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Original research article

THE CORRELATION BETWEEN ANTHROPOMETRIC CHARACTERISTICS AND MOTOR ABILITIES IN SEVEN-YEAR-OLD GIRLS

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Abstract. *The aim of this research was to determine whether there is a connection between anthropometric characteristics and motor abilities in normal and overweight seven-year-old girls. The sample consisted of 75 first grade female elementary school students in the town of Niš, which were classified based on their BMI values as belonging to a normal weight group (N = 47) and overweight group (N = 28). The anthropometric characteristics were determined by measuring 16 parameters of longitudinal, transversal, circular dimensionality and body mass, and subcutaneous fatty tissue by measuring skin fold thickness. For the assessment of motor abilities (explosive strength, coordination and speed), a battery of nine tests was applied. Relations between anthropometric characteristics and motor abilities were assessed by a canonical correlation analysis. The results indicate that the correlations were statistically significant only in the group of overweight children (p = 0.00), and defined by three pairs of canonical factors. The factors of the canonical correlation between anthropometric characteristics and motor abilities in the group of overweight girls indicate that body voluminosity and subcutaneous fatty tissue hinder the realization of motor tasks that require lifting or transferring body mass, while higher parameter values of longitudinal dimensionality contribute to the better performance in the explosive strength of arms and legs, but impair coordination.*

Key words: *anthropometric characteristics, motor abilities, nutritional status, correlation.*

INTRODUCTION

Great attention of the scientific community is focused on the study of the anthropological status of children, which is in modern life conditions exposed to many risks. Within the growth and development and the mutual relations between morphological characteristics and motor abilities in children, certain rules can be defined that depend on the endogenous

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and exogenous factors, such as gender, age and physical activity (Bala, 2009). Defining the rules is based on the fact that individual differences among children influence different body constitutions and types of motor abilities. Knowledge of these rules, which are manifested, among others, by relations between the anthropological dimensions, is necessary for understanding the efficiency of any motor ability. The manifestation of motor abilities, among others, depends on anthropometric characteristics. Motor abilities in children are quantitatively lower and structurally different than in adults. Accordingly, the relations between anthropometric characteristics and motor abilities in children are different compared to those of adults. It was observed that in young children almost all potential motor abilities are interrelated, so we talk about a general motor factor (Bala, 1981).

The biological development of children is manifested through changes in physical and motor development. One of the important aspects of the development, which is associated with physical and motor development, is the level of nutritional status. The nutritional status of children and adolescents is one of the important indicators of the health of young people, their mental and physical capabilities and potentials for normal and healthy growth and development (Lobstein, Baur & Uauy, 2004). It is assumed that bigger deviation from optimal body weight is one of the indicators of health disorder symptoms.

Several authors have investigated the problems associated with obesity and motor abilities in children of different ages (Minck, Ruiter, Van Mechelen, Kemper & Twisk, 2000; Mota, Santos, Guerra, Ribeiro & Duaret, 2002; Thompson, Baxter-Jones, Mirwald & Bailey, 2003; Deforche et al., 2003; Ara, Moreno, Leiva, Gutin & Casajús, 2007). Excess of adipose tissue (obesity) is an obstacle for motor development and generation of motor habits (Bala, 2007). Obese children had a weaker performance, which included transferring or lifting their own body mass (Casajús, Leiva, Villarroya, Legaz & Moreno, 2007). In boys aged two to three, obesity is associated with reduced motor abilities, verbal, social skills and daily activities (Cawley & Spiess, 2008). Overweight and obese children have poorer motor development than children who are of normal weight (Graf et al., 2004a, 2004b; Wrotniak, Epstein, Dorn, Jones & Kondilis, 2006).

The aim of this research is to determine whether there is a connection between anthropometric characteristics and motor abilities in normal and overweight seven-year-old girls.

