THE RELATIONSHIP BETWEEN MORPHOLOGICAL CHARACTERISTICS AND THE MANIFESTATION OF EXPLOSIVE POWER OF LOWER LIMBS IN BASKETBALL PLAYERS

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Abstract

Vertical jump is seen as the main motor skill in basketball, on which the final result largely depends. The research was conducted with the aim of identifying the connection between morphological characteristics and the manifestation of tests for assessing the explosive power of lower limbs of adolescent basketball players (14.99±0.82 years of age). The assessment of the explosive power of lower limbs was done using the tensiometer Quattro Jump - Kistler Portable performance analysis system 2019, Type 9290DD Switzerland, and standardized tests countermovement jump and squat jump were applied. The system of predictor variables included the factor of longitudinal skeletal dimensions, transverse skeletal dimensions, body volume and weight factor, and subcutaneous adipose tissue factor. All anthropometric measures were strictly taken in accordance with IBP standards. The results of the regression analysis indicated that the system of predictor variables had a statistically significant effect on the manifestation of explosive power of lower limbs in the variable countermovement jump (P=0.05) and squat jump (P=0.01). High values of the coefficients of determination in both cases explain from 92% to 97% of the total variation. The predictor variable Wrist diameter (Beta = -0.78) had the highest significant negative correlation in the countermovement jump test, while the following predictor variables also had the highest significant negative correlation with the squat jump criterion: Chest circumference (Beta=-1.07), Body weight (Beta=-060) and Thigh circumference (Beta=-0.39). Furthermore, negative correlations of variables for the assessment of transverse skeletal dimensions in young basketball players and negative linear correlation of variables for the assessment of subcutaneous adipose tissue in both criteria were observed. The authors recommend dividing athletes by positions they play in, in order to obtain more accurate information about the negative correlation between morphological characteristics and vertical jump tests.

Keywords: *basketball, morphology, connection, vertical jump*

Introduction

Basketball is a cyclical predominantly anaerobic team sport in which athletes compete at different levels (Tessitore et al., 2006; Scanlan, Dascombe, Reaburn, & Dalbo, 2012), where vertical jump is seen as one of the main skills (Rodríguez-Rosell, Mora-Custodio, Franco-Márquez, Yáñez-García, & González-Badillo, 2017).

The characteristics of collective ball sports, basketball being one of them, is a large number of jumps during the game where the explosive power of the lower limbs is the predominant activity (Ademović, Kocić, Berić, & Daskaloski, 2015). These jumps are mostly vertical but also horizontal. One of the main components in basketball is the change in the direction of players' movement with fast moves in the field, and the players are expected to react quickly. It is a team sport and as an activity it is extremely dynamic, and it is characterized by an explosive character in almost all directions (Abraham, 2015). It is structurally complex and composed of a large number of movements. It requires the player to possess a number of anthropological traits and skills, some of which are: longitudinal skeletal dimensions, explosive power, agility, coordination, speed, precision, intelligence and others. Basketball activity is characterized by movements of different intensity and duration, sudden changes of course and direction, both horizontal and vertical. During the game, players move in different ways: walk in different directions and with different body orientation in relation to the movement direction, walk with pivot turns, run in a straight line, run in different directions and with different body orientation in relation to the direction of movement, vertical jump off one foot, vertical jump off both feet (Nazaraki, Berg, Stergiou, & Chen, 2008), which brings the different energy supply of the organism, aerobic-anaerobic.

During the training process, every expert in the field of kinesiology needs precise, operational data that can be used during the training process. By knowing the factors that affect success in basketball, their better selection is possible. What is extremely important in working with younger people is the fact that they are at the beginning of their development and that all factors that affect success in sports must be developed. This should as the final result have unequivocal progress (Bowerman, Freeman, & Vern Gambetta, 1999).

Explosive power can be characterized as the ability to generate maximum muscular force in the shortest possible time (Santos, & Janeira, 2008) and as such is crucial for basketball (Lehnert, Hůlka, Malý, Fohler, & Zahálka, 2013); Zhang, 2013). Exercises for the development of explosive power, plyometrics, are very common in the training of basketball players (Ziv, & Lidor, 2010). A group of authors led by Khlifa et al., (2010) state that plyometric training is inevitable in the training process of basketball players if better vertical jumps are desired, but that it still depends on other (morphological) factors. It is clear that players in different basketball positions differ in body composition, primarily in height but also body weight. Jelicic, Sekulic, & Marinovic (2002a) claim that players differ in morphological characteristics, but without statistical significance, however, it is evident that the centers are the most dominant in height, with larger skin folds due to higher body weight compared to other groups of basketball players. Fattorini (2005) indicates differences in body composition and maximum jump height of young basketball players depending on their position in the team.

