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Correlations Between Motor Abilities, Morphological Characteristics, and Preparedness for School at Pre-school Boys

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ABSTRACT The associations between motor abilities (MA), morphological characteristics (MC), and cognitive preparedness (PP) for school in pre-school aged boys should provide a platform for improved systematic educational work. The main goal of this research is to determine the correlation between children's MA, MC and PP, using univariate and multivariate statistical methods. Randomized sample of pre-school boys (N=106), aged 6-7, was examined. Eighteen composite motor tests were utilized to measure MA; Test for School Preparedness (TSS) with five sub-tests was used in estimating boys' PP; additionally, 14 morphological characteristics were measured. Findings revealed that all the canonical correlations were statistically significant: between MA and MC, between MA and PP, as well as between MC and PP. Thus, the correlation is the lowest between MC and PP. MC could be a less important factor for estimating the overall preparedness for school, than boys' MA at the age of six or seven years.

INTRODUCTION

The insight into the associations between three sets of data in pre-school aged boys (motor abilities, morphological characteristics, and their preparedness for school) should provide a platform for improved systematic educational work. Hence, the purpose of this article is to investigate these sets of data in boys in their pre-school age.

Kinanthropology

Kinanthropology is a field related to the interdisciplinary (biological, psychological, cultural, and social aspects) investigation of physical activities. Consequently, it is a scientific discipline, which is focused on the research of the variability of human characteristics and abilities when related to physical activity, physical exercise and sports, during one's life span (Mišigoj-Durakovic 2008). Under the influence of various kinesiological programs, quantitative and qualitative changes in kinanthropological dimensions may occur, affecting the dimensions themselves, as well as their relationships (Ismail 1976; Mišigoj-Durakovic 2008). The structure of particular dimension is constantly changing within the dimension itself and in relation to other dimensions, during a child's growth (Bala 2003a). These changes are dependent on certain developmental periods (Bilic 2007) and on the children's individual characteristics (Bala 2003b). Sexual dimorphism in certain kinanthropological dimensions is particularly noticed at the end of the second developmental period (Bala et al. 2009; Horvat et al. 2010). The interaction and the nature and intensity of that interaction between individual characteristics and abilities, are responsible for the entire child's development, which includes physical, cognitive, emotional, and social development (Horvat et al. 2013). Sedentary way of living in combination with inadequate nutrition has detrimental effects on children's growth and development. Hypokinesis is a continuous enhancement of average values in children's body volume and body mass (measures BMI, FFM, body mass, measures of subcutaneous fatty tissue, body parts circumferences) (Abalkhail 2002; Datar and Sturm 2004; Horvat et al. 2009).

Morphological Characteristics

Results of several studies suggest that regular growth and development of *morphological dimensions* have an influence on the development of the child's general motor ability, while regular development of motor abilities has an influence on the growth and development of morphological characteristics (Bala et al. 2009). Longitudinal and transverse skeleton dimensionality often comprises of a single dimension which is named skeleton dimensionality or occasionally longitudinal skeleton dimensionality. However, it can be referred to as a three-dimensional model (Malacko et al. 1981). In adolescents, a three-dimensional morphological model includes skeleton dimensionality, body mass and volume, and subcutaneous adipose tissue (Viskic-Štalec 1974; Kurelic et al. 1975). A two-dimensional model of morphological dimensions, consisting only of skeleton dimensionality and voluminosity, as well as subcutaneous adipose tissue, is usually found in very young children (Bala 1981).

Motor Abilities

Motor abilities can be defined as the latent motor structure, which is responsible for an infinite number of manifest motoric reactions, and can be measured and described (Mrakovic 1992). Thus, determining the motor abilities structure of pre-school boys is one of the priorities. The problem is the relatively small number of appropriate measure instruments that could be applied. In previous studies (Horvat et al. 2010; Horvat 2011; Hraski et al. 2011; Horvat et al. 2013), the latent motor abilities structure of boys was defined. Therefore, this consists of four dimensions: general factor of motor abilities, coordination, balance, and flexibility. It can be concluded that certain factors have appeared. Hence, a more significant definition of the latent structure can be expected only in the later periods of life. The research on motor abilities of pre-school children has a relatively long history. The first research of throwing a ball at the moving and stationary target was conducted in the first half of the 20th century (Hicks 1930), while jumping over an obstacle could be used as an indicator of motor development (Cowan and Pratt 1934). A deficit of motor activities or their complete absence during children's growth cannot be recovered in later periods of the growth and maturation. Insufficient motor experience and opportunities for the participation in kinesiological activities can slow down a child's motor and intellectual development (Kelly and Kelly 1985; Humphrey 1991).

Preparedness for School

Systematic stimulation of developmental characteristics which are the base of *preparedness for going into the elementary school* is an important task for children's educators, parents, and teachers in kindergartens. Various authors see the readiness of going to school as a complex set of characteristics. In addition, listing similar sets of characteristics are also important. Furlan (1984) speaks of the physical, speech, intellectual, emotional and social maturity for school, while Tolicic (1970) from Šimunec-Muhek (1995) lists physical, personal, and functional maturity. Physical development is one criterion to define school readiness; and regular physical development allows a child to cope more easily with various physical and mental efforts that awaits him at school (Vasta et al.1997). Mental readiness as a criterion for school readiness is a complex set which unify the dimensions of psychomotor, cognitive, emotional and social readiness, as well as the child's motivation to learn. (Psycho)motor development of pre-school children includes gaining skills such as walking, running, dressing/undressing, as well as the fine movement of muscles, as the prerequisites for the adoption of complex psychomotor skills (for example; reading and writing) (Vasta et al. 1997). Emotional readiness considers issues about child's acquisition of certain emotional stability and control (developing a certain level of tolerance toward frustration), the relative stability of their emotions, acceptance of school discipline, and the ability to work cooperatively with others. Social readiness refers to the interpersonal skills which include working together with others (especially peers and teachers), development of socially desirable behaviors, skills and motives, and the formation of a child's idea of itself. Cognitive readiness (adequate speech development, perception, thinking and memory, closely linked with the extent and stability of attention) is the most important aspect of the preparation for going to school. This is because it is related with the most important academic functions. Therefore, it is necessary to evaluate cognitive readiness more carefully. A speech development is emphasized as a particularly important aspect of school readiness (Furlan 1984; Gathercole and Baddeley 1993; Vasta et al. 1997). Motivation for learning is a very important determinant of the school's success. Mental reluctance is a major cause of school failure. However, it is necessary to combine the legal-administrative and psychophysical criteria.

