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Original empirical article

THE RELATION BETWEEN THE MOTION COORDINATION, VOLUME AND BODY MASS OF 11-12 YEAR-OLD FEMALE BASKETBALL PLAYERS

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Abstract. *The aim of this research has been to identify the relation between the motor coordination factor, latent volume dimension and body mass. The sample of participants consisted of 180 preadolescent female basketball players. The motor coordination ability has been estimated with the help of 3 motor tests (threading and leaping, agility in the air and the backward polygon), while the morphological characteristics were measured with the help of a battery of 6 anthropometric measures (body mass, forearm volume, outstretched arm volume, thigh volume, shin volume and abdomen volume). The obtained results were processed using the canonical correlation analysis. The results indicated the existence of only one statistically significant canonical pair factor, which explains 68% of variance, or a moderate correlation of two canonical components between the motor and morphological variables sets (Rc = .59), at the (p < .01) level of significance. The extracted canonical dimension in anthropometric space has been defined as the volume and body mass factor, and the canonical structure of coordination abilities has been interpreted as the canonical factor of body movement coordination. When analyzed partially, body mass (r= .95), forearm volume (r= .89) and threading and leaping (r= .48) variables have mostly contributed to the structure of this canonical dimension. The achieved variance percentage (Rc² = .68) assumes relevant prediction possibility relation between two linear variable combination systems of female basketball players, younger pioneers and mini-basketball players. The obtained information about the one-componential canonical model of the motor and morphological structure of female players has its practical application in selection improvement, as well as in training female basketball players' operators modeling.*

Key words: *female mini-basketball players, motor tests, anthropometric measures, canonical relations.*

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INTRODUCTION

Contemporary basketball is a very popular team sport for men and women. Basketball is played by two teams of 5 players, who are situated on different positions (playmaker, point guard, small forward, power forward and center), on a 29 x 15 m field. The basic ways of playing basketball (taking the ball, passing, dribbling and shooting) are preformed immediately and on the move (walking, running and jumping). During four periods (quarters) of 10 minutes or two half-times of 20 minutes, the basketball players, without body contact, try to perform ball-handling by tapping the ball with one hand, and then to propel the ball through the opponent's basketball hoop, or to defend their hoop from attack.

Women's basketball is a sport activity which belongs to the category of semi structural complex movements (Matvejev, 1981). It was developed at the end of XIX century and played by 9 female basketball players on a basketball court, which is half the size than the current professional NBA basketball court. The first women's basketball world champion ship was held in 1953, in Chile. Women's basketball was included in the Olympic program in 1976, in Montreal, Canada.

Mini-basketball is a basketball variant in which rules, equipment and props are adjusted to the age characteristics of 6-12 year-old children. It is one of the most popular sport games in the world, which is manifested in minimal body contact between the female players (Dežman, 1993). Mini-basketball was invented by Jay Archer, a physical education teacher from New York. Since it is simple and popular, this sport quickly spread from America to Canada, Puerto Rico, Mexico and Japan. It started being played in 1964 in Europe, first in Spain and then in Italy. In 1968, FIBA founded the International committee for mini-basketball (CIM), which numbers more than 190 countries as members at the moment.

Movement coordination represents one of the most important motor abilities, which enables the precise, quick and economical management of complex movements. It is connected with the central nervous system, which harmonizes muscle work. Multiple motion exercising causes an improvement in precision, better space orientation, more successful motion on bumpy surfaces without any injures and with the ability to maintain balance and so on. Movement coordination development positively influences brain work, the circulation system and energy transportation system, sportsmen's work ability improvement, i.e. smaller exhaustion after body and intellectual work.

Accelerated growth and development, as well as the occurrence of pre-adolescent girls' first menstruation present a very sensitive period for motor development. It is very important not to miss that biological period, for the selection for training processes in clubs and future professional basketball playing is usually done during this period.

The preadolescent period of female basketball players is characterized by increased activity of the pituitary, endocrine gland, or the creation of its hormones, which directly influences the stimulation of bone growth (Erčulj, 1996). The results (Babic and Viskić-Štalec, 2002) indicate to pre-pubescent girls' continuous growth and more intense development of morphological characteristics and motor abilities. Apart from that, this period also marks the maturation of central nervous system, which is very important for fine motor skills, which condition successful shooting with one hand from a great distance (Horvat, 1987).