Given the fact that jumping skill may depend on body composition, the research started from the assumption that morphological characteristics explain in some way the manifestation of explosive power of the lower limbs, and the aim of the research was to link certain morphological characteristics to the manifestation of explosive power of lower limbs in adolescent basketball players.

Material and methods

The sample included 26 basketball players from OKK "Šabac" from Šabac, with an average age of 14.99±0.82 years of age. At the time of measurement (April, 2019), all participants had doctor's reports that they could engage in regular sports acitivities, thus it can be said that these were healthy individuals at the time of assessing morphological characteristics and motor skills. At the time of measurement, the participants had been playing basketball for at least 3 years with a training volume of 5 hours per week - 3 training sessions per week for at least 90 minutes.

For the purposes of this research, the explosive power of the lower limbs was tested, using the tensiometer "Kistler Quatro Jump" - type 9290 DD. It was used to obtain data on the values of explosive power of the lower limbs, which were the criterion variables in the study, and the following standardized tests were applied according to Sudarov, & Fratrić, (2010), as follows: 1) Counter Movement Jump - CMJ - rebound height (cm) and 2) Squat Jump - SJ - rebound height (cm).

Predictor variables in the study included the morphological dimensions defined by IBP standards (Lohman, Roche, & Martorell, 1988), and the following anthropometric measurements were measured: I) to assess the longitudinality of the skeleton: 3) Body height (cm), 4) Arm length (cm), 5) Leg length (cm) and 6) Thigh length (cm); II) to assess body volume and weight: 7) Body weight (kg) 8) Calf circumference (cm), 9) Upper arm circumference (cm), 10) Chest circumference (cm) and 11) Thigh circumference (cm); III) to assess the transverse skeletal dimensions: 12) Ankle diameter (cm), 13) Knee diameter (cm), 14) Wrist diameter and 15) Shoulder width (cm); IV) to assess subcutaneous adipose tissue: 16) Calf skinfold (mm), 17) Back skinfold (mm), 18) Triceps skinfold (mm), 19) Chest skinfold (mm), 20) Thigh skinfold (mm), and 21) Abdomen skinfold (mm).

The following measuring instruments were used to take anthropometric measurements: medical decimal scale, a metal tape measure, the Martin anthropometer and a John Bull skinfold caliper.

During the motor test to assess the explosive power of the legs, Counter Movement Jump - CMJ, all phases of the jump were connected. There was no pause at the moment of the change in direction. The participants' hands were on their hips (for the maximum isolation of arms when performing the jump). The examinee stood in an upright position for a few seconds, and after that he lowered himself into a squat position (knees flexed to 90 degrees angle), no pause at the moment of the change in direction, the examinee performed a maximum vertical jump. This was followed by a soft landing with a slight flexion of the knees, and re-taking the starting position. The test evaluated the eccentric-concentric component of the explosiveness of the jump. The height of the jump was measured in centimeters.

The motor test used to assess the explosive power of legs, the Squat Jump – SJ, was also performed from a static position. The participants' arms were on the hips (due to their maximum isolation during the jump), and the subject stood in an upright position for a few seconds from which he descended to a squat position (knees flexed to 90 degrees angle as well) where the body should rest 2 seconds before performing the jump. After the resting phase, the maximum vertical jump was performed, and after that, the landing phase followed with a slight flexion in the knee joint. The test ended with re-taking the starting position. The test assessed the concentric component of the jump explosiveness, and the jump height was also measured in centimeters.

