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Original research article

ANALYSIS OF DIFFERENCES IN MORPHOLOGICAL AND MOTOR STATUS OF PUPILS AND THEIR CONNECTION WITH AGILITY

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Abstract. *The current study was conducted on a sample of 302 participants, divided into two sub-samples: 150 boys and 152 girls, aged 10 and 11, to determine gender differences in morphological characteristics and motor skills, as well as their relations to the abovementioned space test for assessing agility. The battery of tests prescribed by the Committee for the Development of Sport of the Council of Europe was used. By applying a multivariate (MANOVA) analysis of variance for the two genders, differences in the morphological characteristics (F=2.544; P=0.006) and motor performance (F=15.451; P=0.000) were found. At the univariate level, the differences were manifested in volume and body mass, muscle strength of the knee extensors, wrist flexor muscle strength, static strength of the arms and shoulders, repetitive force of the upper body and tests for the assessment of agility, all in favor of the boys. The research findings also indicate that the relationship between morphological characteristics and the test for assessing agility indicate a statistically significant relation only in the case of the girls. In addition, the relationship between the motor skills on the test for the assessment of agility was established both in boys and in girls. Indicated gender differences suggest the need for additional work with girls, and relationships indicate the possibility of planning the transformation process.*

Key words: *Anthropometric measurements, motor skills, sexual dimorphism, students.*

INTRODUCTION

Morphological characteristics and motor abilities are complex due to the fact that the efficiency of children based on body activities is actually the result of all the abilities and characteristics of a child as a biological and psycho-social individual, but also the result

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of specific motion activity on which efficiency depends up to 30%, or even, in some activities, up to 70% (Sozański, 1987). One of the most important periods of the motor development of a child is the interval between the ages of 9 and 12. This is the period when children are developmentally ready to learn through concrete structures that form the basis of motor development (Balyi, & Hamilton, 2001; Rushall, 1999). The process of developing motor skills is going from the general to the specific, and motor behavior of children is significantly conditioned by the functional mechanisms of the central nervous system (Bala, Stojanović, M., & Stojanović, M., 2007). The sensitive periods in the development of motor skills among children have been the subject of study for the following authors: Hettinger, 1964; Gužalovski 1984; Haken, Kelso, & Bunz, 1985; Drabik, 1996; McKenzie et al., 2002; Bala, 1981; Jovanović, 1998, Mirkov et al., 2010. Most authors agree that there is a need for continuous monitoring of motor skills and their relation to the other features and capabilities of the anthropological status of children.

At a certain age between 7 and 17, physical activity with the aim of developing motor skills has the best effects, and developmental status and biological maturity significantly affects motor performance tasks (Malina, Koziel, & Bielicki, 1999; according to Pelemiš, M., Martinović, & Rankić, 2013a). Gender differences are reflected in morphological characteristics, motor and functional abilities, but also in other anthropological characteristics. The motor skills of boys are greater in terms of strength, endurance, speed, and of girls in terms of coordination, precision, flexibility and balance (Krsmanović, & Berković, 1999). In addition, gender differences in motor but not intellectual abilities in 7 to 10 year-old children have been noted at all levels (Fratrić et al., 2012).

The position of agility as a combined motor skill, composed of coordination, maximum strength and maximum speed (Bompa, 1999). Most researchers believe that agility should be divided among the skills that are subordinate to the mechanism for structuring movement (Gredelj et al., 1975, according to Pelemiš, V., Pelemiš, M., Lalić, & Prica, 2012a). The correlation between the morphological characteristics and agility of both sexes at the age of 14 has been established (Stanić, Pržulj, Grbić, & Stamenković, 2013).