Playing mini-basketball: catching and holding a ball, passing, dribbling, shooting, positively influences the communication between and socialization of teammates, motor abilities development, mainly movement coordination, speed and explosive strength, the respiratory and cardiovascular system and quicker mental development of preadolescent females.

Subject matter of this work is motor factor-coordination movement and latent morphological dimensions – the volume and body mass of 11-12 year-old female basketball players. The aforementioned motor and morphological sportsmen status has been studied by a relatively small number of authors.

It is a fact that in any sport activity, as well as in basketball, no technical element can be performed well without adequate motor ability and body composition, which indicates the unity and mutual effect of the motor and body constitution. For all of that, this empirical research is directed at the identification of some anthropometric basketball players' subsystems, which are a precondition for successful selection and training procedures.

In the last few decades, the canonical structure and relations of some morphological characteristics and coordination body movements of the preadolescent population have been researched by: Ciliga et al. (2006), Gredelj et al. (1975), Jukić et al. (2005), Ivanović (2001, 2005, 2008a, 2008b), Malacko (2007), Metikoš et al. (1979) and Stojanović et al. (1975). The achieved results of the aforementioned studies have shown the existence of mass and body volume and the motor coordination factor of different genders and ages.

According to the empirical studies of Kostić et al. (2009), Lozovina et al. (2003), Mraković (1994), Findak (1999), Foretić et al. (2010) and Viskić-Štalec et al. (1975), the definition of the relation between the relevant coordination body movement factor and the morphological latent body volume dimension represents atheoretical and practical problem, which is significant, since there is a possibility of the creation of a reasonable procedure for perfect direction, and the selection of the youngest sportsmen, planning, control and training processes programming, as well as successful monitoring of the development of dominant anthropometric characteristics.

Unfortunately, the data from past studies has been collected on a relatively small sample of participants, so there are a very few kinesiology data bases, which allow reasonable canonical models appliance in this field.

Taking the previous studies into consideration, it can be determined that there is an objective need for empirical research of the relation between the mentioned motor and morphological latent preadolescent dimensions in the female basketball player population. Apart from that, it is assumed that the actual information achieved in this research will enable the acquisition new theoretical knowledge, which might contribute to the creation of more practical diagnosis procedures and monitoring of researched latent variables development in the case of the youngest female basketball players.

The aim of this transversal research is to test the statistically significant correlation between the morphological latent dimension variables set of volume dimension and body mass, and motor movement coordination of 11-12 year-old female basketball players.

The research hypothesis has been the initial step in the analysis, and it represents the empirical expectation regarding gaining statistically significant connection between body volume and body mass and coordination body movements in the later childhood period. The acceptance or rejection of the hypothesis, as well as the statistical significance of the obtained Pearson's and canonical coefficients, will be determined at the $p<.01$ level of significance.

THE METHOD

Sample of participants and the procedure

The sample in this quantitative research consisted of (N = 112) female basketball mini-jam players, ($\overline{X}$ = 11.34 years; σ = 1.21). The population from which the participants were extracted was represented by female competitors from 3 basketball clubs, including: "Metalac"– Super League (Valjevo), "Zicer – Summer League (Valjevo), "Loznica" – Summer League (Loznica). The participants were all involved in the regular one-year training process (5–6 times a week).

The research data were collected in December 2010. During anthropometric measuring and motor testing, all the female basketball players were clinically healthy and trained regularly.

The anthropometric measures and motor testing of the female participants were carried out in the sports halls during the morning hours and lasted for one school class.

Measuring techniques and measuring instruments

A standard battery sample of anthropometric measures for *volume and body mass* evaluation was the following: body mass – MASTEL (o, 1 kg), forearm volume – OBIPOD (mm), stretched arm volume - OBINAD (mm), thighs volume - OBINAT (mm), shin volume - OBIPOT (mm) and abdomen volume - OBITRB (mm).

The anthropometric measuring was conducted in accordance with the standard International Biological Program - IBP.

The female participants, when measured, had sport equipment, wore no footwear and were in standard positions.

Body mass was measured with a medical digital scale, and the result was read with an accuracy of 0, 1 kg. For body volume, the *Holtain* flexible measuring tape (Holtain Ltd, Croswell, UK) was used and had a measuring accuracy of 0, 1 cm. Extremity volumes were measured on the right body side in the standing position, on standard anatomic locations.