When measuring morphological characteristics, certain standards were followed during anthropometric measurements. The participants' position was standard standing position (the participants were barefoot wearing underwear, head in the Frankfurt horizontal position). According to the defined research objectives, technical conditions for precise and accurate results were provided, which is part of the organization of measurements of the mentioned morphological characteristics, as follows: measurement of anthropometric measures was performed in the morning (from 7 am to 1 pm); instruments were of standard construction and calibrated every day before the measurement started and during the measurement, after each 10 measured participants; the participants were measured in the gym where they have basketball training. The gym was spacious and bright enough, and the air temperature was such that the participants felt comfortable (from 17 ºC to 22 ºC); it was necessary to prepare two measurement spots before the start of the measurement. The distance between these spots had to be at least 5 meters; all measurements were performed by four people, with each of them always taking the same measurements. One of them measured body height and body weight, the other measured limb circumference and chest circumference, the third measured skin folds, and the fourth recorded the measurement results; the participants were barefoot and wore only sports shorts; the measurement results were read while the instrument was on the measured parameter of the examinee, and the person who recorded the data spoke the results aloud before entering them in the examinee's card.

The research was conducted on a sample of athletes from the municipality of Sabac. The assessment of morphological characteristics and motor skills was done after obtaining the consent of parents and coaches in the sports club, since the participants were minors. In the distributed questionnaires, parents/guardians gave their consent for their child's participation in the research study. All participants were measured and tested according to the same procedures, as well as under the same conditions, adhering to ethical principles. The conditions in which the measurements and tests were conducted were the same for all participants, and that meant enough space for each test, appropriate temperature, humidity, the examinees were in sports equipment necessary for testing, and everything was conducted in accordance with World Medical Association Declaration of Helsinki, (2013).

Basic descriptive statistics was determined for all variables: measures of central tendency - arithmetic mean (AM), variability measures - standard deviation (S), minimum (MIN) and maximum measurement results (MAX), coefficient of variation (CV). The normality of the distribution was checked by Shapiro-Wilk test for normality (ShW) at the significance level of $p \leq 0.05$. Linear regression analysis determined the connection between anthropometric variables (predictor variables) and variables for estimating the explosive power of the lower limbs, which were the criterion variables in the paper.

Results

Based on the research study results presented in Table 1 in the form of descriptive statistics, the homogeneity of the results in terms of skeletal longitudinality, body volume and weight as well as transverse skeletal dimensions can be observed. The heterogeneity of the results was found in the variables assessing subcutaneous adipose tissue, while relative homogeneity was observed in the motor variables assessing the explosive power of the lower limbs, with greater individual differences in the variable Counter Movement Jump - CMJ. Based on the Shapiro-Wilk coefficient and its statistical significance, it can be stated that nine morphological variables and two motor variables were normally distributed, while a statistically significant deviation from the normal distribution is observed in ten morphological variables (ShW <0.05): two variables for estimating longitudinal skeletal dimensions (Leg length and Thigh length), three variables for assessing the transverse skeletal dimensions (Diameter of the ankle, wrist and knee), as well as five variables for assessing subcutaneous adipose tissue (Calf skinfold, Back skinfold, Chest skinfold, Thigh skinfold and Abdomen skinfold), which could have been expected given the positions of the basketball players and their morphological status.

Table 1. Descriptive statistics

Variable	Basketball players N=26					
	AM	S	MIN	MAX	CV	ShW
Body height (cm)	176.54	5.61	164.00	185.10	3.18	0.11
Arm length (cm)	79.30	3.80	71.00	86.00	4.79	0.93
Leg length (cm)	98.75	9.37	66.31	111.39	9.49	**0.00**
Thigh length (cm)	79.58	6.94	67.00	103.00	8.72	**0.01**
Body weight (kg)	60.44	7.93	48.90	79.84	13.12	0.23
Calf circumference (cm)	36.00	2.00	31.00	41.00	5.56	0.08
Upper arm circumference (cm)	24.92	2.13	20.00	28.00	8.55	0.26
Chest circumference (cm)	82.69	5.84	72.00	94.00	7.06	0.76
Thigh circumference (cm)	53.42	4.76	40.00	61.00	8.91	0.10
Ankle diameter (cm)	7.50	0.65	6.00	8.00	8.67	**0.00**
Knee diameter (cm)	9.54	0.65	8.00	10.00	6.81	**0.00**
Wrist diameter (cm)	5.65	0.63	5.00	7.00	11.15	**0.00**
Shoulder width (cm)	37.77	2.61	32.00	45.00	6.91	0.15
Calf skinfold (mm)	8.54	3.26	4.00	15.00	38.17	**0.01**
Back skinfold (mm)	6.62	1.68	4.00	10.00	25.378	**0.03**
Triceps skinfold (mm)	7.81	2.50	4.00	13.00	32.01	0.12
Chest skinfold (mm)	7.27	1.91	5.00	12.00	26.27	**0.02**
Thigh skinfold (mm)	10.88	3.91	6.00	18.00	35.94	**0.00**
Abdomen skinfold (mm)	8.73	3.12	4.00	15.00	35.74	**0.00**
Counter Movement Jump CMJ (cm)	28.50	4.53	21.32	37.36	15.89	0.31
Squat Jump (SJ) (cm)	26.61	3.89	20.11	35.76	14.62	0.53