THE METHOD

Participants

The research was conducted on the sample of 75 first grade elementary school students attending "Ratko Vukićević," "Car Konstantin" and "Sveti Sava" elementary schools in Niš, aged 7.07±0.5. The sample included those children whose parents had given signed consent for their participation, and who were healthy on the day of the testing. The measuring took place in the school facilities which met the necessary requirements.

After measuring body height and body weight and calculating the body mass index (BMI), two sub-samples were formed, according to children's BMI in accordance with the work of Cole, Bellizzi, Flegal & Dietz (2000). The first sub-sample consisted of 47 children with normal body weight and an average BMI value of 16.04 (± 1.2) and age of 7.20 (± 0.40). The second sub-sample consisted of 28 overweight children and an average BMI value of 18.91 (± 0.7) and age of 6.94 (± 0.60).

Measuring instruments

Anthropometric characteristics were determined by measuring 16 parameters of longitudinal, transversal, circular dimensionality and body mass, and subcutaneous fatty tissue by measuring skin fold thickness. Within the longitudinal dimensionality of the skeleton, the following parameters were determined: body height, leg length and arm length; within the transversal dimensionality: shoulder width, pelvic width, and hip width; within the body mass and circular dimensionality: thorax volume, upper arm volume, thigh volume and calf volume; within the subcutaneous fatty tissue: sub-scapular skin fold, abdominal skin folds, thigh skin folds and medial calf skin folds.

The measuring technique for the anthropometric characteristics followed the guidelines of the methodology recommended by the International Biological Program (Weiner & Lourie, 1969).

The basic parameters of the motor abilities were determined by using the battery of tests used in the study by Kostić et al. (2010): the plyometric jump (Nazarenko, 2000), hyperextension, twist, and throw (Kostić et al., 2009), the standing depth jump (Kurelić et al., 1975), 20 sidesteps with a baton (Kurelić et al., 1975), horizontal jump rope (Kurelić et al., 1975), running and rolling (Kostić et al., 2009), hand tapping (Kurelić et al., 1975), 5x10 meter run (Kurelić et al., 1975), and foot tapping against a wall (Kurelić et al., 1975).

Procedure

For all the parameters of the anthropometric characteristics and motor abilities, mean arithmetic values and standard deviations were calculated, while the connection between the anthropometric characteristics and motor abilities was determined by using a canonical correlation analysis. The bi-orthogonal method of canonical correlation analysis was used. For each isolated canonical function the following parameters were given: extent of the canonical correlation (R), canonical root of determination (R^2), Bartlett's Chi-square test (H^2), degree of freedom (df) and significance level (p). All of the analyses were carried out with help of the SPSS 16.0 program.

RESULTS

Table 1 shows the arithmetic mean values and standard deviations of all the variables of anthropometric characteristics and motor abilities for both sub-samples. The descriptive statistical parameters indicate that the group of overweight girls is superior in all anthropometric characteristics compared to the group of girls with normal body weight. In the area of motor abilities, in the group of girls with normal body weight, better results were achieved in the following tests: the plyometric jump, standing depth jump, horizontal jump rope, 20 sidesteps with a baton, running and rolling, and foot tapping against a wall. Overweight girls achieved quantitatively better results on the following tests: hyperextensions, twist, and throw, hand tapping and the 5×10 meter run.

Based on the application of the canonical correlation analysis for the group of participants with normal body weight, statistically significant correlation coefficients between anthropometric characteristics and motor abilities were not found. Thus, these results were not presented and will not be analyzed.

Table 2 shows the cross-correlation matrix between anthropometric characteristics and motor abilities for the group of overweight girls. Based on the results shown in Table 2, it is evident that there were no extremely high correlations, but that the total number of statistical

significant correlations was considerable. Generally speaking, most of the significant correlations with motor abilities are present with the variables of circular dimensionality and subcutaneous fatty tissue. The course of the relationship varies, which is evident in the trend of the correlation coefficients, which may be the result of the correlation essence, but also the result of the method used for measuring and assessing some time-related motor abilities.

