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Original empirical article

THE INFLUENCE OF ANTHROPOMETRIC CHARACTERISTICS ON THE AGILITY ABILITIES OF 14 YEAR-OLD ELITE MALE BASKETBALL PLAYERS

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Abstract. *The aims of this study were: a) to identify the anthropometric characteristics and agility abilities of 14 year-old elite male basketball players, and b) to investigate the influence of anthropometric characteristics on agility test results. The following 11 anthropometric variables were measured on a sample of 50 young basketball players, age 14,: four longitudinal measures, two transversal measures, body mass, four circumferences, six skinfolds and, also, 2 derived variables: the body mass index – BMI, and sum of skinfolds – SUM SKF (predictor variables). In addition, the participants carried out 3 agility tests: the agility T-test, zigzag agility drill and 4x15 m agility run (dependent variables). For the assessment of the influence of predictor variables on the dependent variables, a regressive analysis, the Stepwise method, was applied. The results of three regression analyses indicate a moderate, but significant influence of anthropometric variables on agility test results. Longitudinal and transversal measures, body mass, and circumferences had no influence on agility tests results. Only SUM SKF had a significant influence. This variable was extracted during the first step in all three regression analyses, and the circumference of the mid-upper-arm was extracted during the second step in the case of the dependent variable zigzag agility drill.*

Key words: *rapid moving / young / longitudinal measures / transversal measures / sum of skinfolds / regression analysis.*

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INTRODUCTION

The worldwide popularity of basketball is unquestionable, especially among the young. Basketball is a dynamic team sport which involves a pattern of intermittent, dynamic and skilled movement activities. There are complex demands that require a combination of individual skills, team plays, tactics, and motivational aspects (Trninić, & Dizdar, 2000). During a basketball game we can see variety of movements such as running, dribbling, shuffling, and jumping. These movements are directional, multidirectional, intense and short-lasting (Crisafuli et al, 2002). Ben Abdelkrim et al. (2007) have found 1050 ± 51 different actions per basketball game. Because of a great number of atypical game situations, which demand multiple rapid changes of direction in the relatively small space of the court, agility has a special importance in basketball. Basketball practice must contain agility exercises with an emphasis on technique, sprint and strength training, and the development of perception and decision making (Young, & Farrow, 2006). Coaches are advised to focus on short and intense activity (speed and agility) and tests such as the vertical jump, the agility T-test, sprints over very short distances (5 or 10 m), etc. (Cronin, McNair, & Marshall, 2003). In senior basketball we can see very fast, agile, powerful and versatile players.

Agility is also important in youth basketball. The age of fourteen represents the second phase in youth sports training: athlete development, talent identification, development of basic technical skills, development of basic tactical skills, and competition (Bompa, 2000). There are three good periods for developing speed and agility (Holm, 1987): the accelerated run from the ages of 12 to 14, agility run at 13 and interval training of speed at 15 years of age.

Besides the importance of speed abilities, in team sports (basketball) the importance of tall stature is commonly accepted. Body height has a positive influence on all the body segment lengths and, in turn, athletic performance. Successful competition in sports has been associated with specific anthropometric characteristics, body composition and somatotype (Classens et al., 1991; Carter & Heath, 1990). For example, often tall stature is the first criteria for the selection of youth in basketball, because basketball is an activity of more than average tall people. Anthropometric dimensions of basketball players have been linked with playing positions and individual player success (Bale, 1991; Angyan et al., 2003; Coelho et al., 2008; Greene et al., 1998; Hoare, 2000; Jeličić, Sekuliuć & Marinović 2003), team success (Carter et al, 2005) and skill performances (Kinnunen et al., 2001; Angyan et al., 2003). But, a little information is available on elite basketball players younger than juniors (Coelho et al., 2008; Sickles & Lombardo, 1993).

Anthropometric characteristics and speed abilities are very important factors of selection in basketball. Usually, there are boys with deferent body height and other anthropometrics characteristics, and also with different agility abilities. It is very desirably to have very tall and very agile players. Because of that, the aim of this study was primarily to investigate anthropometric variables and agility abilities in children aged 14 participating in competitive basketball. The second aim was to examine the relationship between the anthropometric characteristics and agility abilities.