Legend: AM – arithmetic mean; S - standard deviation; MIN - minimum recorded measurement result; MAX - maximum recorded measurement result, CV - coefficient of variation, ShW - level of statistical significance of Shapiro Wilk coefficient.

Tables 2 and 3 show the results of regression analyzes for each criterion variable within the system of predictor variables. In accordance with the research goal, regression analysis was supposed to show the connection between morphological characteristics and motor skills - explosive power of the lower limbs of young basketball players.

A review of the regression analysis results shown in Table 2, shows that there is a statistically significant influence of predictor variables on the criterion variable Counter Movement Jump – CMJ in basketball players (P=0.05). The high value of the multiple correlation coefficient R = 0.96 explain 92% of the total variability. These results indicate that the predictor system of variables plays a very significant role in the manifestation of this motor test for the assessment of vertical jump. Only the predictor variable Wrist diameter indicated a statistically significant negative effect on the criterion (pbeta=0.04). Subjects with a larger wrist diameter had poorer results, which can be associated with a higher body mass, which in any case acts as a negative factor to the force of gravity.

Linear correlation result (which was significant) for individual predictor variables obtained by Pearson's correlation coefficient indicates that subjects with higher body weight and more pronounced calf, upper arm and chest circumference had poorer results in the variable for estimating explosive leg power. Also, subjects with higher and more pronounced values of knee and wrist diameter, and also with higher values of skin folds achieved statistically significant lower results in the variable for estimating the explosive power of legs.

The values of the partial correlation coefficient for the variable Wrist diameter (rpart=-0.73) indicate that correlation in this predictor variable is negative and statistically significant (ppart=0.04), so it can be stated that this variable is the main disturbing factor for the manifestation of this motor test.

Table 2. Regression analysis *Counter Movement Jump - CMJ*

Variable	r	p	r_{part}	p_{part}	Beta	pbeta
Body height	-0.05	0.40	-0.02	0.96	-0.02	0.96
Arm length	-0.08	0.35	0.27	0.52	0.16	0.52
Leg length	-0.30	0.07	0.25	0.56	0.32	0.56
Thigh length	-0.11	0.30	0.48	0.23	0.60	0.23
Body weight	-0.39	**0.03**	0.14	0.74	0.16	0.74
Calf circumference	-0.41	**0.02**	-0.17	0.69	-0.15	0.69
Upper arm circumference	-0.36	**0.04**	0.13	0.76	0.17	0.76
Chest circumference	-0.51	**0.00**	-0.12	0.78	-0.22	0.78
Thigh circumference	-0.03	0.45	035	0.40	0.25	0.40
Ankle diameter	-0.14	0.24	-0.44	0.27	-0.46	0.27
Knee diameter	-0.34	**0.05**	-0.51	0.20	-0.38	0.20
Wrist diameter	-0.40	**0.02**	-0.73	**0.04**	-0.78	**0.04**
Shoulder width	-0.16	0.21	-0.08	0.86	-0.06	0.86
Calf skinfold	-0.44	**0.01**	0.25	0.55	0.48	0.55
Back skinfold	-0.54	**0.00**	0.20	0.63	0.22	0.63
Triceps skinfold	-0.55	**0.00**	-0.39	0.34	-0.45	0.34
Chest skinfold	-0.47	**0.01**	0.36	0.38	0.25	0.38
Thigh skinfold	-0.60	**0.00**	-0.44	0.28	-0.67	0.28
Abdomen skinfold	-0.68	**0.00**	-0.36	0.39	-0.49	0.39
R=0.96 R²=0.92 **P=0.05**						

Legend: r - Pearson's correlation coefficient; p - level of statistical significance for r; r_{part} - value of partial correlation coefficient; p_{prat} - level of statistical significance for r_{part}; Beta - regression coefficient; pbeta - level of significance of the regression coefficient; R - multiple correlation coefficient; R^2- coefficient of determination; P - significance of multiple correlation coefficient.