For structuring movement mechanism evaluation or the 2. level factor body movement coordination, according to Kurelić et al. (1975), the system consisting of 3 following composite motor test was applied: threading and leaping - KPRPRE (o,1 s), agility in the air - KOKTVZ (0,1 s) and the backward polygon - POLNAT (0,1 s). Motor testing was conducted according to the rule of working items, which did not include more than 10 examinees at the same time.

I *Threading and leaping (KPRPRE)*

Four frames of a vaulting box are placed parallel and at a distance of 1, 5 m. Lines, which are parallel to the frames, have been drawn in front of the first and behind the second frame. On the signal: 'Now!', a participant, as fast as he can, goes to the start line, runs, leaps over the first frame of vaulting box, threads through the second frame, leaps over the third and threads through the fourth, passes the turnstile line, turns to a half-turn, goes back running, leaps over the fourth frame, threads through the third, leaps over the second frame and threads through the first frame of vaulting box, lifts up and runs over the start line. The test is repeated three times.

II Agility in the air

From the initial sitting position, in which he is turned with his back to both tail leather medicine balls, the participant sits on the balls and straightens his legs across two front leather medicine balls, with each leg situated on one ball. On the examiner's signal: 'Now!' the participant rolls backwards. Then he quickly straightens up and rolls forward across the leather medicine balls. Then he straightens, makes a 180 degree turn and with his palms touches all four leather medicine balls at random. When the participant touches the last leather medicine ball, the examiner turns off the stopwatch. The test is repeated three times.

III Backwards polygon

The participant is in a tiger paw position and on the examiner's signal: Now, crawling (backwards) on all fours and at maximal speed, the participant moves his body between the marked lines, which are 10 meters apart. The first obstacle should be overcome by climbing across the first of the vaulting box's sections, while other is can be overcome by threading through the frame of the vaulting box. During the task performance, the participant is not allowed to turn his head around, and the test is finished when participant crosses the line with both hands. The test is repeated three times.

Motor testing is conducted according to the items on the agenda, involving a maximum of 10 participants at the same time.

The anthropometric measuring and motor testing of the female examinees have been conducted in a sports hall during the morning hours and lasted for 45 minutes.

Statistical analyses

After data gathering, all of the variables were coded and entered into a database in the personal computer.

The obtained results were processed using a correlation analysis (Hotelling, 1936), while using the program package STATISTIKA 5.0. In order to check the linear relation, motor and morphological latent dimensions (coordination body movement and body volume), cross-correlations have been calculated, while the cross-correlation function has given the characteristic stems of those equations (λ), the canonical correlation coefficients (Rc) and determination coefficient or canonical correlation square (Rc^2). The acceptance or rejection of the hypothesis, as well as the statistical relativity of the achieved Pearson's and canonical coefficients, was carried out at the $p<.01$ level of significance.

RESULTS

The central tendency measures (arithmetic mean and standard deviation) and basic descriptive statistic results of all the applied variables are shown in table 1.

According to the asymmetry distribution, skewness and kurtosis, it was determined that all of the analyzed variables do not statistically deviate in the distribution of the results from Gaus' curve, since their values do not extend 1.00.

Table 1 Descriptive statistics results

	AS	MIN	MAX	SD	SK	KU
MASTEL	34.12	25	55	3.17	0.74	0.21
OBIPOD	196.24	155	273	12.15	0.49	0.17
OBINAD	205.32	156	273	20.39	0.63	0.05
OBINAT	446.96	360	565	42.14	0.41	-0.26
OBIPOT	290.21	241	382	26.31	0.69	0.28
OBITRB	612.17	478	878	65.27	0.95	1.12
KPRPRE	1838.73	1120	2959	410.34	0.82	0.23
KOKTVZ	703.96	5	1916	236.24	0.19	1.06
POLNAT	2185.83	1164	3970	522.16	0.57	0.38

After the normalization, a correlation analysis was carried out (Table 2). Using the visual inspection of Pearson's correlation coefficient correlation matrix, a statistically significant partial degrees relation, with a positive direction, was noticed between the motor and morphological variables pairs at the ($p < .01$) level. The calculated height correlation coefficients, range between zero to medium mathematical correlations (in range of -.02 to .75).

The negative direction of the partial motor variable *agility in the air* correlation represents an exception. Their correlations are not statistically significant, or in other words, they do not depend on the analyzed variables of the latent dimension body volume and body mass.