Towards the Creation of Adjusted Educational Programs

Motor and cognitive growth in children may be influenced by sport practice. The results of the study conducted by Alesi et al. (2015) support the thesis that the improvement of motor and cognitive abilities is related not only to general physical activity but also to specific ability related to the ball. Therefore, Football Exercise Programs could be a natural and enjoyable tool to enhance cognitive resources as well as promoting and encouraging the participation in sport activities from early development (Alesi et al. 2015). In the study that examined the relationship between general motor skills and body composition for boys and girls aged 7.39 decimal years, it was obtained that the total amount of body fat, body weight, negatively affect general motor skills and for the girls, while body height has a positive effect (Lepes et al. 2014). There is a close interrelationship between motor and cognitive domains in individuals with atypical development (Alesi et al. 2014). In the study on developmental horse-riding program (SDHRP), combined with fitness training influenced the motor proficiency and physical fitness of children with ADHD. Children with ADHD exhibit low levels of motor proficiency and cardiovascular fitness, but using the combined 12-week SDHRP and fitness training, positive effects for children with ADHD are revealed (Pan et al. 2014). In a very similar program, a 12-week table tennis exercise showed clinical relevance in motor skills and executive functions of children with ADHD (Pan et al. 2015). Similarly, Chen et al. (2015) obtained that table tennis could be considered a therapy option while treating cognitive/perceptual problems in children with mild intellectual disabilities and borderline intellectual functioning.

Therefore, in order to design proper kinesiological programs for pre-school children, educators must have an insight into a possible sexual dimorphism among pre-school children in their motor abilities, morphological characteristics, and cognitive preparedness for school. Obtaining the correlations between these three sets of characteristics in pre-school aged boys, should provide the prerequisites for adequate pre-school physical education plans and programs' designs. Moreover, findings of this research would be a starting point for further research about the correlations between these three sets of data in pre-school aged girls. Therefore, these insights would provide the information about sexual dimorphism.

Goal and Hypothesis

The main *goal* of this research is to determine the correlation between three sets of data in pre-school boys: motor abilities, morphological characteristics, and their preparedness for school. Our hypothesis was that there are statistically significant correlations between motor abilities and morphological characteristics, between motor abilities and preparedness for school, as well as between morphological characteristics and preparedness for school.

METHODOLOGY

Subjects

From the Croatian population of kindergarten children from the urban environment (cities of Zagreb and Varaždin), a random sample of 106 boys was measured. At the time of the research, the children were 6.5 years ± 6 months old. For each subject involved in the sample, a parental written consent was obtained, by which parents allowed their children to participate in the research. Thus, this was in compliance with the Code of Ethics prepared by the Children Council and the counselling body of the Government of the Republic of Croatia. In this study, only data from boys were used.

Materials (Tests and Measures)

Motor Abilities

Motor abilities of the subject sample were assessed with a set of eighteen composite motor tests known in the area of physical education because they are usually used for assessing motor and energy supply abilities of schoolchildren. However, for the present research they had been modified to comply with the capabilities of pre-school children (Horvat 2010). Generally, all measurement courses and measurement periods were shortened and the number of stands was reduced. In addition, at least one tryout was introduced before each test performance. This was to ensure approximately equal level of motor skill and familiarization with the tasks in all the examinees.

Subsequently, the tests assessed latent dimensions of coordination, flexibility, strength, agility, accuracy, and balance in pre-school boys of 6-7 years of age. For each of the latent dimensions, there were three composite tests used which were performed three times. The following variables were measured:

Coordination - pushing a ball around 2 stands with hands (MKGR); pushing a ball around 2 stands with feet (MKGN); moving backwards on all fours (MKHN)

Flexibility - arm backward circumduction with a stick (MFIP); straddle seated forward bend (MFSR); forward bend on a bench (MFPK)

Strength/Power - 10 m running (MS10); standing long jump (MSSD); sit ups (MSPT)

Agility - side steps (MAKS); slalom around stands (MAOO); figure of eight with a bend (MAOS)

Accuracy - shooting at the target (MPGC); shooting at a frame (MPGO); aiming with a stick (MPCS)

Balance - transversal balancing on one leg (MRJU); transversal balancing on both legs (MROP); longitudinal balancing on one leg (MRJO)

Cognitive Preparedness for School

Preparedness for school was tested using the psychological measuring instrument constructed by Vlahovic-Štetic et al. (1995). "Test of preparedness for school" consists of five sub-tests: Perceptual test (TSS - P), Test knowledge of the facts (TSS - T). Numerical test (TSS - N), Test connecting points (TSS - T), and Test strikethrough (TSS - C).

The first three sub-tests (Perceptive test, Test connecting points, and Test strikethrough) are designed to assess the specific abilities of children, while the other two sub-tests (Test knowledge of the facts and Numerical test) are designed to determine the children's knowledge.