Regression analysis of the criterion variable Squat Jump - SJ shown in Table 3 showed that there was a statistically significant influence of the system of predictor variables on the examined criterion, because the significance of the multiple correlation coefficient is P = 0.01. The value of the multiple correlation coefficient is R = 0.97, which explains the very large common variability between the predictor system and criterion.

After reviewing each variable separately, the following variables had a statistically significant influence on the criterion (pbeta> 0.05): *Body weight, Chest circumference* and *Thigh circumference*. Participants with higher average values of these variables had worse results, which can be related to higher body mass, which in this case also acts as a negative factor to the force of gravity.

Pearson's correlation coefficient indicates a negative and statistically significant correlation of the predictor variables *Leg length, body weight, calf circumference, upper arm circumference, chest, knee and wrist diameter*, and all variables assessing skin folds: *Calf skinfold*, *Back skinfold*, *Chest skinfold*, *Triceps skinfold, Thigh skinfold* and *Abdomen skinfold*. Basketball players with higher values of these parameters had lower values for the *Squat Jump – SJ* motor skill.

Table 3. Regression analysis *Squat Jump - SJ*

Variable	r	p	r_{part}	p_{part}	Beta	pbeta
Body height	-0.10	0.32	0.37	0.37	0.16	0.37
Arm length	-0.17	0.20	0.23	0.58	0.09	0.58
Leg length	-0.42	**0.02**	-0.49	0.22	-0.45	0.22
Thigh length	-0.15	0.24	-.029	0.48	-0.21	0.48
Body weight	-0.39	**0.02**	0.65	0.08	-0.60	**0.05**
Calf circumference	-0.49	**0.01**	-0.59	0.13	-0.40	0.13
Upper arm circumference	-0.44	**0.01**	0.55	0.16	0.56	0.16
Chest circumference	-0.57	**0.00**	-0.67	0.07	-1.07	**0.04**
Thigh circumference	-0.13	0.27	0.67	0.07	-0.39	**0.04**
Ankle diameter	-0.13	0.26	-0.06	0.90	-0.03	0.90
Knee diameter	-0.33	**0.05**	-0.28	0.50	-0.12	0.50
Wrist diameter	-0.43	**0.01**	-0.58	0.13	-0.34	0.13
Shoulder width	-0.22	0.15	0.25	0.56	0.12	0.56
Calf skinfold	-0.42	**0.02**	-.014	0.74	-0.17	0.74
Back skinfold	-0.53	**0.00**	0.02	0.95	0.02	0.95
Triceps skinfold	-0.53	**0.00**	-0.48	0.22	-0.37	0.22
Chest skinfold	-0.45	**0.01**	.042	0.30	0.19	0.30
Thigh skinfold	-0.65	**0.00**	-0.41	0.31	-0.40	0.31
Abdomen skinfold	-0.69	**0.00**	.016	0.70	0.14	0.70
R=0.98	R^2=0.97	**P=0.01**				

Legenda: r - Pearson's correlation coefficient; p - level of statistical significance for r; r_{part} - value of partial correlation coefficient; p_{prat} - level of statistical significance for r_{part}; Beta - regression coefficient; pbeta - level of significance of the regression coefficient; R - multiple correlation coefficient; R^2- coefficient of determination; P - significance of multiple correlation coefficient.