Table 2 Pearson's inter-correlations and anthropometric variables

	MASTEL	OBIPOD	OBINAD	OBINAT	OBIPOT	OBITRB
KPRPRE	0.27*	0.62**	0.39**	0.75**	0.39**	0.24*
KOKTZR	-0. 05	-0.11	0.05	-0.07	-0.02	0.08
POLNAT	0.24*	0.68**	0.71**	0.49**	0.56**	0.23*

*p <0 .05 **p < 0.01

In order to gain insight into the structure of the relationship between the latent dimension body volume and body mass variable and motor coordination body movement variable set, the canonical correlation analysis was used.

Solving the characteristic equation of the cross-correlation in table 3, according to Caiser-Gutman's criterion ($\lambda \geq 1$), one statistically significant pair of canonical factors with a medium correlation ($Rc = .59$) was extracted, at the ($p < .01$) level. Using the canonical equation of the correlation analysis model, one statistically significant determination coefficient or canonical correlation square has been isolated. It represents the square average of one set of multiple correlation coefficients and some variables from the other set and separates significant mutual variance amount ($Rc^2 = .68$), at the ($p < .01$) level of significance. From the total variability of the 9 applied variables in two sets, the first determination coefficient explains 68% of the mutual variable variance from the total analyzed variable variability and was taken for the interpretation. The remaining 32% of variability probably explains some other characteristics and abilities, which were not included in the applied predictor system.

The canonical procedure of data processing identified two more independent linear composite pairs (canonical factors), which do not represent significant canonical functions. They are mentioned only for informational reasons and will not be interpreted for

two reasons: a) they do not have significant mutual variance amounts of the 2. and 3. variable sets, so mutual variability does not have any impact to the linear combinations of those two variables sets and b) the statistical conclusion error is greater than 5%.

Table 3 Canonical correlation coefficients, determinant coefficients and their significance

	λ	Rc	Rc^2	df	p
1	0.49	0.59	0.35	32	0.01
2	0.77	0.37	0.14	21	0.09
3	0.98	0.29	0.08	12	0.13

By analyzing table 4, it is perceived that the first factorial extracted canonical dimension structure is defined by significant positive projections of all the analyzed morphological variables (in a range of .74 to .95), in which the *body mass* variable (r = .95) has a dominant role. Partially analyzing the following variables: body mass (r = .95), forearm volume (r = .89) and upper arm volume (r= .85), we can determine that they have mostly contributed to the set of this canonical dimension.

These achieved canonical pressures reflect the variance part, which the original variable with the new canonical variable share, and can be interpreted as factorial pressures in sense of relative participation of each variable in each canonical function. According to the variables, which define it, and taking the correlation height with the first factor into consideration, the achieved canonical dimensions in latent space can, hypothetically, be interpreted as BODY VOLUME AND BODY MASS.

Table 4 Canonical factor for body volume structure

Variable	Fc - 1	Fc - 2
MASTEL	0.95	-0.06
OBIPOD	0.89	-0.09
OBINAD	0.85	0.27
OBINAT	0.77	0.21
OBIPOT	0.74	0.26
OBITRB	0.81	0.29

Analyzing the canonical function pressure of the variable mechanism for motion structuring in Table 5, it is obvious that all coordination body motion variables saturate the first significant canonical variable stem (in a range of -.37 to .48), along with a dominating positive canonical motor test *threading and leaping* coefficient (r = .48). Considering the achieved linear applied variables combinations in latent space, the structure of the first isolated canonical stem can, theoretically, interpreted as canonical latent factor dimension BODY MOTION COORDINATION.

Table 5 Canonical coordination body motion factor structure

Variable	Fc – 1	Fc – 2
KPRPRE	0.48	0.25
KOKTZR	-0.37	0.14
POLNAT	0.39	0.29

DISCUSION AND CONCLUSION

The great number of significant and detached correlations between the system of anthropometric and motor variables, as well as the correlation and determination coefficient enabled us to have a clearer picture in latent space about moderate mutual connections of the applied variables intensity on a sample of female basketball mini-jam players, at a significance level of ($p< .01$). Based on the research, the assumption about latent dimension body volume and the motor coordination body motion factor system intensity has been confirmed.

The obtained canonical relations imply that between the two studied variable sets there is a statistically significant correlation, or in other words the legal relation of certain phenomenon: linear growth of the resulting vector canonical factor variable values from one anthropological field is in proportion to the linear growth of the resulting variable canonical factor vector values from other anthropological field, and vice versa.