The testing was conducted in the small groups (up to seven children), and lasted about an hour. After the first three sub-tests, breaks were given for a period of fifteen minutes, so that the limited concentration of children would not have a negative effect on the measurement results. Psychologists employed in these children's kindergartens performed the assessment of each child's preparedness for school.

Morphological Characteristics

Variables for the assessment of morphological characteristics of children include: body height (AVIS), body mass (ATTE), sitting height of the body (AVSJ), arm length (ADRU), upper arm skinfold (ANNA), abdominal skinfold (ANTR), back skinfold (ANLE), lower leg skinfold (ANPK), upper arm circumference (AONO), forearm circumference (AOPD), upper leg circumference (AONK), lower leg circumference (AOPK), hip width (ASKU), and shoulder width (ASRA).

All measurements were performed using standard methods and instruments as described in the instructions of the International Biological Program (IBP - Weiner and Lourie 1968). Measurements of height, width, weight, and circumference were measured once. Every skinfold measurement was measured three times using the John Bull caliper.

Measurements of morphological characteristics were carried out in the morning, immediately upon arrival of children to the kindergarten. Students who were attending the elective course Kinesiological transformations, and who during a course of mandatory exercises were adopting methods and techniques of measurement in the field of kinesiology, have conducted the measurements. Particular attention was given to the acquisition of knowledge regarding the implementation of measurements just for those variables that were used in this study. In this way, the measurers were specially prepared for this research.

Procedure

Three times a week in a 30-minute sessions, children had an opportunity to familiarize themselves with the motion and moving patterns they were going to perform as the future test tasks. This was done to even as much as possible, the level of motor knowledge and skill in the future examinees. Also, it aims to reduce its probable impact on the results when testing motor abilities.

Motor abilities were measured during three consecutive days. At the beginning of each measurement, day children were specially prepared. The preparations commenced each day with 3-minute cyclic gross movements with various tasks. Various tasks included walking (on the toes, on the heels, step-shuffle step-step-shuffle step), various rate running, and jumps (two-legged and one-legged). Afterwards, a set of general preparatory exercises (10 to 12) for the whole body were applied. The drills were selected to address those big muscle groups that were going to be under special loading in the forthcoming testing for that day.

The tests were scheduled across three days with the aim of preventing, as much as possible, the negative impact of previous tests on the performance of the subjects in the later ones. In addition, fatigue was avoided as much as possible, as well as loss of motivation in the examinees. Therefore, the test assessing dynamic muscular endurance or repetitive strength of the trunk (sit-ups) was performed at the end of the measurement of each day (three measurements altogether).

Statistical Analysis

Canonical analysis provides a method of relating two of such sets of variables on each side of an equation. It weights the variables on each side to produce two sets of composite scores. Then, it calculates one or more canonical correlations, which are equivalent to product-moment correlations between the sets of weighted variables. The number of canonical correlations computed is equal to the number of variables in the smaller set. First canonical root correlation (Rcan1) can be interpreted as the maximum correlation that can be obtained through the best linear combinations of both sets of variables. Second canonical root correlation (Rcan2) is the next best linear combination of the variables, under the constraint that this pair of composite scores is uncorrelated with the first pair, and so on. Whether the first or any of the subsequent correlations are significant, of course, depends on the relationships within the data. In essence, the number of significant canonical regressions indicates the number of clusters of relationships in the set of elements analyzed. Since the researchers have posited two sets, they expect two groupings from the canonical analysis. Canonical correlations are essentially product-moment correlations between sets of weighted scores. Therefore, the squared canonicals express the variance in one set of variables explained by the other. Each correlation represents a different and unrelated solution of the relationship among the observations. The analyst's task is to interpret these solutions by referring mainly to two sets of values on the computer output. One set is the standardized canonical variate coefficients, which are akin to the beta-coefficients in an ordinary regression equation. Consequently, these coefficients can be compared to the relative effect of each variable in one set to the composite score constructed from the other set of the variables. The other and perhaps more useful indicators are the simple correlations between the canonical scores and their composite variables. These correlations are called canonical 'loadings', which is similar to variable loadings in factor analysis. The statistical program SPSS (Statistical Package for the Social Sciences 20.0) was used.

RESULTS

In Table 1, the researchers showed the cross-correlations between morphological measures and motor tests for the sample of boys in kindergartens. Among 252 cross-correlations between all the variables in those two sets, the statistically significant were 49. All significant correlations are in fact very low.

Canonical analysis of morphological measures and motor tests is guided by the hypothesis discussed in the introduction. The need for complete data for all variables on all cases reduced the number of motor tests to 18. Thus, in the set of morphological characteristics, the researchers took the data of 14 anthropological measures. Most of the findings discussed above reappear in the canonical results in Table 2. Of all the canonical correlations produced from the analysis, only the first two, R2can1 = 0.784 and R2can2 = 0.692, were significant at the 0.01 level.