Discussion

The objective of this study was to identify morphological parameters that determine the explosive power of the lower limbs in adolescent basketball players. In part, information was obtained regarding the vertical jump skill in this population of athletes. When looking at the measurement results, it can be stated that they point to the exceptional homogeneity of the participants from the aspect of dimensions that assess the longitudinal skeletal dimensions, which perhaps completes the first phase of selection of children for this sport. The longitudinal skeleton dimension is extremely important for basketball (Karaleić and Jakovljević, 2001), so boys who want to play this sport must have a higher body height at their age, and must be more advanced in terms of this hypothetical morphological factor. The average height of the basketball players surveyed was 176.54 ± 5.61 cm, and compared to the slightly younger basketball players (12.3 years) from Braille (159.5 cm) they were drastically taller (Silva, Petroski, & Araujo, 2013) but also quite similar to the average values of basketball player heights measured at the Australian Institute for Sport (180.4cm), (Drinkwater, Hopkins, McKenna, Hunt, & Pyne, 2007). Furthermore, it can be stated that the surveyed sample had average lower body weight in comparison to the same population from Australia (60.44 ± 7.93 kg versus 77.3 + 11.0 kg). They are also on average taller than other basketball players of similar age (186 ± 9.75 cm) (Karalejić, Pajić, Gardašević, Mandić, & Jakovljević, 2011). Body height is the first criterion in the selection of young people for basketball, because it is a sports activity that requires players to be taller. The morphological characteristics of basketball players are in correlation with playing positions (Jeličić, Sekulić, & Marinović, 2002b; Karalejic, Jakovljevic, & Macura, 2011), team success (Carter, Ackland, Kerr, & Stapff, 2005) and performance skills (Kinnunen, Colon, Espinoza, Overby, & Lewis, 2001). Anthropometric measures of basketball players are a very important factor for the correct selection of basketball players, but other factors must be taken into account as well.

For a more efficient training process in the multi-year training cycle of young basketball players, it is necessary to continuously track the morphological parameters. Some parts of the body have different dynamics of growth and they reaching the growth maximum at different time points, such as the upper limbs due to the cephalocaudal principle, because it is the hands and feet, as well as the arms that grow first, followed by other parts of the body. For these reasons, the morphological structure of the basketball player's body, which is based on the interaction among all anthropological measurements, is not linear at all stages of development. Therefore, certain morphological characteristics may participate at different time points with different coefficients of participation in the morphological structure of basketball players (Paiva, Neto, & César, 2005). Morphological characteristics have a two-way deterministic dimension. This indicates that in some cases they can be viewed as a cause, and in others as a consequence of body movement (Pelemiš, Prskalo, Badrić, & Madić, 2019). Therefore, the question arises as to what extent they determine certain motor structures and skills and to what extent they participate in their performance. The results of the research indicated that it is valid and justified to select children for basketball depending on morphological characteristics, primarily depending on body volume and body weight and especially subcutaneous adipose tissue, because the predictor system of anthropometric variables had a significant negative correlation (from 92% to 97%) to the manifestation of both motor tests of vertical jumps. The research study findings also indicate, based on Pearson's correlation coefficient, that the skin folds were negatively correlated with the vertical jump skill of the study participants, which supported the results of research conducted by other authors. As it could have been assumed, the percentage of adipose tissue, is negatively correlated with the vertical jump skill of the study participants, which is also confirmed by the research conducted by Apostolidis, Nassis, Bolatoglou, & Geladas (2004). The constant growth of overall adipose tissue is influenced by genetic factors, diet, endocrine factors and physical activity (Prskalo, & Sporiš, 2016), so changes can be expected in further work with this group of basketball players. Adipose tissue, from the perspective of players' position in the team, can be harmful in basketball, especially in playmakers and wing players (Martinchik et al., 2003). Therefore, it is necessary to constantly monitor this parameter and prevent it from deviating from the normative range through interventions in nutrition and supplementation.

The negative effects of the transverse skeleton dimensions and subcutaneous adipose tissue on the manifestation of vertical jumps can be explained by the total body weight. Only the greater body mass, which was accompanied by a greater accumulation of subcutaneous fat, led to the wrist diameter to be considered as perhaps a potential predictor that negatively affects the explosive power of the lower limbs in adolescent basketball players. As a consequence of the increase in body weight, the volume (circumference) of the upper arm, chest, and calf that also increased, which had a negative effect on the manifestation of an important component of motor skills in basketball players. The fact that subcutaneous adipose tissue negatively affects the manifestation of strength and explosiveness in basketball players was proven in the study by Garcia-Gil et al., (2018), who pointed out significant negative correlations of variables assessing subcutaneous fat in young basketball players.