The longitudinal and transversal dimensionality of the skeleton is influenced by the genetic factors to a higher percentage compared to the circular dimension, body mass and subcutaneous adipose tissue (Malacko, & Popović, 2001). The first phase of rapid growth of the body happens from birth to the age of 3, and it is followed by slower growth from the age of 4 to 10 or 11. After that, at the age of 10 and 11 (girls) and 13 and 16 (boys), children enter the second phase of accelerated growth which is again followed by a re-occurring phase of slower growth (Medved, R. et al., 1987; according to Popović, 2008a). Studies have shown that body height constantly increasea with age by an average of approximately 5-8 cm and body mass by approximately 2-3 kg per year (Medved et al., 1987b; Zdravković, 1978; Pavlović, 1999; Božić - Krstić, Rakić, & Pavlica, 2003; according to Popović, 2008b). In the physical development of children between the ages of 10 and 12, there is a favorable ratio of the anthropometric measures of height and weight.

The differences in morphological characteristics between children from rural and urban areas have also been confirmed. Children in urban areas are much heavier and have a markedly greater amount of subcutaneous adipose tissue (Plotnikoff, Mayhew, Birkett, Loucaides, & Fodor, 2004). Gender differences between children from urban and rural areas indicate that the boys in urban areas are significantly heavier than the girls (Pelemiš, V., Pelemiš, M., Mitrović, Lalić, & Prica, 2012). No significant gender differences in morphological characteristics were determined between the children from city centers

and the periphery (Božić-Krstić, Rakić, & Pavlica, 2005). It has been noticed that overweight children enjoy physical education classes but believe that they are not sufficiently appreciated by the other group members, a fact that points to low self-esteem in both boys and girls (Petracovschi, 2012).

The aim of the study was to determine the statistically significant differences between boys and girls in morphological characteristics and motor skills, as well as the relation between morphological characteristics and motor skills on the test for the assessment of agility.

THE METHOD

The study had a transversal character, and the ex post facto research design was used. The sample for the study was derived from a population of younger school children from Belgrade by quota sampling. The measurements of morphological characteristics and motor abilities were taken at the beginning of the second half of 2012/2013 school year, on a sample of 302 children, average age 10 and 11, divided into two sub-samples: 150 boys and 152 girls, who, at the time of the measuring, were not included in the kinesiology treatment (training process). Prior to the commencement of the research, the children had been given a survey questionnaire, therefore, the data on the kinesiology treatment was provided by themselves. At the time of the measuring, all respondents attended the following elementary schools: "Kralj Petar II", "Đorđe Krstić", "Josif Pančić", "Vladimir Nazor", "Aca Milosavljević", "Filip Kljajić", "Vladislav Ribnikar", "Svetozar Marković", "Jefimija", "14th oktobar", "Jovan Jovanović Zmaj" and "Živojin Perić" in Belgrade. Also, prior to the anthropometric and motor measurement had taken place, parental consent had been obtained (Declaration of Helsinki for Biomedical Research, 1975).

As a sample of measuring instruments, the following motor tests and anthropometric measures were chosen (based on the "EUROFIT" battery of tests prescribed by the Committee for the Development of Sport of the Council of Europe (Council of Europe, 1993)).

MOTOR SPACE: the assessment of general equilibrium *The Flamingo Balance Test (sec.),* for the assessment of segmental motion *The Hand Tapping Speed (sec.),* for the evaluation of flexibility in the hip joint *Bending forward in a Seated Position (cm.),* for the assessment of explosive leg strength *The Long Jump (cm.),* for the assessment of muscle strength of the wrist flexor *Hand Dynamometer (kg.),* for assessing the repetitive strength of the abdominal muscles *Lying Body Lift (sec.),* for the assessment of static strength of arms and shoulders *Bend Endurance (sec.),* for assessing agility *Pin Running 10x5 meters (sec.).*

MORPHOLOGICAL SPACE: the assessment of longitudinal dimensionality of the skeleton B*ody Height (cm.),* to estimate the volume and body weight *Body Weight (kg),* for assessment of subcutaneous fat *The Back skin fold (cm).*

The statistical analysis involved in the calculation of basic descriptive statistics for the measures of central tendency: the mean (AS); variability measures: the standard deviation (S); distribution feature measures: asymmetrical distribution – skewness (Sk), the homogeneity of distribution - kurtosis (Kurt). In order to justify the use of parametric statistical methods, the normality of distribution was tested using the Kolmogorov-Smirnov test. To determine the differences between the groups of respondents in the morphological characteristics and motor abilities, the multivariate (MANOVA) analysis of variance was applied, and differences within the groups were calculated by a univariate (ANOVA) analysis of variance. Interaction according to gender between the morphological characteristics and motor abilities as the

predictor system with the test for the assessment of agility as the criterion was calculated using the linear regression analysis.