The first canonical solution (first pairs of canonical roots) is found between the set of morphological variables (high values for AVSJ, ANNAX, ANTRXS, ANPKX, ASRA) and set of motor variables (high values for MKHNY, MRJOY, MROPY, MAOSY) (Table 2). The simple correlations in the space of morphological measures show that ASRA and ANPKX correlated 0.52 and 0.51 with the composite score, while ANLEX barely had any correlation (-0.03). On the other hand, the simple correlations in the space of motor variables show that MKHNY and MRJOY correlated 0.57 with the composite score, while MPGOY barely had any correlation (0.03). The canonical

Table 1: Cross-correlations between morphological measures and motor tests (boys)

	ATTE	*AVIS*	*AVSJ*	*ADRU*	*ANNAX*	*ANTRXS*	*ANLEX*	*ANPKX*	*AONO*	*AOPD*	*AONK*	*AOPK*	*ASKU*	*ASRA*
MKGRY	**-0.267****	-0.079	-0.186	**-0.228***	0.073	0.113	0.115	0.032	-0.125	**-0.298****	-0.037	0.004	**-0.227***	**-0.236***
MKGNY	**-0.254****	-0.103	**-0.225***	-0.180	0.065	0.063	0.022	0.003	-0.150	**-0.287****	-0.063	-0.088	**-0.254****	**-0.234***
MKHNY	-0.090	0.055	-0.042	-0.147	**0.266****	**0.301****	0.182	**0.248***	0.076	-0.150	0.088	0.030	**-0.218***	**-0.240***
MFIPY	0.187	**0.222***	**0.256****	0.172	0.129	0.137	0.133	0.134	0.198	0.126	0.177	0.156	-0.057	0.025
MFSRY	0.018	0.036	**0.207***	-0.061	-0.025	0.012	0.011	0.021	-0.019	-0.056	0.015	0.009	0.056	0.128
MFPKY	-0.138	-0.082	-0.054	-0.191	-0.051	-0.017	-0.041	0.047	-0.118	-0.171	**-0.212***	-0.096	0.012	0.013
MS10Y	-0.006	0.010	-0.024	0.065	0.139	0.019	0.082	0.128	-0.024	0.076	0.034	-0.053	-0.003	0.024
MSSDY	**0.221***	-0.030	**0.195***	0.095	**-0.352****	**-0.296****	**-0.295****	**-0.334****	-0.078	0.026	-0.049	-0.013	0.131	0.170
MSPTY	0.049	-0.027	0.063	-0.020	-0.148	-0.044	-0.080	-0.103	0.037	**0.192***	-0.020	-0.063	-0.079	-0.078
MAKSY	-0.180	-0.025	-0.188	-0.079	**0.293****	0.166	0.083	0.156	0.072	0.065	0.084	0.007	-0.081	-0.065
MAOOY	**-0.255****	-0.118	**-0.355****	-0.085	**0.231***	0.086	0.037	0.099	0.032	0.008	-0.019	-0.070	-0.032	-0.074
MAOSY	**-0.200***	-0.066	**-0.223***	-0.096	**0.220***	0.134	0.070	0.149	-0.035	-0.129	0.020	-0.035	-0.185	-0.173
MPGCY	0.083	-0.029	0.103	0.054	-0.154	**-0.271****	-0.111	-0.091	-0.142	0.014	-0.104	-0.107	0.101	**0.199***
MPGOY	0.014	-0.055	-0.023	0.042	-0.052	0.013	-0.031	0.018	-0.041	0.015	-0.107	-0.014	0.096	0.125
MPCSY	**0.225****	0.107	0.191	0.123	-0.063	0.045	-0.073	0.039	0.054	0.126	0.112	0.073	0.070	0.122
MRJUY	0.007	-0.062	0.064	0.055	**-0.207***	**-0.214***	**-0.203***	-0.113	-0.110	0.016	-0.140	-0.179	0.068	0.098
MROPY	0.118	0.046	**0.260****	0.075	-0.108	-0.155	-0.097	-0.177	-0.034	0.086	-0.023	-0.043	**0.231***	**0.291****
MRJOY	0.044	-0.024	0.080	0.096	**-0.307****	**-0.252****	**-0.213***	**-0.202***	-0.107	0.007	-0.125	-0.060	**0.347****	**0.402****

Legend: ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).
Morphology: body height (AVIS), body mass (ATTE), sitting height of the body (AVSJ), arm length (ADRU), upper arm skinfold (ANNA), abdominal skinfold (ANTR), back skinfold (ANLE), lower leg skinfold (ANPK), upper arm circumference (AONO), forearm circumference (AOPD), upper leg circumference (AONK), lower leg circumference (AOPK), hip width (ASKU), shoulder width (ASRA).
Motor tests: MKGRY, MKGNY, MKHNY (coordination), MFIPY, MFSRY, MFPKY (flexibility), MS10Y, MSSDY, MSPTY (strength), MAKSY, MAOOY, MAOSY (agility), MPGCY, MPGOY, MPCSY (accuracy), MRJUY, MROPY, MRJOY (balance)

Table 2: Canonical correlations between morphological measures and motor tests – first canonical root (boys)

Correlations with composite scores[a]	*Morphological measures*	*Canonical variate coefficients*[b]		*Canonical variate coefficients*	*Motor tests*	*Correlations with composite scores*
First Canonical Analysis: Boys						
0.322	ATTE	0.479	R can1=0.784	-0.210	MKGRY	-0.465
0.022	AVIS	0.411	R^2can1=0.616	0.195	MKGNY	-0.421
0.417	AVSJ	0.098	$|^2$= 365.245			
			-0.198	MKHNY	**-0.570**	
0.229	ADRU	-0.323	df=252	0.037	MFIPY	0.05
-0.470	ANNAX	-0.355	Wilks			
		⌊=0.016	0.117	MFSRY	0.137	
-0.506	ANTRXS	-0.372				
			0.004	MFPKY	-0.130	
-0.371	ANLEX	-0.032	p<0.01	0.376	MS10Y	-0.085
-0.432	ANPKX	-0.401		0.520	MSSDY	0.709
-0.147	AONO	-0.312		0.126	MSPTY	0.231
0.181	AOPD	0.423		0.081	MAKSY	-0.403
-0.082	AONK	0.195		-0.162	MAOOY	-0.479
-0.105	AOPK	-0.066		-0.042	MAOSY	**-0.503**
0.386	ASKU	-0.297		0.160	MPGCY	0.444
0.524	ASRA	0.631		-0.151	MPGOY	0.032
				-0.014	MPCSY	0.297
				-0.042	MRJUY	0.304
				0.381	MROPY	**0.519**
				0.310	MRJOY	**0.567**
	Redundancy	24.491 %			Redundancy	22.270 %