METHOD

Participants

The experts from the Serbian Basketball Federation have selected the best 14 (±0.5) year old boys from each region of Serbia who were participating in regional and/or national competitions. All of the participants (N=50) were at the end of their regular season and agreed to participate in the study. The testing was done under the supervision of the Ethical Board of Faculty of Sport and Physical Education, University of Belgrade.

Variables

There were 11 independent variables obtained directly from the anthropometric measurements and 2 variables derived from some of these variables. The anthropometric measurements included 17 anthropometric dimensions. *Body height* was measured by means of a stadiometer (Seca 220, UK), to the nearest 0.1 cm. Also, *Sitting height, lower limb length* and *upper limb length* were measured. *Biacromial breadth* and *bitrochanteric breadth* were measured by means of a pelvimeter (Martin Scientific Pelvimeter, SUI) and reported in centimeters. *Body mass* was recorded using a portable scale (Tanita BF683W, GER) to the nearest 0.1 kg. The *circumference of the mid-upper-arm, forearm, thigh* and *calf* were also measured. Six skinfolds were measured using a skinfold caliper (J. Bull, USA) to the nearest 0.1 mm: biceps, forearm, thigh, medial calf, abdominal, chest. Two variables were derived: the body mass index (BMI), weight divided by height squared and sum of skinfolds (SUM SKF) from the previously measured skinfolds.

A total of 3 agility tests were applied (dependent variables): *agility T-test*, *zigzag agility drill* and *4x15 m agility run.* Time in seconds and hundreds of seconds was determined using an electronic timing system (Micro Gate, IT).

Agility T-Test. The T-test is widely used by sport researchers and coaches as well (Figure 1) and has been established as a valid and reliable method for measuring linear to lateral agility_(Pauole, et al., 2000). The participants begin from the standing point at cone A, and they are asked to sprint in a straight line to cone B. Then, they slide to the left (cone C). After touching cone C, they slide to the right and touch cone D. After that they slide again to the left, touch cone B, and run backward to the start position (cone A). The performance time was the fastest attempt of three (Seminick, 1990).

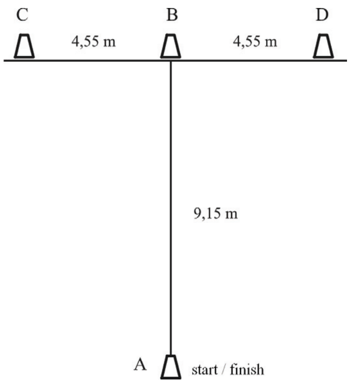

Fig. 1 T-test

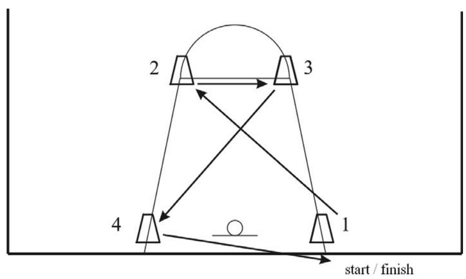

Fig. 2 Zigzag agility drill

Zigzag Agility Drill. This is a specific agility test performed at basketball lane (Figure 2). The participants begin at cone 1 with their hand in contact with the cone and feet behind the baseline. Then, they sprint to cones 2, 3 and 4, and then back to cone 1 (each cone must be touched). The best time of two trials was recorded (Bloomfield, Ackland, & Elliot, 1994).

The 4x15 m Agility Run. There is a 15-meter track bordering with two lines on the basketball court. The participants have to complete 4 lengths of 15 m. They are asked to sprint straight to the 15 m line, pass the line with both feet, then sprint back to the start line, pass the start line and repeat this run one more time (Kurelic, et al, 1975).

Statistical analysis

The elementary descriptive parameters: means (M), standard deviations (SD), maximum (Max) and minimum (Min) were calculated. For the assessment of the influence of predictor variables on the dependent variables a regressive analysis, Stepwise method was applied. The statistical analysis was performed using the SPSS 16 statistical program.