Table 1 Basic descriptive statistical parameters

Anthropometric characteristics			Motor abilities		
	Normal body weight (n=47)	Overweight (n=28)		Normal body weight (n=47)	Overweight (n=28)
Body height in cm	125.41 ± 5.9	131.15 ± 5.6	Plyometric jump	12.74 ± 4.9	11.79 ± 5.1
BMI	16.04 ± 1.2	18.91 ± 0.7	Hypertension, twist, and throw	38.74 ± 16.7	43.63 ± 11.8
Leg length	68.94 ± 4.1	72.76 ± 4.2			
Arm length	52.70 ± 2.7	55.23 ± 7.6	Standing depth jump	106.17 ± 16.6	103.68 ± 17.3
Shoulder width	28.35 ± 6.7	29.1 ± 1.8	Horizontal jump rope	2.91 ± 3.5	2.14 ± 2.4
Pelvic width	19.60 ± 1.7	20.81 ± 1.1	20 sidesteps with a baton	31.13 ± 7.9	32.91 ± 9.4
Hip width	21.02 ± 1.3	22.58 ± 1.2	Running and rolling	21.09 ± 2.9	22.56 ± 3.5
Body weight	25.27 ± 3.0	32.58 ± 3.1	Hand tapping	27.09 ± 4.1	28.14 ± 5.5
Thorax volume	59.85 ± 3.3	66.47 ± 3.8	Foot tapping against a wall	13.23 ± 2.2	12.68 ± 1.9
Upper arm volume	17.97 ± 1.6	20.67 ± 1.4			
Thigh volume	37.07 ± 3.3	41.24 ± 3.5	5×10 meter run	18.98 ± 2.2	18.82 ± 0.9
Calf volume	26.07 ± 1.8	28.43 ± 1.7			
Triceps SF	10.42 ± 2.9	14.51 ± 2.6			
Sub-scapular SF	7.08 ± 2.9	11.84 ± 3.5			
Abdominal SF	8.79 ± 4.3	16.41 ± 5.3			
Thigh SF	16.24 ± 5.6	21.7 ± 6.3			
Medial calf SF	11.89 ± 5.1	16.64 ± 6.9			

Table 2 The cross-correlation matrix between anthropometric characteristics and motor abilities in overweight girls

	Plyometric jump	Hyperextension, twist, and throw	Standing depth jump	Horizontal jump rope	20 sidesteps with a baton	Running and rolling	Hand tapping	Foot tapping against a wall	5×10 meter run
Body height	-0.15	0.42	0.11	-0.37	-0.14	-0.29	0.03	0.02	-0.14
Leg length	-0.07	0.48	-0.01	-0.34	-0.09	-0.21	-0.04	0.09	-0.12
Arm length	0.06	0.15	0.09	-0.12	0.06	-0.23	0.07	-0.27	-0.3
Shoulder width	-0.02	0.07	-0.06	0.17	0.20	-0.10	-0.19	0.02	-0.09
Pelvic width	-0.14	0.21	-0.36	0.10	0.11	0.20	-0.07	0.10	-0.08
Hip width	0.14	0.42	0.01	0.11	-0.05	-0.12	-0.17	0.09	-0.1
Body weight	-0.41	0.35	-0.05	-0.32	-0.12	-0.15	0.01	0	-0.04
Thorax volume	-0.15	0.25	-0.08	0.09	-0.35	-0.24	-0.14	0.06	0.23
Upper arm volume	0.07	-0.01	0.16	0.08	-0.55	0.02	-0.06	0	0.34
Thigh volume	0.01	0.18	0.10	0.18	-0.54	-0.37	-0.31	0.15	0.25
Calf volume	0	0.39	0.06	-0.28	-0.12	-0.19	0.26	-0.03	-0.14
Triceps SF	-0.16	0.07	0	-0.34	-0.37	0.17	0.04	-0.13	0.31
Sub-scapular SF	-0.3	0.04	-0.08	0.02	-0.31	0	-0.04	-0.31	0.43
Abdominal SF	-0.35	-0.23	-0.13	-0.19	-0.21	0.19	0.06	-0.27	0.4
Thigh SF	-0.12	0.11	-0.11	0.06	-0.45	0.05	0.04	0.13	0.41
Medial calf SF	-0.47	0.08	-0.05	-0.46	-0.21	-0.01	0.17	0.07	0.16

The results shown in Table 3 indicate that the areas of anthropometric characteristics and motor abilities are interrelated with three pairs of statistically significant canonical factors ($p = 0.00$).