Legend: [a]The simple product-moment correlations between the variable and the composite scores computed in the canonical analysis.
[b]The standardized coefficient of the variable used in computing the canonical variate that generated the composite scores.
Morphology: body height (AVIS), body mass (ATTE), sitting height of the body (AVSJ), arm length (ADRU), upper arm skinfold (ANNA), abdominal skinfold (ANTR), back skinfold (ANLE), lower leg skinfold (ANPK), upper arm circumference (AONO), forearm circumference (AOPD), upper leg circumference (AONK), lower leg circumference (AOPK), hip width (ASKU), shoulder width (ASRA).
Motor Tests: MKGRY, MKGNY, MKHNY (coordination), MFIPY, MFSRY, MFPKY (flexibility), MS10Y, MSSDY, MSPTY (strength), MAKSY, MAOOY, MAOSY (agility), MPGCY, MPGOY, MPCSY (accuracy), MRJUY, MROPY, MRJOY (balance)

correlation squared reveals that 61 percent of the variance in the performance composite can be linked to the composite score of both morphological and motor variables.

The second canonical solution (second pairs of canonical roots) is found between the set of morphological variables (high values for AVSJ, AOPD, ASKU) and set of motor variables (high values for MKGRY, MAOOY, MFSRY, and MFIPY) (Table 3). The simple correlations in the space of morphological measures show that AVSJ and AOPD correlated 0.43 and -0.37 with the composite score, while ANPKX barely had any correlation (0.05). On the other hand, the simple correlations in the space of motor variables show that MAOOY and MKGRY correlated - 0.52 and 0.41 with the composite score, while MRJOY barely had any correlation (0.01). The canonical correlation squared reveals that 48 percent of the variance in the performance composite can be linked to the composite score of both morphological and motor variables.

In Table 4, the researchers showed the cross-correlations between morphological measures and cognitive tests for the sample of boys in kindergartens. Among 60 cross-correlations between all the variables in those two sets, statistically significant were only 5. All significant correlations are in fact very low. However, most of the significant correlations were found for ANTRXS and ANPKX in the space of morphological measures, while most of the significant

Table 3: Canonical correlations between morphological measures and motor tests–second canonical root (boys)

Correlations with composite scores[a]	*Morphological measures*	*Canonical variate coefficients*[b]		*Canonical variate coefficients*	*Motor tests*	*Correlations with composite scores*
First Canonical Analysis: Boys						
0.152	ATTE	-0.877	R_{can2}=0.692	0.563	MKGRY	**0.414**
0.184	AVIS	0.648	R^2_{can2}=0.479	0.206	MKGNY	0.230
0.432	AVSJ	0.894	χ^2= 280.590	0.545	MKHNY	0.266
			0.112		MFIPY	**0.283**
-0.141	ADRU	-0.135	df=221			
-0.111	ANNAX	-0.874	Wilks Λ=0.042	0.163	MFSRY	**0.390**
0.199	ANTRXS	0.409		-0.096	MFPKY	0.116
0.124	ANLEX	0.133	$p<0.01$	-0.153	MS10Y	-0.260
0.051	ANPKX	-0.064		0.001	MSSDY	0.076
-0.081	AONO	-0.025		-0.001	MSPTY	-0.037
-0.367	AOPD	-0.644		-0.175	MAKSY	-0.276
0.103	AONK	0.337		-0.729	MAOOY	**-0.523**
0.119	AOPK	0.351		-0.087	MAOSY	-0.089
-0.331	ASKU	-0.441		0.054	MPGCY	-0.115
-0.250	ASRA	0.175		0.002	MPGOY	-0.142
				0.321	MPCSY	0.085
				0.164	MRJUY	-0.076
				0.093	MROPY	0.071
				-0.134	MRJOY	0.010
	Redundancy	22.270 %			Redundancy	24.491 %

Legend: [a]The simple product-moment correlations between the variable and the composite scores computed in the canonical analysis.
[b]The standardized coefficient of the variable used in computing the canonical variate that generated the composite scores.
Morphology: body height (AVIS), body mass (ATTE), sitting height of the body (AVSJ), arm length (ADRU), upper arm skinfold (ANNA), abdominal skinfold (ANTR), back skinfold (ANLE), lower leg skinfold (ANPK), upper arm circumference (AONO), forearm circumference (AOPD), upper leg circumference (AONK), lower leg circumference (AOPK), hip width (ASKU), shoulder width (ASRA).
Motor Tests: MKGRY, MKGNY, MKHNY (coordination), MFIPY, MFSRY, MFPKY (flexibility), MS10Y, MSSDY, MSPTY (strength), MAKSY, MAOOY, MAOSY (agility), MPGCY, MPGOY, MPCSY (accuracy), MRJUY, MROPY, MRJOY (balance)

correlations were found for TSST in the space of cognitive tests.

Canonical analysis of morphological measures and cognitive tests is guided by the hypothesis discussed in the introduction. The need for complete data for all variables on all cases reduced the number of cognitive tests to 5. Thus, in the set of morphological characteristics, we took the data of 14 anthropological measures. Of all the canonical correlations produced from the analysis, only the first one, R^2can1 = 0.568, was significant at the 0.05 level (Table 5).