RESULTS

Table 1 displays the basic descriptive parameters of all the variables: means (M), standard deviations (SD), and minimum (Min) and maximum (Max) values.

Table 1 Means (M), Standard Deviation (SD), minimum values (Min) and maximum values (Max) of all the variables

Variable	M	SD	Min	Max
Agility T-test (sec)	10.95	0.83	9.49	13.37
Zigzag agility drill (sec)	7.18	0.58	5.93	8.37
Agility run 4x15 m (sec)	14.59	0.96	12.77	17.42
Body height (cm)	1.86	9.754	163.00	205.00
Sitting height (cm)	91.98	4.847	80.50	102.00
Lower limb length (cm)	99.33	5.907	87.00	112.00
Upper limb length (cm)	81.94	4.361	72.00	90.00
Biacromial breadth (cm)	42.24	4.117	36.00	65.00
Bitrochanteric breadth (cm)	31.24	2.336	26.00	38.00
Arm circumferences (cm)	24.34	1.972	21.00	28.50
Forearm circumferences (cm)	24.58	1.928	21.50	33.00
Thigh circumferences (cm)	51.17	4.045	44.00	61.00
Calf circumferences (cm)	35.21	2.674	30.50	43.00
Body mass (kg)	68.72	11.091	47.00	93.00
BMI (kg/m^2)	19.75	2.069	15.53	26.59
SUM SKF (mm)	37.22	9.310	23.30	68.20

The results of the regression analysis – the Stepwise method, dependent variable - *Agility T-test* and predictors – anthropometric variables are shown in table 2. The values of the regression coefficient (R=0.53) and determinant coefficient (R^2=0.28) indicate the influence of anthropometric variables on the agility T-test results. In the first and only step, the variable *sum of skinfolds* (*SUM SKF*) was extracted.

Table 2 The results of the regression analysis, Stepwise method: dependent variable - Agility T-test, predictors – anthropometric variables (Predictor variable: first and only step - *SUM SKF*)

Model Summary					
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	
1	0.53	0.28	0.26	0.71	
Coefficients					
Model	B	Std. Error	Beta	t	Sig.
(Constant)	9.157	0.42		21.838	0
SUM SKF	0.05	0.01	0.53	4.350	.000

The influence of anthropometric variables on the *Zigzag agility drill* results is shown in table 3. There were two steps: in the first step the *sum of skinfolds* variable (SUM SKF) was extracted (R=0.55; R^2=0.30), and the forearm circumference variable was extracted in the second step (R=0.60; R^2=0.36). Table 4 displays the results of the regression analysis – the Stepwise method, dependent variable – *4x15 m agility run* and the predictors – anthropometric variables. There was only one step and the variable *sum of skinfolds* (SUM SKF) was extracted (R=0.49; R^2=0.24).

Table 3 The results of the regression analysis, Stepwise method: the dependent variable – *Zigzag agility drill*, predictors – anthropometric variables (Predictor variable: first step - *SUM SKF*; second step - *forearm circumference*)

Model Summary					
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	
1	0.55	0.3	0.29	0.49	
2	0.6	0.36	0.34	0.47	
Coefficients					
Model	B	Std. Error	Beta	t	Sig.
(Constant) First step	5.901	0.29		20.479	.000
SUM SKF	0.03	0.01	0.55	4.572	.000
(Constant) Sec. step	7.573	0.84		8.981	.000
SUM SKF	0.04	0.01	0.67	5.175	.000
Forearm circumference	-0.08	0.04	-0.27	-2.101	.041

Table 4 The results of the regression analysis, Stepwise method: dependent variable – *4×15 m agility run*, predictors – anthropometric variables (Predictor variable: first and only step - *SUM SKF*)

Model Summary					
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	
1	0.49	0.24	0.23	0.85	
Coefficients					
Model	B	Std. Error	Beta	t	Sig.
(Constant)	12.674	.501		25.288	.000
SUM SKF	0.05	0.01	0.49	3.941	.000

DISCUSSION

According to the anthropometric measurements, the participants of this study belong to the elite population of young basketball players. Fourteen year-old players were of similar body height compared to Australian players of the same age (Pattison, 1989). According to the means of body height the 14 year-old players were in the 95th percentile, when compared to the American population (Malina, Bouchard, & Bar-Or, 2004). The body mass of the 14 year-olds were in the 90th percentile compared to the American population (Malina, Bouchard, & Bar-Or, 2004). These results could be incorporated into a database against which talented 14 year-old basketball players could be compared.

