHD) to 0.89 (MBSSO), while ANOVA F coefficient is statistically significant only for MKHCN.

The basic descriptive characteristics of all the tests were calculated (mean and standard deviation). Analysis of the construct validity using Principal Components Analysis (PCA) with Equamax Rotation, showed two-component structure (without clear discriminating of different motor abilities), with very low reliability of the second component. Principal components are named: strength coordination balance (1) and speed coordination balance (2). Both components together explained overall for about 58 percent of the total variance (Table 2).

The correlation (Pearson) between age and factor scores in the first component (strength coordination balance) was -0.440 ($p< 0.01$), while the correlation between age and factor scores in the second component (speed coordination balance) was 0.487 ($p< 0.01$). Among 21 correlations between the scores in the motor tests for 4-year

Table 2: Component structure and descriptive characteristics of the motor tests for 4-year old children (Principal Component Analysis, Equamax Rotation)

	Component		*Communalities*	*Mean*	*Std. dev.*
	1	2			
MSPN		**.422**	.222	10.080	3.533
MRHD		**.857**	.785	5.094	2.649
MBT10M	**.668**		.507	4.015	0.508
MBSSO	**.642**		.435	5.481	2.501
MRSJN		**.803**	.764	4.910	3.305
MKHCN	**.765**		.589	19.190	6.646
MKHCS	**.851**		.738	11.129	3.449
Reliability (based on standardized items - Cronbach)	0.740	0.547			
Eigenvalues	2.633	1.408			
Variance explained (%)	37.612	20.115	57.727		
Kaiser-Meyer-Olkin	.633	Bartlett test (df=21)	82.537**		

Legend: **significant at p<0.001
coordination (walking on all fours around the stem, that is, MRHD; walking on all fours in the back, that is, MKHCS); speed (running at 10 meters, that is, MBT10M; two-leg jumping through hoops, that is, MBSSO); balance (standing on one leg, that is, MRSJN; walking on the plank, that is, MKHCN); strength (raising the leg, that is, MSPN)

old children, 9 of them were statistically significant and mainly low to moderately high. Negative statistically significant correlations are found between MRSJN and MKHCS, as well as between MRSJN and MBT10M. The highest number of statistically significant correlations (4) are found for MKHCS and then for MKHCN and MRSJN (3) (Table 3).

The only statistically significant gender difference in the scores of the motor tests for 4-year old children is found in MSPN, in the direction of higher scores for boys (Table 4).

DISCUSSION

In terms of kinesiometric properties of the motor tests, reliabilities of the tests for motor abilities (Cronbach's alpha) varied in range from 0.45 (MRHD) to 0.96 (MBSSO), while intraclass correlation coefficients (similarly) varied in range from 0.46 (MRHD) to 0.95 (MBSSO). Hence, all tests except MRHD showed satisfactory reliability. The results of the Kolmogorov Smirnov tests revealed that already satisfactory discriminability is not found only for the tests MBSSO and

Table 3: Correlations between the scores in the motor tests for 4-year old children (Spearman)

	MSPN	*MKHCS*	*MRHD*	*MBT10M*	*MBSSO*	*MRSJN*	*MKHCN*
MSPN	1	-.276	.105	-.017	-.271	.265	-.013
MKHCS		1	.075	.533**	.402**	-.353*	.556**
MRHD			1	-.071	.000	.491**	.086
MBT10M				1	.322*	-.410**	.335*
MBSSO					1	-.243	.347*
MRSJN						1	-.260
MKHCN							1

Legend: **significant at p<0.01; *significant at p<0.05
coordination (walking on all fours around the stem, that is, MRHD; walking on all fours in the back, that is, MKHCS); speed (running at 10 meters, that is, MBT10M; two-leg jumping through hoops, that is, MBSSO); balance (standing on one leg, that is, MRSJN; walking on the plank, that is, MKHCN); strength (raising the leg, that is, MSPN)

Table 4: Gender differences in the scores in the motor tests for 4-year old children

	Gender	*Mean*	*Std. dev.*	*t-test (df=48)*
Component strength coordination balance	M	-0.031	1.025	-0.211
	F	0.029	0.996	
Component speed coordination balance	M	-0.099	0.871	-0.670
	F	0.092	1.115	
MSPN	M	11.170	4.188	**2.125***
	F	9.080	2.481	
MKHCS	M	10.624	3.188	-0.996
	F	11.596	3.673	
MRHD	M	4.531	2.028	-1.485
	F	5.614	3.063	
MBT10M	M	4.015	0.515	0.003
	F	4.015	0.511	
MBSSO	M	5.817	3.448	0.910
	F	5.172	1.055	
MRSJN	M	4.501	3.312	-0.837
	F	5.287	3.318	
MKHCN	M	19.905	6.283	0.727
	F	18.530	7.023	