RESULTS

Tables 1 and 2 show the values of the descriptive statistics for the tested variables with statistically significant coefficients of Kolmogorov-Smirnov test, and the multivariate and univariate differences for both sexes, all at the $p>0.01$* level.

Table 1 Descriptive statistics and differences in the morphological variables

Variable	Gender	AS	S	Sk.	Kurt.	p-K-S	f*
Body height (kg)	Boys	140.690	6.893	0.091	-0.518	0.828	0.346
	Girls	140.217	7.069	-0.086	-0.214	0.509	
Body weight (cm)	Boys	37.966	8.517	0.768	0.159	0.125	7.333*
	Girls	35.377	8.095	0.918	0.832	0.072	
Back skin fold (cm)	Boys	72.306	22.535	1.137	0.769	0.047	2.031
	Girls	68.651	22.039	0.403	-0.949	0.055	
		F=2.544; P=**0.006**					

Legend: AS – arithmetic mean; S - the standard deviation ; Sk- measure of distribution symmetry; Kurt- measure of distribution homogeneity; p-K-S - the level of statistical significance of the Kolmogorov-Smirnov test; f * univariate F - test and its statistical significance ; F – Wilks' multivariate F test; P - statistical significance of multivariate Wilks' F test.

Based on Wilks' F test from Table 1, a statistically significant difference between boys and girls in morphological characteristics can be noted. Individual differences were found in the variables *Body Weight* in favor of the boys. Based on the distribution feature measure, sufficient homogeneity and curvature distribution of the test variables was confirmed. No significant differences were found in terms of normality of distribution of data which was also indicated by the statistical significance of Kolmogorov-Smirnov test values. They have justified the application of parametric statistical methods for data analysis in further research.

By analyzing Table 2 and the values of Wilks' multivariate F test, a statistically significant difference between the groups of participants in terms of motor skills can be noted. At the univariate level, differences were found for the following variables: *Long jump*, *Hand Dynamometry*, *Body lift*, *Bend endurance and Pin running 10x5 meters* in favor of the boys. A similar conclusion could be derived by the simple inspection of their arithmetic means. The asymmetrical distribution was noted for the variable *Bend endurance*, and most of the results have fallen into the lower values section for both boys and girls, which indicates the severity of the test for this sample group. No significant differences were discovered for the other variables. The homogeneity of the distribution is generally good and medium kurtosis was noted in most of the variables, except for the variable *Hand Dynamometry* where extremely narrow kurtosis distribution occurs indicating a grouping around the midpoint. Also, based on the statistical significance of the Kolmogorov-Smirnov test from Table 2 it can be concluded that none of the tested distributions significantly differ from normal values.

Table 2 Descriptive statistics and differences of motor variables

Variable	Gender	AS	S	Sk.	Kurt.	p-K-S	f*
Flamingo balance test (sec)	Boys	19.133	8.637	-0.591	0.233	0.362	0.928
	Girls	18.197	8.247	-0.342	0.476	0.179	
Hand tapping (sec)	Boys	16.784	2.365	0.442	0.013	0.765	1.322
	Girls	16.473	2.344	0.938	1.211	0.067	
Bending forward in a seated position (cm)	Boys	15.446	6.487	-0.246	-0.271	0.419	5.218
	Girls	17.276	7.396	-0.211	-0.628	0.422	
Long jump (cm)	Boys	127,200	17.892	0.181	0.907	0.937	24.33*
	Girls	116.526	19.655	0.079	-0.233	0.712	
Hand Dynamometry (kg)	Boys	19.960	3.877	0.162	-0.394	0.209	40.71*
	Girls	17.144	3.789	0.855	2.996	0.261	
Lying body lift (sec)	Boys	18.706	4.383	-0.705	1.795	0.126	18.75*
	Girls	16.703	3.622	0.160	0.181	0.169	
Bend endurance (sec)	Boys	10.632	7.017	1.072	0.731	0.034	41.26*
	Girls	6.520	3.588	1.103	1.422	0.021	
Pin running 10x5 meters (sec)	Boys	24.534	2.414	0.301	-0.321	0.656	16.53*
	Girls	25.757	2.793	0.518	0.498	0.605	