The extracted canonical pattern regarding medium linear combination variables relation, along with the significance criterion of 99%, indicates that according to the first statistically significant pair of canonical factors, female basketball players achieve worse results in the motional body movement coordination system, if they have maximal latent dimension body volume and body mass variable values, and vice versa: female basketball players accomplish better motor coordination factor results if they have minimal body mass and body volume variable values.

Regardless the fact that the second extracted canonical function pair is not so significant for the two variables factor set relation analysis - it is characterized by the explained variance misbalance, or with its minimal informative variable value - this canonical pattern about linear variables relation describes the tendency of some increased body volume and body mass variable values towards adversary reflection of motor variable agility in the air, or 2. level motor factor-coordination body motion, and vice versa.

Observing the canonical body volume and body mass factor structure and coordination body motion motor factor, it can be supposed that the linear combinations of this canonical variable are more genetically conditioned and they do not represent the influence of everyday training processes, i.e. preadolescent females are not optimally conditioned in the anthropometric and motor segments of anthropologic field.

According to the achieved results, it can be concluded that the realization of mini basketball girls' volume dimension canonical factor mostly depends on partial predictors' contribution of the following anthropometric characteristics: body mass, forearm and upper arm volume, while the structure of the canonical coordination movement factor is maximally conditioned by the standard motor threading and leaping test.

The obtained findings regarding the canonical correlation structure and intensity are in accordance with Malacko's (2007) earlier research results.

These results are interpreted in the form of a proposed advancement of a plan and program of the youngest female basketball players training context (training content, selection and training process management).

The listed results indicate the necessity for new training processes contents for female basketball players, which are directed to the accomplishment of maximal value reduction in the latent dimension *body volume and body mass* variables and optimal relation for integral and balanced 2. level coordination body movement motor factor generation growth.

The obtained findings about the relations between latent mass dimension and body volume and coordination body motion motor factor systems are significant for future research. They can be included into the database as the next longitudinal research base, including the size and relation direction prediction of these two relevant anthropologic basketball areas related to preadolescent females.

The contribution of this study is reflected in the acquisition of new and relevant information, compared to the earlier studies in this anthropologic field, which enable more complete problem insight, and therefore more fruitful implications for practice.

However, relatively small number of participants, at the age of 11-12 years, limits the generalization results possibilities, so it would be more convenient to use a greater number and more representative female basketball players' coordination body movement tests sample, as well as a greater number of morphological variables, mainly skin folds, which would provide a better picture of these, very important, latent dimensions.

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POVEZANOST KOORDINACIJE POKRETA I VOLUMINOZNOSTI I MASE TELA KOŠARKAŠICA UZRASTA 11–12 GODINA

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Cilj istraživanja bio je ispitivanje relacija koordinacije pokreta i latentne dimenzije voluminoznosti i mase tela. Uzorak ispitanika činilo je 112 košarkašica u predadolescentnom uzrastu. Sposobnost koordinacije pokreta procenjena je pomoću 3 motorička testa (provlačenje i preskakivanje, okretnost u vazduhu i poligon natraške), dok su morfološke karakteristike merene pomoću baterije od 6 antropometrijskih mera (masa tela, obim podlaktice, obim opružene nadlaktice, obim natkolenice, obim potkolenice i obim trbuha). Dobijeni podaci obrađeni su kanoničkom korelacionom analizom. Rezultati su ukazali na egzistenciju samo jednog statistički značajnog para kanoničkih faktora, koji objašnjava 68% varijanse, odnosno umerenu korelaciju između skupova motoričkih i morfoloških varijabli (Rc = ,59), na nivou značajnosti (p < .01). Ekstrahovana kanonička dimenzija u antropometrijskom prostoru definisana je kao faktor volumena i mase tela, a struktura u motoričkom prostoru interpretirana je kao kanonički faktor koordinacije pokreta. Parcijalno analizirajući, strukturi ove kanoničke dimenzije najviše su doprinele varijable: masa tela (r = ,95), obim podlaktice (r = ,89) i provlačenje i preskakanje (r = ,48). Izračunati procenat varijanse (Rc² = ,68), pretpostavlja mogućnost relevantne predikcije povezanosti dva sistema linearnih kombinacija varijabli kod košarkašica mini-basketašica. Dobijene informacije o jednokomponentnom kanoničkom modelu motoričke i morfološke strukture svoju aplikaciju u praksi mogu da imaju u unapređenju selekcije i modeliranju trenažnih operatora košarkašica.

Ključne reči: *mini-basketašice, motorički testovi, antropometrijske mere, kanoničke relacije.*