However, it should be explained that adipose tissue is not always useless. Namely, adipose tissue in younger age categories indicates a faster start of puberty, and this is explained by the fact that cells are filled with fat, which in this case serves as fuel to make bone growth in length fast and efficient (Pelemiš, Mandić, Momčilović, Momčilović, & Srdić, 2021). It should be noted that the structure of fat cells in younger age is built of multinucleated smaller cells until growth and development stops, so it is natural that their decomposition is easier and faster, while with the cessation of growth and development, this structure changes into mononuclear fat cells which are larger, and much harder to break down, and grow much faster (Stamatović, Šekeljić, Martinović, & Pelemiš, 2019). This is the reason why adipose tissue is the only tissue in the human body that continues to grow even after growth and development is finished.

Conclusion

Several critical implications can be drawn from this study in order to optimize the assessment of the explosive power of the lower limbs in adolescent basketball players, as the most important ability for basketball.

The tensiometer tests can be used to assess vertical jump skill since both tests assess the same physical component, and can also be used in field and laboratory conditions. Secondly, the coefficient of correlation with anthropometric variables was negative, and it can be assumed that the portion of the subsample that had more pronounced average values of body weight, chest circumference, larger wrist and knee diameters, and higher values of subcutaneous adipose tissue during adolescence have drastically poorer vertical jump results. Based on these results, the authors advise caution during the training process, especially plyometric training, with individuals of this age who may have more pronounced body weight, and it is recommended that in cooperation with a nutritionist and sports doctor a dietary correction alongside with additional strength training should be introduced in order to transform part of the fat into muscle tissue. The authors add that the research study participants are mostly experiencing morphological changes, therefore body weight and adipose tissue are prone to change.

References

Abraham, B. (2015). Comparative effects of selected motor components of school level basketball players on plyometric, circuit training and circuit breaker programmes. *International Online Multidisciplinary Journal Review Of Research*, *3*(7), 1-4.

Ademović, I., Kocić, M., Berić, D. i Daskaloski, B. (2015). Eksplozivna snaga nogu vrhunskih košarkaša [Explosive leg power of high-level basketball players]. *Facta universitatis - series: Physical Education and Sport*, *13*(2), 253-261.

Apostolidis, N., Nassis, G.P., Bolatoglou, T., & Geladas, N.D. (2004). Phyisiological and technical characteristics of elite young basketball players. *Journal of Sports Medicine and Physical Fitness, 44*(2),157-63.

Bowerman, W. J., Freeman, W. H. & Vern Gambetta, T. A. C. (1999). *Atletika.* Zagreb: Gopal.

Carter, J. E., Ackland, T. R., Kerr, D. A. & Stapff, A.B. (2005). Somatotype and size of elite female basketball players. *Journal of Sports Science, 23*, 1057–1063.

Drinkwater, E. J., Hopkins, W. G., McKenna, M. J., Hunt, P. H., & Pyne, D. B. (2007). Modelling age and secular differences in fitness between basketball players. *Journal of Sports Sciences, 25*(8), 869–878.

Fattorini, I. (2005). Body composition and vertical jump performance in junior players. *FIBA Assist Magazine,* 15, 57-58.

Garcia-Gil, M., Torres-Unda, J., Esain, I., Duñabeitia, I., Gil, S. M., Gil, J., & Irazusta, J. (2018). Anthropometric Parameters, Age, and Agility as Performance Predictors in Elite Female Basketball Players. *Journal of Strength and Conditioning Research, 32*(6), 1723–1730.

Jeličić, M., Sekulić, D. & Marinović, M. (2002). Anthropometric characteristics of high level European junior basketball players. *Collegium Antropologicum,* 26, 69–76.

Karalejic, M., Jakovljevic, S. & Macura, M. (2011). Anthropometric characteristics and technical skills of 12- and 14-year-old basketball players. *Journal of Sports Medicine and Physicah Fitness, 51*(1), 103-110.

Karalejić, M., Pajić, Z., Gardašević, B., Mandić, R. & Jakovljević, S. (2011). The Influence Of Anthropometric Characteristics On The Agility Abilities Of 14 Year-Old Elite Male Basketball Players. *FACTA UNIVERSITATIS Series: Physical Education and Sport 9*(2), 141-149.

Khlifa, R., Aouadi, R., Hermassi, S., Chelly, M.S., Jlid, M.C., Hbacha, H. & Castagna, C. (2010). Effects of a plyometric training program with and without added load on jumping ability in basketball players*. Journal of Strength and Conditioning Research,24*(11), 2955–2961.