The first canonical solution (first pairs of canonical roots) is found between the set of morphological variables (high values for ANNAX, ANPKX, AONO, AOPD, ASRA) and set of cognitive variables (high values for TSST, TSSC) (Table 5). The simple correlations in the space of morphological measures show that ASRA and AOPD correlated 0.96 and -0.85 with the composite score, while AVIS barely had any correlation (0.02). On the other hand, the simple correlations in the space of cognitive variables show that TSST and TSSC correlated –0.91 and -0.28 with the composite score, while TSSP barely had any correlation (0.02). The canonical correlation squared reveals that 32 percent of the variance in the performance composite can be linked to the composite score of both morphological and cognitive variables.

In Table 6, the researchers have shown the cross-correlations between motor tests and cognitive tests for the sample of boys in kindergartens. Among 90 cross-correlations between all the variables in those two sets, statistically sig-

Table 4: Cross-correlations between morphological measures and cognitive tests (boys)

	TSSP	*TSSCC*	*TSSN*	*TSST*	*TSSC*
ATTE	0.052	0.126	0.089	0.030	0.050
AVIS	-0.165	0.013	-0.069	-0.165	-0.064
AVSJ	0.097	0.164	**0.209***	0.065	0.029
ADRU	0.081	0.081	0.019	0.085	0.085
ANNAX	-0.124	-0.066	-0.188	-0.276	-0.085
ANTRXS	-0.163	-0.059	-0.203	**-0.301****	**-0.268****
ANLEX	-0.153	-0.055	-0.122	**-0.266****	-0.116
ANPKX	-0.070	-0.115	-0.107	**-0.201***	-0.205*
AONO	-0.182	-0.068	-0.183	**-0.201***	-0.071
AOPD	-0.111	-0.010	-0.070	-0.045	0.145
AONK	-0.129	-0.046	-0.161	-0.171	-0.019
AOPK	-0.075	-0.030	-0.093	-0.066	0.021
ASKU	0.057	0.061	0.013	0.085	0.146
ASRA	0.070	0.066	0.030	0.097	0.068

Legend: **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).
Morphology: body height (AVIS), body mass (ATTE), sitting height of the body (AVSJ), arm length (ADRU), upper arm skinfold (ANNA), abdominal skinfold (ANTR), back skinfold (ANLE), lower leg skinfold (ANPK), upper arm circumference (AONO), forearm circumference (AOPD), upper leg circumference (AONK), lower leg circumference (AOPK), hip width (ASKU), shoulder width (ASRA).
Cognitive Tests: perceptual (TSSP), knowledge of the facts (TSSCC), numerical (TSSN), connecting points (TSST), strikethrough (TSSC).
Legend: body height (AVIS), body mass (ATTE), sitting height of the body (AVSJ), arm length (ADRU), upper arm skinfold (ANNA), abdominal skinfold (ANTR), back skinfold (ANLE), lower leg skinfold (ANPK), upper arm circumference (AONO), forearm circumference (AOPD), upper leg circumference (AONK), lower leg circumference (AOPK), hip width (ASKU), shoulder width (ASRA).

nificant were 28. All significant correlations are in fact low or very low. However, most of the significant correlations were found for MSSDY, MRJUY, and MRJOY in the space of motor tests, while most of the significant correlations were found for TSSCC, TSSN, and TSST in the space of cognitive tests.

The researchers' canonical analysis of motor and cognitive tests is guided by the hypothesis discussed in the introduction. The need for complete data for all variables on all cases reduced the number of cognitive tests to 5, while the set of motor tests consist of 18 variables. Of all the canonical correlations produced from the analysis, only the first one, R^2can1 = 0.650, was significant at the 0.01 level (Table 7).

The first canonical solution (first pairs of canonical roots) is found between the set of motor variables (high values for MKGNY, MKHNY, MFPKY, MAOSY, MRJUY, MROPY, MRJOY) and set of cognitive variables (high values for TSST, TSSN, TSSC, TSSCC) (Table 7). The simple correlations in the space of motor measures show that MKHNY and MRJUY correlated 0.59 and 0.58 with the composite score, while MFSRY barely had any correlation (0.02). On the other hand, the simple correlations in the space of cognitive variables show that TSSC and TSSCC correlated 0.83 and 0.71 with the composite score, while TSSP barely had any correlation (-0.23). The canonical correlation squared reveals that 26 percent of the variance in the performance composite can be linked to the composite score of both motor and cognitive variables.

DISCUSSION

Simple generalization of the main findings in this research is a consideration that correlations (in spite of their statistical significance) between morphological measures and cognitive tests are the lowest, while the correlations between morphological measures and motor tests are higher, as well as the correlations between motor and cognitive tests.

One of the explanations of the lowest associations between morphological and cognitive characteristics in pre-school aged boys could be found in sexual dimorphism in this domain. Consequently, cognitive aspects showed higher correlations with motor abilities in female than in male children in the research conducted by Bala and Katic (2009). The results of this study replicated the finding that cognitive functioning

Table 5: Canonical correlations between morphological measures and cognitive tests–first canonical root (boys)

Correlations with composite scores[a]	*Morphological measures*	*Canonical variate coefficients*[b]		*Cannical variate coefficients*	*Cognitive tests*	*Correlations with composite scores*
Second Canonical Analysis: Boys						
-0.050	ATTE	0.134	R can1=0.568	0.281	TSSP	0.024
-0.016	AVIS	-0.391	R^2can1=0.322	0.119	TSSCC	-0.100
0.023	AVSJ	0.060	χ^2= 92.716	-0.080	TSSN	-0.141
				0.277	TSST	**-0.276**
-0.080	ADRU	0.000	df=70			
-0.006	ANNAX	-0.572	Wilks Λ=0.377	-1.180	TSSC	**-0.907**
0.346	ANTRXS	1.143				
0.043	ANLEX	-0.273	$p<0.05$			
0.285	ANPKX	0.561				
-0.028	AONO	0.669				
-0.371	AOPD	-0.845				
-0.095	AONK	-0.284				
-0.106	AOPK	-0.183				
-0.223	ASKU	-0.712				
-0.050	ASRA	0.961				
	Redundancy	5.203 %			Redundancy	18.935 %