In order to explain the structure of canonical dimensions, the isolated canonical factors were defined in the observed areas (Table 4).

Table 3 The canonical correlation between anthropometric characteristics and motor abilities in overweight girls

	Canonical-R	Canonical-R^2	Chi-sqr.-H^2	df	p
0	1	1	717.99	144	0.000
1	1	0.99	230.92	120	0.000
2	0.99	0.98	157.66	98	0.000

Table 4 The canonical factor of the anthropometric characteristics (left) and motor abilities (right) in overweight girls

	Root 1	Root 2	Root 3		Root 1	Root 2	Root 3
Body height	-0.52	0.19	0.43	Plyometric jump	0.09	-0.89	0.17
Leg length	-0.43	0.10	0.48	Hyperextension, twist, and throw	-0.25	-0.15	0.28
Arm length	-0.21	-0.03	0.51	Standing depth jump	-0.38	-0.26	-0.09
Shoulder width	0.16	0.11	0.29	Horizontal jump rope	0.41	-0.28	-0.17
Pelvic width	0.08	0.02	0.12	20 sidesteps with a baton	0.70	0.33	0.36
Hip width	-0.18	-0.18	0.40	Running and rolling	0.31	0.06	-0.28
Body weight	-0.49	0.38	0.28	Hand tapping	0.05	0.04	-0.10
Thorax volume	-0.37	0.02	0.19	Foot tapping against a wall	0.06	-0.08	-0.22
Upper arm volume	-0.43	-0.27	-0.36	5×10 meter run	-0.21	-0.04	-0.16
Thigh volume	-0.45	-0.10	0.06				
Calf volume	-0.34	-0.05	0.32				
Triceps SF	-0.58	-0.02	-0.16				
Sub-scapular SF	-0.48	0.08	0.11				
Abdominal SF	-0.33	0.18	-0.22				
Thigh SF	-0.29	-0.12	-0.31				
Medial calf SF	-0.41	0.43	-0.18				

On the first isolated canonical factor in the area of anthropometric characteristics (Table 4, left), the highest values with a negative correlation are present in the triceps skin fold (-.58), body height (-.52) and body weight (-.49). Statistically significant negative correlations are determined for all the variables except the parameters of transversal dimensionality. In the area of motor abilities (Table 4, right) the highest projections on the first isolated canonical factor are determined for the 20 sidesteps with a baton (.70), horizontal jump rope (.41) and standing depth jump (-.38).

On the second isolated canonical factor in the area of the anthropometric characteristics, the highest projections are present with medial calf skin folds (.43) and body weight (.38), and in the area of motor abilities with the plyometric jump (-.89) and 20 sidesteps with a baton (.33).

The third canonical factor in the area of anthropometric characteristics is defined by the variables for the evaluation of longitudinal and transversal dimensionalities and body mass, and the negative correlation was recorded in abdominal skin folds, thigh skin folds and upper arm volume. The highest projection on this factor in the area of motor abilities

is present with 20 sidesteps with a baton (.36), hyperextension, twist, and throw (.28) and running and rolling (-.28).