Kinnunen, D.A., Colon, G., Espinoza, D., Overby, L.Y. & Lewis, D.K. (2001). Anthropometric correlates of basketball free-throw shootings by young girls. *Perceptual and Motor Skills, 93*, 105–108.

Lehnert, M., Hůlka, K., Malý, T., Fohler, J., & Zahálka, F. (2013). The effects of a 6 week plyometric training programme on explosive strength and agility in professional basketball players. *Acta Gymnica, 43*(4), 7-15.

Lohman, T. G. Roche, A.F., & Martorell, R. (1988). *Antropometric standardization reference manual.* Chicago: Human Kinetics Books.

Martinchik, A.N., Baturin, A.K., Petukhov, A.B, Baeva, V.S., Zemlianskaia, T.A., Sokolov, A.I., Peskova, E.V. & Tysiachnaia, E.M. (2003). Energy requirements in adolescents playing basketball in russian olympic reserve team. *Voprosy Pitaniia, 72*(2), 35-40.

Narazaki, K., Berg, K., Stergiou, N. & Chen, B. (2008). Physiological demands of competitive basketball. *Scandinavian Journal of Medicine & Science in Sports, Early View* 1–8.

Paiva Neto, A. & César, M.C. (2005). Body composition assessment in male basketball players in Brazilian National Basketball League 2003. *Revista Brasileira de Cineantropometria e Desempenho Humano, 7*, 35–44.

Pelemiš, V., Prskalo, I., Badrić, M., & Madić, D. (2019). Latent dimensions of morphological characteristics of preschool children. *Acta Kinesiologica, 13*(2), 28-36.

Pelemiš, V., Mandić, D., Momčilović, Z., Momčilović, V., Srdić, V. (2021). Body composition and nutritional status of preschool children, *Facta Universitatis Series: Physical Education and Sport, ONLINE FIRST,* 1-10.

Prskalo, I., & Sporiš, G. (2016). *Kineziologija [Kinesiology].* Zagreb: Školska knjiga. Učiteljski fakultet Sveučilišta u Zagrebu, Kineziološki fakultet Sveučilišta u Zagrebu.

Rodríguez-Rosell, D., Mora-Custodio, R., Franco-Márquez, F., Yáñez-García, J. M., & González-Badillo, J. J. (2017). Traditional vs. Sport-Specific Vertical Jump Tests. *Journal of Strength and Conditioning Research, 31*(1), 196–206.

Santos, E. J., & Janeira, M. A. (2008). Effects of complex training on explosive strength in adolescent male basketball players. *The Journal of Strength & Conditioning Research, 22*(3), 903-909.

Scanlan, A. T., Dascombe, B. J., Reaburn, P. & Dalbo, V. J. (2012). The physiological and activity demands experienced by Australian female basketball players during competition. *Journal of Science and Medicine in Sport, 15*(4), 341-347.

Silva, D. A. S., Petroski, E. L., & Araujo Gaya, A. C. (2013). Anthropometric and Physical Fitness Differences Among Brazilian Adolescents who Practise Different Team Court Sports. *Journal of Human Kinetics, 36*(1), 77–86.

Stamatović, M., Šekeljić, G., Martinović, D., Pelemiš, V. (2019). Comparative study of motor performances of the boys with different body mass indices. *Croatian Journal of Education, 21*(2), 511-537.

Sudarov, N., & Fratrić, F. (2010). *Dijagnostika treniranosti sportista [Diagnosis of athlete training].* Novi Sad: Pokrajinski sekretarijat za sport.

Tessitore, A., Tiberi, M., Cortis, C., Rapisarda, E., Meeusen, R. & Capranica, L. (2006). Aerobic-anaerobic profiles, heart rate and match analysis in old basketball players. *Gerontology 52*(4)*,* 214-222.

Zhang, X. (2013). Research of Jumping Ability and Explosive Power Based on Plyometric Training. *Lecture Notes in Electrical Engineering*, 206, 427-433.

Ziv, G., Lidor, R. (2010). Vertical jump in female and male basketball players-a review of observational and experimental studies. *Journal of Science and Medicine in Sport,13*(3), 332-339.

World Medical Association Declaration Of Helsinki. (2013). Ethical Principles for Medical Research Involving Human Subjects, 64th WMA General Assembly, Fortaleza, Brazil, October 2013. Available at: http://www.wma.net/en/30publications/10policies/b3/index.html

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