The results of three regression analyses indicate a moderate but significant influence of anthropometric variables on the results of three applied agility tests.

Agility represents one of the most complex motor abilities. Most coaches believe that the different motor characteristics represent the "foundation" of agility or change in the speed /direction of motion. Rooney (2005) indicates the following motor characteristics are the basis of agility: relative strength (compared to the athletes body mass), linear speed, motor coordination (timing), balance (stability) and motor programs (technique).

When the running (moving) speed is near the value of $7ms^{-1}$, the speed increases at the expense of the increasing step length, provided that the frequency does not change significantly. This speed represent the entry into the zone of the upper limit for the maximum extension step, because when running speed exceeds $7ms^{-1}$, the stride begins to grow more slowly, while at a speed of $8\text{-}9ms^{-1}$ it reaches its maximum. A further increase in speed is achieved on the basis of increasing frequency steps, which continue to grow rapidly (Luhtanen & Komi, 1978; Williams, 1985; Mero, & Komi, 1985; Majdell & Alexander, 1991; Mero, Komi & Gregor, 1992). Thus, the result that the variables of the longitudinal dimensionality had no influence on the variables of speed directional changes in all of the tests is understandable considering that during the implementation of any of the applied agility tests adequate speed ($7ms^{-1}$) cannot be achieved. The reason for this is their spatial organization that requires frequent and rapid change of acceleration and deceleration performance at very short distances. The speed of movement, in all three agility tests, is significant above $7ms^{-1}$, according to running distance and time, and longitudinal dimensionality, and thus it led to the length of the steps having less influence on the running speed. If speed is the same or declining, during deceleration, reducing the length of each step resulted in increased frequency. The importance of step frequency is greater than step length during running at maximum speed in performing tests that contain the rate of change of movement direction, which agrees with the findings of many authors (Mero, Komi, Rusko & Hirvonen, 1987; Mero & Komi, 1994).

The poor influence of anthropometric parameters on rapid movement tests results was determined in other studies (Malina, Bouchard, Bar-Or 2004; Hoare 2000; Marković, & Jarić 2004). The efficacy and economics of motor skills were determined by the trajectory of the end of the kinetic chain (Schmidt & Lee, 2005) as a reflection of joint or multi-joint coordination between body segments. This coordination does not depend of anthropometric parameters. Because those motor programs are accepted on the basis of the trajectory of the end of the kinetic chain, the limitation of the segment lengths could be compensated by the movement of the neighboring joints. That is why in rapid, composite movements (without much muscular force) alometric parameters are not included, which should equate subjects of different body sizes (Marković & Jarić 2004). Knowing that applied agility tests contain extremely rapid movements with little external force, a close relationship between anthropometric parameters and agility tests is not expected. Jakovljević et al. (2011) found similar results for the sample of senior elite basketball players.

The sum of skinfolds was used in this study to assess the influence of body fat mass on agility abilities of the 14 year-old male basketball players. It is known that body mass may be an aggravating factor in the speed at which a change in direction takes place, since basketball player needs to overcome his inertial characteristics. He has to produce a rapid increase in work effort to get started, as well as reduce the moment of inertia of the body in the deceleration phase. So to say, a heavier athlete has a greater inertia due to larger amounts of fat, which requires greater force production per kilogram of lean mass to derive a change in flow velocity (Sheppard & Young, 2006). Given that this study dealt with the anthropometric characteristics of basketball players which are related to body mass, the evaluation of the relationship between body mass and the speed of the motor expression is current. There was a statistically significant negative influence of the variables sum of skinfolds on the agility of young basketball players.