Legend: [a]The simple product-moment correlations between the variable and the composite scores computed in the canonical analysis.
[b]The standardized coefficient of the variable used in computing the canonical variate that generated the composite scores.
Morphology: body height (AVIS), body mass (ATTE), sitting height of the body (AVSJ), arm length (ADRU), upper arm skinfold (ANNA), abdominal skinfold (ANTR), back skinfold (ANLE), lower leg skinfold (ANPK), upper arm circumference (AONO), forearm circumference (AOPD), upper leg circumference (AONK), lower leg circumference (AOPK), hip width (ASKU), shoulder width (ASRA).
Cognitive tests: perceptual (TSSP), knowledge of the facts (TSSCC), numerical (TSSN), connecting points (TSST), strikethrough (TSSC).

Table 6: Cross-correlations between motor tests and cognitive tests (boys)

	TSSP	*TSSCC*	*TSSN*	*TSST*	*TSSC*
MKGRY	-0.041	-0.130	-0.087	-0.112	-0.167
MKGNY	-0.066	-0.096	-0.107	-0.142	**-0.288****
MKHNY	-0.012	-0.179	-0.179	**-0.256****	**-0.371****
MFIPY	0.084	-0.026	0.006	0.028	-0.065
MFSRY	0.010	0.058	0.073	0.074	-0.116
MFPKY	0.075	-0.162	0.071	-0.108	**-0.217***
MS10Y	-0.033	**-0.203***	-0.095	-0.094	-0.029
MSSDY	0.179	**0.291****	**0.211***	**0.355****	**0.270****
MSPTY	0.018	0.035	0.120	0.132	-0.018
MAKSY	0.073	-0.028	-0.084	-0.089	-0.026
MAOOY	-0.029	-0.177	**-0.328****	-0.114	-0.051
MAOSY	-0.017	-0.178	-0.157	**-0.207***	-0.159
MPGCY	0.175	0.053	**0.213***	0.071	0.157
MPGOY	0.004	0.156	-0.021	0.063	0.013
MPCSY	-0.120	-0.046	-0.009	-0.084	-0.022
MRJUY	0.090	**0.257****	**0.270****	**0.270****	**0.300****
MROPY	-0.090	0.145	0.073	0.129	**0.210***
MRJOY	0.106	**0.236***	**0.214***	**0.218***	**0.252****
MPGOY	-0.039	-0.078	-0.112	**-0.253****	-0.129
MPCSY	**-0.342****	**-0.344****	**-0.276****	-0.096	-0.024
MRJUY	-0.089	-0.125	**-0.208***	0.030	-0.081
MROPY	-0.111	**-0.213***	-0.153	0.039	0.035
MRJOY	-0.108	**-0.219***	**-0.348****	0.051	0.109

Legend: ** Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).
Cognitive Tests: perceptual (TSSP), knowledge of the facts (TSSCC), numerical (TSSN), connecting points (TSST), strikethrough (TSSC).
Motor Tests: MKGRY, MKGNY, MKHNY (coordination), MFIPY, MFSRY, MFPKY (flexibility), MS10Y, MSSDY, MSPTY (strength), MAKSY, MAOOY, MAOSY (agility), MPGCY, MPGOY, MPCSY (accuracy), MRJUY, MROPY, MRJOY (balance)

is relatively independent of physical growth, while motor abilities and morphological growth and development are higher interrelated in male children (Bala et al. 2009). Simply explained, boys in the same age probably have less balanced development and growth than girls have.

Therefore, these results are in accordance with the theory of integral development of children (Bala and Katic 2009). The relations between morphological characteristics and motor abilities suggest that in pre-school boys, voluminosity derived mostly from subcutaneous adipose tissue could be an interfering factor in the movement structuring, synergy, and energy regulation. However, this is same as in the study conducted by Bala et al. (2009). On the contrary, regular growth of bone tissue (particularly longitudinal), together with proportional pattern of body weight and soft tissue volume, enable better functioning of all aspects responsible for the child's motor behavior. Better functioning of nervous system and the child's proper motor behaviour are both preconditions and consequences of harmonious functioning of the mechanism of movement regulation, as well as the mechanism of energy regulation (Bala and Katic 2009). All these factors are preconditions for successful solving important motor tasks, appropriate for the certain age group (Bala et al. 2009), and consequently could be positively correlated with cognitive functions.

There was quite a high association of morphological and motor structures in the group of boys for age group 6 to 7. This relation explained about 62 percent of common variability for the first pairs of canonical roots and 48 percent for the second pairs of canonical roots. These findings suggest that motor development and therefore motor behavior in boys was to a considerable extent, defined by both morphological growth and development. In the study conducted by Bala et al. (2009), the covariance explained for the first pairs of canonical roots was 37 percent of common variability and 30 percent for the second pairs of canonical roots (age group 6.01-6.5). The covariance explained for the first

Table 7: Canonical correlations between motor tests and cognitive tests – first canonical root (boys)