DISCUSSION

The growth and development of children as well as their anthropometric characteristics influence the realization of various motor tasks (Pate, 1989; Taylor & Baranowski, 1991; Malina et al., 1995). However, this phenomenon does not always hold true. The results of the cross-correlation matrix between anthropometric characteristics and motor abilities in a group of girls with normal weight indicate an extremely low number of statistically significant connections. A statistically significant connection was observed between the motor test of hand tapping and body height (.32), leg length (.30) and arm length (.40). Also, a connection between the motor test of the 5x10 meter run and subscapular skin folds (.31) and thigh skin folds (.33) was observed, while between other variables of anthropometric characteristics and tested motor abilities, statistically significant connections were not found. From the following, it can be concluded that the subcutaneous adipose tissue is negatively correlated with the running speed in girls with normal weight aged seven, as confirmed by the results of other studies (Raudsepp & Jürimäe, 1997; Suchomel, 2005; Malina et al., 1995; Milanese, Bortolami, Bertucco, Verlato & Zancanaro, 2010; Yavuz, 2013). The research (Milanese et al., 2010) conducted on a sample of children aged 6 to 12, which was aimed at determining the relationship between motor abilities (the standing long jump, 30 meter sprint) and anthropometric characteristics (BMI, waist circumference, waist-to-hip ratio, sum of five skin folds) indicates that the subcutaneous adipose tissue is a better indicator of the level of motor abilities than BMI. The obtained results indicate that there were no statistically significant connections between BMI and motor abilities, while the subcutaneous adipose tissue is negatively correlated with speed and explosive leg strength. Also, it should be noted that the results of some studies (Silva, Birkbeck, Russel, & Wilson, 1984; Ball, Massey, Misner, McKeown & Lohman, 1992) established that the association between biological factors and motor abilities/skills is relatively low in the population of pre-pubescent children. Based on the results, we can conclude that in our study there were no statistically significant correlations between the area of anthropometric characteristics and motor abilities in the group of participants with normal body weight, which corresponds with the results obtained in the research conducted by Fiørtoft (2000). The results of his study, conducted on a sample of children aged five to seven, revealed the lack of a relationship between the anthropometric features (body height, body weight, BMI) and motor abilities (EUROFIT test). These results corroborate the fact that the level of motor abilities in the specified group is largely independent of anthropometric characteristics.

On the other hand, the results of numerous studies (Ara et al., 2007; Rodić, 2012; Ostojić, Stojanović, Stojanović, Marić & Njaradi, 2011; Brunet, Champut & Tremblay, 2007; Podstawski & Boryslawski, 2012; Milanese et al., 2010; Yusuf, Siman, Zawi, Hasan & Radzi, 2013) confirm that there is a statistically significant correlation between anthropometric characteristics and motor abilities in children, which is consistent with the results obtained in our research on the sub-sample of overweight girls. The research carried out by Ivanović (2008) was carried out in order to determine the connection between morphological and motor dimensions on a sample of patricipants aged 7,5. The data was processed by means of a canonical correlation analysis. A statistically significant canonical

correlation coefficient was obtained ($p < 0.1$) with 55% of the information explained in relation to the overall variance. The canonical function was defined as the general morphological factor and general motor factor. It was concluded that the participants who showed greater values in morphological dimensions achieved better results in motor abilities and vice versa.

The results of the cross-correlation matrix (Table 2) indicate that body mass and voluminosity as well as subcutaneous fatty tissue are the factors that interfere with the realization of motor tasks that require lifting or transferring body weight (the plyometric jump, horizontal jump rope, 5×10 meter run). These results are directly or indirectly related to many other studies (Ara et al., 2007; Brunet et al., 2007; Podstawski & Boryslawski, 2012; Milanese et al., 2010, Yusuf et al., 2013). Explosive arm strength, which is required in the realization of these motor tasks, is positively correlated with body height, leg length, hip width, body mass and calf volume. This concludes that the higher values of longitudinal and transversal dimensionalities and increased body mass facilitate their performance.

The standing depth jump, hand tapping and foot tapping against a wall do not have statistically significant correlations with the parameters of anthropometric characteristics. The 20 sidesteps with a baton test has a positive correlation with the measures of circular dimensionality and subcutaneous fatty tissue; Running and rolling is positively correlated with the measures of longitudinal and circular dimensionality. These data can most likely be explained by the small sample of patricipants as well as their previous motor experiences.