F=15.451; P=**0.000**

Legend: AS – arithmetic mean; S - the standard deviation ; Sk- measure of distribution symmetry; Kurt- measure of distribution homogeneity; p-K-S - the level of statistical significance of the Kolmogorov-Smirnov test; f * univariate F - test and its statistical significance ; F – Wilks' multivariate F test; P - statistical significance of multivariate Wilks' F test.

Table 3 Regression analysis of morphological traits and criteria

Variable	Boys				Girls			
Motor ability	rpart.	t	Beta	pbeta	rpart.	t	Beta	pbeta
Body height	-0.143	-1.748	-0.187	0.083	-0.151	-1.859	-0.219	**0.055**
Body weight	0.150	1.837	0.197	0.068	0.210	2.607	0.307	**0.010**
Back skin fold	0.040	0.481	0.039	0.631	-0.096	-1.178	-0.094	0.241
	R=0.167; R^2=0.028				R=0.234; R^2=0.055			
	F=1.389; P=0.249				F=2.847; P=**0.040**			

Legend: rpart. - partial correlation coefficient; t - value of t -test; Beta - standardized regression coefficients; pbeta - the level of statistical significance of the regression Beta coefficient; R - coefficient of multiple correlation; R2 - determination coefficient; F - value of F ratio ; P - multiple correlation coefficient statistical significance.

Based on the results of the multiple regression analysis of morphological characteristics and the criterion, it can be concluded that the system of predictors had a statistically significant impact on the results for the variable pin running 10x5 meters for the girls. The adjusted coefficient of determination is generally small and explains only 5.5 % of the common variance. This is because the predictor system is composed of only three morphological variables, and other anthropological characteristics and capabilities are responsible for the rest of the variability. Based on the standardized regression coefficient Beta and their statistical significance, a mathematically negative but logically positive impact of the *Body height* variable on the results of tests for the assessment of agility is visible. Also, a mathematically positive but logically negative influence was found between the variables of *Body weight* and results in a *Pin running 10x5 meters* variable.

No statistically significant effect of the predictor system and the criterion was found for the boys.

Table 4 Regression analysis of motor skills and criteria

Variable	Boys				Girls			
Motor ability	rpart.	t	Beta	pbeta	rpart.	t	Beta	pbeta
Flamingo balance test	0.175	2.121	0.143	**0.036**	-0.108	-1.302	-0.087	0.195
Hand tapping	0.172	2.075	0.148	**0.040**	0.198	2.418	0.171	0.198
Bending forward in a seated position	0.048	0.577	0.040	0.565	0.168	2.048	0.139	**0.042**
Long jump	-0.303	-3.784	-3.413	**0.000**	-0.532	-7.359	-5.672	**0.000**
Hand Dynamometry	-0.069	-0.826	-0.058	0.410	-0.016	-0.192	-0.013	0.848
Lying body lift	-0.240	-2.949	-0.237	**0.004**	0.077	0.921	0.069	0.359
Bend endurance	-0.013	-0.149	-0.011	0.882	-0.017	-0.204	-0.015	0.839
	R=0.629; R^2=0.365				R=0.615; R^2=0.348			
	F=13.259; P=**0.000**				F=12.515; P=**0.000**			

Legend: rpart. - partial correlation coefficient; t - value of t -test; Beta - standardized regression coefficients; pbeta - the level of statistical significance of the regression Beta coefficient; R - coefficient of multiple correlation; R2 - determination coefficient; F - value of F ratio ; P - multiple correlation coefficient statistical significance.