Correlations with composite scores[a]	*Morphological measures*	*Canonical variate coefficients[b]*		*Canonical variate coefficients*	*Motor tests*	*Correlations with composite scores*
Third Canonical Analysis: Boys						
0.287	TSSP	-0.232	R can1=0.650	-0.012	MKGRY	-0.288
0.706	TSSCC	0.481	R^2can1=0.423	-0.187	MKGNY	**-0.376**
0.477	TSSN	0.052	χ^2= 124.492	-0.373	MKHNY	**-0.592**
			-0.091		MFIPY	-0.089
0.714	TSST	0.332	df=90			
0.833	TSSC	0.558	Wilks Λ=0.261	0.094	MFSRY	-0.016
				-0.187	MFPKY	**-0.383**
			p<0.01	-0.042	MS10Y	-0.219
				0.469	MSSDY	0.582
				-0.122	MSPTY	0.081
				0.544	MAKSY	-0.121
				-0.163	MAOOY	-0.249
				-0.050	MAOSY	**-0.380**
				-0.072	MPGCY	0.165
				0.038	MPGOY	0.156
				-0.401	MPCSY	-0.054
				0.368	MRJUY	**0.575**
				0.208	MROPY	**0.391**
				0.109	MRJOY	**0.482**
	Redundancy	27.813 %			Redundancy	8.283 %

Legend: [a]The simple product-moment correlations between the variable and the composite scores computed in the canonical analysis.
[b]The standardized coefficient of the variable used in computing the canonical variate that generated the composite scores.
Cognitive Tests: perceptual (TSSP), knowledge of the facts (TSSCC), numerical (TSSN), connecting points (TSST), strikethrough (TSSC).
Motor Tests: MKGRY, MKGNY, MKHNY (coordination), MFIPY, MFSRY, MFPKY (flexibility), MS10Y, MSSDY, MSPTY (strength), MAKSY, MAOOY, MAOSY (agility), MPGCY, MPGOY, MPCSY (accuracy), MRJUY, MROPY, MRJOY (balance)

pairs of canonical roots was 54 percent (age group 6.51-7.0). Hence, in our study, the explanation of covariance is quite higher. The relation between the morphological and motor structures was higher in male children in majority of age groups analyzed in the study conducted by Bala et al. (2009). These results are similar as the results obtained in our study could be explained, in terms of the trend and level of growth and development of morphological structure, motor structure and central nervous system, and also in terms of physical activity which is more emphasized in boys than in girls (Bala et al. 2009). Hence, the researchers' next step is to investigate the correlation between morphological and motor structures in girls on the same age.

Previous findings show that boys are the most often successful in the motor dimensions under the primary influence of the movement regulatory mechanism (coordination, agility and balance) and energy-supply regulation mechanism (strength/power). On the contrary, girls aged 6-7 achieve better results in assessing flexibility, which is primarily under the influence of the synergy and regulation mechanisms (Brodie and Royce 1998; De Privitellio et al. 2007). In the previous research using the same data (Horvat et al. 2013), it was revealed that only the variable *straddle seated forward bend* statistically significantly discriminated the boys from the girls, while other flexibility tests did not show statistical significant sex differences. Therefore, authors explained these results in terms of intrinsic motivation of children to fulfil all the measurement tasks. On the other hand, boys manipulate better than the girls do. Thus, they are better in motor abilities that are under the influence of the excitation-intensity regulation mechanism (Horvat et al. 2013). In a similar study performed on a wider range of the age groups of children, the results showed statistically significant sex differences in morphological characteristics and motor abilities (with higher average values for boys), whereas no such difference was recorded in cognitive functioning (Bala and Katic 2009). Sex differences found in morphological and motor spaces contributed to structuring adequate general factors according to space and sex (Bala and Katic 2009). Therefore, the correlations between the morphological and cognitive structures, as well as between motor structures and cognitive structures in the group of boys, and also in the group of girls (age group 6 to 7), should serve as a guidance for future studies.

Although, the present study included only one age group of children, the results obtained can be taken as indicators of changes in function of the respective age span, using the same tests and measures. It could be also recommended that children could be equalized (and measured) by the higher number of time points, such as according to half-year age groups or shorter time intervals (for example, two months) (Bala et al. 2009). Thus, this stems from the irregularity of the children's development on the inter-individual level. On the other hand, larger samples of participants could be examined from different areas of Croatia or/and outside Croatia.

A shortcoming of the research is relatively small number of participants, for the requests of stable canonical solutions. On the other hand, it is hard to measure and test children in pre-school age, because of their unstable and distractible attention and motivation. Therefore, when conducting research with samples of pre-schoolers, a researcher has to be very careful. He has to take into account: how the tests are performed, the order of their application, the way of presenting the tasks to the children, and the duration of the measurement sessions (Horvat et al. 2013). However, any of the disturbances from standardized procedure could lead to the misleading of the results obtained.

CONCLUSION

The main finding of the study is that all the canonical correlations were statistically significant: between motor abilities and morphological characteristics, between motor abilities and preparedness for school, as well as between morphological characteristics and preparedness for school. However, in spite of its significance, the canonical correlation (in spite of its statistical significance), as well as univariate correlations between morphological measures and cognitive tests (preparedness for school) were the lowest. On the other hand, the correlations between morphological measures and motor abilities are higher, as well as the correlations between motor and cognitive tests. Hence, it could be carefully hypothesized that morphological characteristics could be a less important factor for estimating the overall preparedness for school, than boys' motor abilities at the age of six or seven years.

RECOMMENDATIONS

The insight in relation between three types of data studied in this research is a point of interest for kinesiologists, as well as for professionals in biology, medicine, and education. These results provide a platform for kinesiologists to design appropriate planning and control of training processes in using various motor activities which is convenient for the development of motor behavior or in 'child-adjusted' sports activities. However, it is recommendable when applying certain kinesiological activities to focus shortly on the development of the abilities which are sensitive to the environmental influence. Finally, the need of developing general motor ability and motor behavior in pre-school children is imperative. In the development of general motor abilities and behavior, the interaction of their biological, mental, and social development has to be considered.

NOTE

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