In general, obesity and increased body mass adversely affect the performance of motor abilities (Cureton, Baumgartner & McManis, 1991; Malina et al., 1995), while body mass and voluminosity are variably correlated with the motor abilities in children (Milanese et al., 2010).

By reviewing the relations between the first pair of canonical factors, it can be concluded that the participants who have higher longitudinal and circular measures, higher body mass and subcutaneous fatty tissue, achieve better results in tasks that require explosive strength (hyperextensions, the twist and throw and standing depth jump) and coordination (20 sidesteps with a baton and running and rolling), and lower in tasks that require speed of execution (the5x10 meter run) and vice versa. The obtained relations can probably be interpreted on the basis of other factors that are beyond the control of this study (e.g. previous motor experience, neurological, functional and mental development of girls and others).

Relations between the second pair of canonical factors suggest that participants with higher values of body height, body mass and medial calf skin folds achieve weaker results for explosive leg strength and coordination. The negative correlation of anthropometric characteristics (body height, body mass, BMI, subcutaneous fatty tissue) and explosive leg strength is confirmed in numerous studies (Milanese et al., 2010; Podstawski, & Boryslawski, 2012; Runhaar et al., 2012; Ara et al., 2007; Brunet et al., 2007).

The third pair of canonical factors indicates that the participants with higher values of longitudinal and transversal dimensionality, body weight, thorax volume, and lower values of subcutaneous fatty tissue, perform better on tasks that require explosive arm strength and the tasks of running and rolling, and worse on foot tapping against a wall and 20 sidesteps with a baton. It can be assumed that, in accordance with anthropometric parameters, the athletic type of body constitution is more suitable for the realization of explosive arm strength.

CONCLUSION

Based on the results obtained in the correlation between the anthropometric characteristics and motor abilities of seven-year-old girls, it can be concluded that the relations are statistically significant only in the group of overweight girls (p = 0.00). Overall, body voluminosity and subcutaneous fatty tissue are the ballast mass that hinders the realization of motor tasks that require lifting or transferring body weight. Higher values of the parameters of longitudinal dimensions contribute to achieving better performance in the explosive strength of the arms and legs, and impair coordination.

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POVEZANOST ANTROPOMETRIJSKIH KARAKTERISTIKA SA MOTORIKOM SEDMOGODIŠNJIH DEVOJČICA

Cilj istraživanja bio je da se da se utvrdi da li postoji povezanost antropometrijskih karakteristika i motorike kod normalno i prekomerno uhranjenih devojčica uzrasta sedam godina. Ukupan uzorak činilo je 75 devojčica prvog razreda osnovnih škola grada Niša, koje su na osnovu vrednosti BMI bile klasifikovane u grupu normalno uhranjenih (N=47) i prekomeno uhranjenih (N=28) ispitanica. Antropometrijske karakteristike utvrđene su meremjem 16 parametara longitudinalnih, transverzalnih, cirkularnih dimenzija i mase tela, a potkožno masno tkivo merenjem debljine kožnih nabora. Za procenu motorike (eksplozivne snage, koordinacije i brzine) primenjena je baterija od devet testova. Povezanost antropometrijskih karakteristika i motorike utvrđena je primenom kanoničke korelacione analize. Dobijeni rezultati ukazuju da su relacije statistički značajne samo u grupi prekomrno uhranjenih ispitanica (p=0.00) i definisane sa tri para kanoničkih faktora. Rezultati faktorske strukture antropometrijskih karakteristika i motorike kod prekomerno uhranjenih ispitanica ukazuju da voluminoznost tela i potkožno masno tkivo otežavaju realizaciju motoričkih zadataka u kojima se zahteva podizanje i prenošenje telesne mase u prostoru, dok veće vrednosti parametara longitudinalnih dimenzija doprinose boljim performansama eksplozivne snage ruku i nogu, ali narušavaju koordinaciju pokreta.

Ključne reči: *antropometrijske karakteristike, motoričke sposobnosti, uhranjenost, povezanost.*