The efficiency of locomotion is more complex as the player moves faster. It is inversely proportional to the volume and weight of a player's body, if it is to a large extent determined by fatty tissue. It is well known that of the forces of inertia and resistance that the body provides have an adverse impact depending on the amount of inactive mass. If it is approximately over 20% of body mass, then its impact on the inertial abilities is more significant. Subcutaneous fat acts as a ballast weight, because it reduces the relative power. This leads to deficits in the speed (reactive power), which is of vital importance in the performance of agility under the changed conditions for the process of overcoming gravitational forces, ground reaction forces and limb inertia. Thus, the negative impact of adipose tissue in all the regions of the body on the efficiency of locomotion is undeniable, as indicated by the results of this study.

An interesting finding is that the variable *Forearm circumference* has a positive effect on the expression of the agility test *Zigzag agility drill*. It can be assumed that increased volume of the upper arm indicates a greater ability to manifest power. Since this test contains more variety of movement (changes of direction) than the other two tests, it can be assumed that efficient arm work helped the players to more easily overcome the force of inertia of the arms and the entire body.

Conclusion

The determination of the relationship between anthropometric characteristics and the agility abilities of young basketball players was conducted in a relatively small number of studies and extensive researches on the aforementioned relationship have yet to be implemented. Based on the results of previous research we can assume that body weight, height, length of individual limbs cannot affect the kinematics and dynamics of rapid and complex movements (agility). On the other hand, the amount of muscle, adipose tissue, fat-free component and their relationships can somewhat affect (in a positive or negative way) the kinematics and dynamics of movement. The results of this study indicate that longitudinal and transversal variables have no influence on the results of 14 year-old basketball players in the three applied agility tests. So, both tall and short players of this age can achieve good results in tests of agility. This means that when practicing agility we need to improve some other abilities and characteristics, which are the basis of agility: linear speed, motor coordination (timing), balance (stability) and motor programs (technique), regardless of the longitudinal dimensions of the players.

A significant negative influence of the sum of skinfold (body fat) on the results of all three variables is expected.

Further investigations in this field could be directed towards broadening the numbers of variables in both spaces, especially agility variables.

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UTICAJ ANTROPOMETRIJSKIH KARAKTERISTIKA NA AGILNOST MLADIH ELITNIH KOŠARKAŠA UZRASTA OD 14 GODINA

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Ciljevi ove studije su bili: a) identifikovati antropometrijske karakteristike i karakteristike agilnosti mladih elitnih košarkaša uzrasta od 14 godina, b) ispitati uticaj antropometrijskih karakteristika na rezultate u testovima agilnosti. Na uzorku od 50 mladih košarkaša, uzrasta od 14 godina, izmereno je 11 antropometrijskih varijabli: četiri longitudinalne mere, dve transverzalne mere, telesna masa, četiri obima, šest kožnih nabora, kao i dve izvedene varijable: indek telesne mase – BMI I suma kožnih nabora – SUM SKF (prediktorske varijable). Takođe su primenjena i tri testa agilnosti: test agilnosti T-test, test cik-cak u reketu and test trčanje 4x15 m (zavisne varijable). U određivanju uticaja prediktorskih varijabli na zavisne varijable primenjena je regresiona analiza - Stepwise metod. Rezultati triju regresionih analiza govore o umerenom ali značajnom uticaju antropometrijskih varijabli na rezultate u testovima agilnosti. Longitudinalne i transverzalne mere, telesna masa i obimi, nemaju značajan uticaj na rezultate testova agilnosti. Samo varijabla SUM SKF ima značajan uticaj i to negativan. Ova varijabla je ekstrahovana u prvom koraku u sve tri regresione analize, dok je kod zavisne varijable cik-cak u reketu u drugom koraku ekstrahovana i varijabla obim nadlaktice.

Ključne reči: *brzo kretanje / mladi / longitudinalne mere / transverzalne mere / suma kožnih nabora / regresiona analiza.*