Legend: **significant at p<0.01; *significant at p<0.05
coordination (walking on all fours around the stem, that is, MRHD; walking on all fours in the back, that is, MKHCS); speed (running at 10 meters, that is, MBT10M; two-leg jumping through hoops, that is, MBSSO); balance (standing on one leg, that is, MRSJN; walking on the plank, that is, MKHCN); strength (raising the leg, that is, MSPN)

MRSJN. The homogeneity of the tests (average inter-item correlation) varied in range from 0.22 (MRHD) to 0.89 (MBSSO), indicating low homogeneity only for MRHD. Subsequently, the application of Principal Components Analysis (PCA) revealed two-component structure, without clear discriminating of different motor abilities, with very low reliability of the second component. The only statistically significant gender difference is found in MSPN, in the direction of higher scores for boys. However, age negatively correlates with the first component obtained in PCA ($r= -0.440$; $p< 0.01$) and positively with the second component ($r= 0.487$; $p< 0.01$). Among 21 correlations between the scores in the motor tests for 4-year old children, 9 of them were statistically significant and mainly low to moderately high. The results of this study indicate the potential for validating the new instruments for measuring motor abilities in four-aged children on a larger sample of participants. The similar conclusions brought in their research Hraski et al. (2015). They were on a sample of 59 four-year old children try to determine the metric characteristics of tests for assessing coordination, speed and balance. From the battery of six tests two were acceptable to estimate the speed and balance (*10m running* and *walking on the narrowed field*) while all other tests need to be modified to make suitable for children of this age.

Till date, numerous studies that have been engaged with issues for the construction of measuring instruments for the assessment of motor abilities in preschool children have been conducted. Certain notifications of authors that investigated the characteristics of motor tests applied with young children corresponds with the notifications and results obtained in this research. Stanišic (2012) tried to determine the metric characteristics of speed frequency jumping tests. This research was conducted on a sample of 48 boys and 52 girls at age 6. The results obtained indicate that the tests for evaluation of speed frequency jumping have a solid discrimination, very high reliability, and belongs to a hypothetical factor responsible for the preschool children‘s evaluation of speed frequency jumping. Trajkovski Višic et al. (2007) studied metric characteristics of tests designed to assess the strength, coordination, and flexibility in a four-year old children. On the basis of the research results (reliability and validity), the authors concluded that some tests are convenient to be applied in children, while some are not convenient. The tests transfer of cube, walking back on all four, push-ups, standing long jump and sit and reach, can be used to monitor motor efficiency of 4-years preschool children. On the other hand, the tests of hopscotch, endurance in pull-ups, lateral split and lying hand extension, have good reliability (0.85) but poor discrimination (Trajkovski Višic et al. 2007). Furthermore, Horvat et al. (2008) determined the metric characteristics of tests to assess the balance as one of the hypothetical latent dimensions of motor skills in preschool children. The authors concluded that two tests have good metric characteristics, while the third was a little bit poorer. In addition, the authors believe that it would be justified to familiarize certain changes in test construction (to increase the standing area) to improve the metric characteristics (Horvat et al. 2008).

In general, it can be assumed that all the applied tests except MRHD are noted as tests with satisfactory kinesiometric characteristics in the sample of four-year old children. High reliability and satisfactory discriminability obtained in the number of used tests, is also confirmed in studies with similar aim conducted by Bala (2003) and Popeska and Jovanova-Mitkovska (2014).

The main shortcoming of the research is the small number of participants which is not stratified by gender in Principal Components Analysis. Here, the number of participants was too small to make separate analyses in samples by gender. However, testing the differences between genders revealed that only for MSPN, these differences are statistically significant. Thus, this weakness probably could not reduce the value of the overall study.

CONCLUSION

The results of this study indicate the potential for constructing new instruments, with a purpose to measure motor abilities in four-aged children. Reliabilities of the tests were calculated by Cronbach’s alpha (α) coefficients of internal consistency, ranging from 0.45 (MRHD) to 0.96 (MBSSO). For assessing the discriminability, Kolmogorov Smirnov test was used. This test reveals that already satisfactory discriminability is not found only for the tests MBSSO and MRSJN. The homogeneity of the tests is assessed by average inter-item correlation, ranging from 0.22 (MRHD) to 0.89 (MBSSO). However, the analy-

sis of the construct validity using Principal Components Analysis (PCA) with Equamax Rotation, showed two-component structure (without clear discriminating different motor abilities), with very low reliability of the second component.

RECOMMENDATIONS

Based on the results obtained in this study, the authors argue that the tests, which are designed to assess the speed and coordination, can be used in further research for children who are 4 years of age. On the other hand, the tests for assessing balance and strength requires further investigations. In the future, larger samples of participants could be examined, stratified by gender, as well as for within the same age group. For example, a population of four-year old children could be divided into four groups by three-month periods: children at age four, first to third month, fourth to sixth month, seventh to ninth month, and tenth to twelfth month.

NOTE

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