Based on the multiple correlation coefficient, the F ratio and statistical significance for multiple correlations figures shown in the Table 4, we can conclude that the motor predictor system had a statistically significant effect on the criterion for both boys and girls. A mathematically negative but logically positive impact was realized for the variables: *Long jump* and *Lying body lift* for the boys, a mathematically positive and logically negative one for the variables: *Flamingo balance test* and *Hand tapping*. The determination coefficient explains 36.5 % of the common variance among the boys. The standardized Beta coefficient in the *Long jump* variables was found to have a mathematically negative, but logically positive impact on the criterion among the girls, and the opposite relation was confirmed with the variable *Bending forward in a seated position*. The determination coefficient explains 35 % of the common variance with the criterion among the girls, and the rest of the variability can be attributed to other characteristics and abilities of the anthropological status of the girls e.g. (fitness state, muscle cross-section, cognitive abilities, conative traits, etc.).

DISCUSSION

After analyzing the anthropometric variables results which were statistically significant and different between groups of participants it becomes clear that the differences are attributed to the variables used to estimate body volume and mass. It is evident that higher values of body weight in the study period were measured among the boys, which may indicate higher average values of back subcutaneous fat which is consistent with the findings of Šturm, Strel, & Ambrožić, 1995; Popović, 2008c, obtained in a similar sample of participants. Higher average values of longitudinal dimensionality of the skeleton was found for the girls, but other tested anthropometric variables may indicate the earlier entry of girls into the rapid growth phase and their hormonal status. The human body is going through somewhat lesser changes, and the total amount of muscle tissue is significantly lower in comparison to body weight, therefore, at this period children are

weaker and less vigorous. The skeleton is still in the stage of ossification, and the joints are not sufficiently linked. The body does not yet have the necessary quality to overcome severe physical and mental efforts (Nićin, 2000). Previous research (Stamm, Gebert, Guqqenbuhl, & Lamprecht, 2014) has pointed to the existence of differences between classes in the same grade regarding the body height and weight (BMI) in children, but that it is more pronounced in high school. Overweight as such is largely distributed, however, not equally, therefore we can conclude that socio-economic factors and parental care strongly influence the increase in weight in children.

The analyses of motor skills results revealed significant differences in the group of participants. Differences were found in the evaluation variables: *Knee extensor muscle strength*, *Wrist flexor muscle strength*, *Static strength of arms and shoulders*, *Repetitive body strength* and variables for assessing agility, all in favor of the boys. This is consistent with the findings obtained by Despot, & Viskić-Štalec, (1983); Šturm, Strel, & Ambrožić, (1990); Breslauer, Delija, & Mesarić, (2006); Krsmanović, & Radosav, (2008); Batez, Krsmanović, Dmitrić, & Pantović, (2011); Pelemiš, M. et al., (2013b). The resulting differences can be defined as motor events that are influenced by the mechanisms for the regulation of the exercise intensity and duration, the mechanisms for the regulation of muscle tone and the mechanisms for movement structuring. It is clear that higher levels of volume and body mass and subcutaneous fat on the back do not adversely affect the manifestation of motor skills in boys as was anticipated. Adverse findings by Jozić, 2002; Vraneković, Tkalčić, & Jerković, 2006 indicate that the lower the total amount of subcutaneous adipose tissue, and therefore less volume, the better the results in motor variables assessing hand strength with the optimal representation of muscle at the expense of the subcutaneous adipose tissue. The findings of Katić, Pavić, & Cavala, 2013 regarding the motor differences pertaining to gender in children aged 11 to 14 (older school age), which is actually relevant to all age categories, have confirmed that the differences are most pronounced during puberty, and that muscle development occurs faster in boys rather than in girls which, again, was also confirmed by all of the strength tests.

A statistically significant correlation between the anthropometric variables and test for assessing agility was established but only for the girls. The longitudinal dimension of the skeleton in girls was positively associated with agility (rapid change of direction). Additional body weight had negatively affected the test performance. The body height acted as a mitigating, and the body mass as a disturbing factor. As the girls were taller, better results were achieved more easily. Subcutaneous fat was not associated with performance tests in girls. In addition to the usual and expected correlations, it should be noted that the negative effects of adipose tissue on the motor abilities have been defined, but that they are relatively small and manifested manifest by mastering relatively small mass. This phenomenon supports the hypothesis that the motion of the body, or parts of the body, is affected by its own weight as well as the correlation between fat and muscle tissue, however, the speed of performing simple movements is affected by the amount of muscle mass, considerably but not drastically. The presented analysis is consistent with the findings of Mitić (2011). The results of the research conducted by Zenić, Foretić, & Blažević (2013), indicaate that the highest level of correlation between anthropometric variables and physical readiness gained by a linear and non-linear regression model was achieved by the BMI variable. The authors have suggested the non-linear regression model be utilized for establishing the correlation with the criterion since the linear models supposes a continuous relation (dependence) between the predictor and the criterion, while the non-linear model effectively identifies the possible regression break points, therefore,

making the true nature of the correlation between the variables visible.

A statistically significant correlation was found between motor variables and the test for assessing agility in both sexes. The girls achieved the highest negative correlation with the variable for the evaluation of flexibility in the hip joint, and the highest positive correlation with the variable for assessing the knee extensor muscle strength. In boys the highest negative correlation was recorded in the variables for assessing balance and segment speed movement of the hands, and the highest positive in variables for assessing the knee extensor muscle strength and repetitive strength of the upper body. Girls who are less flexible in the hip joint and have achieved higher values of explosive leg strength have also achieved better results on the test, and are generally more agile. Boys whose balance and segmental hand movement speed was lower and explosive and repetitive strength were higher also achieved better results on the test. Given that explosive strength is the ability to produce the maximum force values within a limited time period, and agility a combined motor ability partially made up of explosive and repetitive strength, coordination and speed, it is obvious that the explosive power has largely defined the rapid change of movement direction in both sexes and achieved the maximum positive correlation. This is consistent with the findings of Pelemiš, V. et al., (2012b), recorded on a sample of boys.

CONCLUSION

As the majority of research in modern and developed countries in the world indicates a general decline in the level of motor skills in children (Boddy, Fairclough, Atkinson, & Stratton, 2012; Tomkinson, & Olds, 2007; Tremblay et al., 2010), with our country following closely, the need to develop and evaluate kinesiology treatments in working with children of a younger school age relying on physical education and sport teachers is emerging since it has been established that at this particular age the physical exercise monitored and led by specialized teachers produces better results (Ristić, et al., 2013). The authors suggest, and the results of this research have confirmed, that in order to improve agility (which builds each specification equation in specifically directed movement activities), explosive and repetitive strength should be developed and built.

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ANALIZA RAZLIKA U MORFOLOŠKOM I MOTORIČKOM STATUSU UČENIKA I NJIHOVA VEZA SA AGILNOŠĆU

Istraživanje je izvršeno na uzorku od 302 ispitanika, podeljenih na dva subuzorka: 150 dečaka i 152 devojčice, starosti 10 i 11 godina u cilju utvrđivanja polnih razlika u morfološkim karakteristikama i motoričkim sposobnostima, kao i relacija pomenutih prostora sa testom za procenu agilnosti. Primenjena je baterija testova propisana od strane Komiteta za razvoj sporta Saveta Evrope. Primenom multivarijatne (MANOVA) analize varijanse utvrđene su polne razlike u morfološkim karakteristikama (F=2,544; P=0,006) i motoričkim sposobnostima (F=15,451; P=0,000). Na univarijatnom nivou razlike su ispoljene u volumenu i masi tela, mišićnoj jačini opružača nogu, mišićnoj jačini pregibača šake, statičkoj snazi ruku i ramenog pojasa, repetitivnoj snazi trupa i u testu za procenu agilnosti, a sve u korist dečaka. Nalazi istraživanja takođe ukazuju da relacije morfoloških karakteristika sa testom za procenu agilnosti imaju statistički značajanu povezanost samo kod devojčica. Utvrđena je povezanost motoričkih sposobnosti sa testom za procenu agilnosti i kod dečaka i kod devojčica. Ukazane polne razlike ukazuju na potrebu dodatnog rada sa devojčicama, a relacije na mogućnost planiranja transformacionih procesa.

Ključne reči: *Antropometrijska merenja, motorika, polni dimorfizam, učenici*.