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Original Article

The influence of the anthropometric characteristics and handgrip strength on the technical skills of young basketball players

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Abstract:
In basketball game the young players involved with the sport, should be discriminated by particular anthropometric characteristics and technical skills. The aim of the present study was to confirm the relationship between anthropometric characteristics, handgrip strength and selected technical skills and mainly to establish a simple prediction model of these technical skills through the most significant anthropometric parameters. Due to this purpose 106 young basketball players 13-14 years old with minimum training experience of two years were measured in six longitudinal measures (body height, stretched arms' length, upraised arms' length, upper arm's length, forearm's length and hand's circumference), body mass, handgrip strength and four basketball skill tests of speed dribble, obstacle dribble, speed spot shooting and free throws performance. The results of the regression analysis and the canonical correlation analysis indicated significant predictability of handgrip strength, stretched arms length, body height, and upraised arms height on speed and obstacle dribble, indicating the influence of these anthropometric parameters on basketball handling ability. Conclusively, the measured anthropometric characteristics of the young basketball players are considered crucial for their basketball game capability. Therefore, coaches involved with training procedure of the specific ages, should take these results under consideration, in order to recruit the most skilled players and facilitate the classification of them on the playing positions.
Key words: anthropometry, ball handling, predictability, pre-pubertal.

Introduction

Basketball is a very popular sport game globally and the last few decades, has developed significantly enough, thus the number of youngsters involved in the sport has significantly increased. Because of the large number of youngsters involved in the sport, selection of the most skilled of them is necessary (Anastasiadis, 2006). The young basketball players undergo certain skills tests, where their physical abilities and technical skills are evaluated thoroughly.

The most widespread and reliable battery of skill tests of AAHPERD (1984), includes: i) speed spot shooting, ii) passing for speed and accuracy, iii) obstacle dribble, iv) defensive sliding movement and v) free throws performance. From the above tests, two of them regarding shooting and another one regarding dribbling the basketball, are the tests which evaluate the players' skill of handling the ball. However, for the proper performance of the sport's technique, the anthropometric and physical characteristics of the young players are significant, since parameters like body height, body mass, stretched arms' length, hand surface, handgrip strength and speed running, positively contribute to their performance (Apostolidis *et al.,* 2004; Vinsapuu and Jurimae, 2009). Specifically, hand surface and handgrip strength in young ages, when body height has not been fully developed, might constitute the most decisive factors of ball handling skill.

In a sample of 193 basketball and handball players 10-17 years old, the influence of anthropometric characteristics on handgrip strength has been studied (Vinsapuu aand Jurimae, 2007). The athletes were divided in 6 groups of 10, 11, 12, 13, 14-15 and 16-17 years old; body height and body mass were measured and their body mass index was calculated. Additionally, the hand surface and handgrip strength of the dominant hand were measured. The results of the study demonstrated strong correlation between general anthropometric characteristics and fingers length with handgrip strength. At the same time an investigation of the influence of anthropometric characteristics on handgrip strength in a sample of 6-10 years old children accomplished (Semproli *et al.,* 2007). Body height was the strongest predictor of handgrip strength, followed by body mass index, while weak predictability referred fingers' span and hand surface. On the same rationale with the above researchers, the relationship of handgrip strength with basic anthropometric parameters like body composition, total body and hand mineral density and hand bone mineral content in pre-pubertal children aged 8-11 years was investigated (Jurimae *et al.,* 2009). Step wise regression analysis indicated significant predictability of body height 50.6% (R^2 X 100) and forearm girths 43.4% (R^2 X 100) on handgrip strength. Skinfold thickness and breadths were not related to handgrip strength.

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A research regarding hand strength on Indian pupils was conducted (Gandhi *et al.,* 2010). Measurements were performed on body height and mass, body mass index, five skinfolds, as well as handgrip strength of both hands, in 330 healthy children (165 males and 165 females) 6-16 years old, all of them pupils from Amritsar. The results indicated considerable correlation between anthropometric parameters and handgrip strength for both hands. Likewise, the prediction of handgrip strength using anthropometric characteristics on a homogeneous population of 100 subjects has been examined (Hewson *et al.,* 2010), aiming to establish a simple prediction model. Independent variables were set: body height, body mass, arm and forearm lengths, wrist and hand circumference. Dependent variable was set the maximal handgrip strength. Among these data, hand circumference referred the strongest correlation with handgrip strength and could clearly predict it ($R^2 = 0.624$).

Finally, the influence of hand dimensions and anthropometric characteristics on handgrip strength in male grip athletes and non athletes was investigated (Fallahi and Jadidian, 2011). In grip athletes group a significant positive correlation between handgrip strength and the most of the hand dimensions was referred.

The relationship between anthropometric characteristics with basic and specialized motor skills in several sports has been also investigated. A remarkable study (Vinsapuu and Jurimae, 2009) in a sample of 133 young handball players from Esthonia, attempted to correlate the anthropometric characteristics of standing body height, body height in sitting position, length of extended arms, arms' and legs' length and body mass index (calculated) with: i) basic motor skills of 30 m speed run from standing position, vertical jump with hands on the hips and arms swing, overhead throw of medicine ball (1 kg) with dominant hand from sitting position, and handgrip strength, and ii) specific motor ability tests of 4X10 m shuttle run, obstacle dribble, 30 m speed dribbling, handball throw with dominant hand from sitting position, vertical jump from one step run-up on dominant leg, and passing on speed and accuracy. Stepwise multiple regression analysis indicated that only part of the anthropometric parameters, were correlated with basic and specialized motor skills. Conclusively, the anthropometric parameters revealed as poor predictors of the young handball players' in both basic and specialized, motor skills.

The influence of 43 anthropometric characteristics on the technical skills' performance, in 33 female young volleyball players was also examined (Stamm *et al.,* 2001). For the evaluation of the players' performance in the game, a specialized recording and analyzing program was used, aiming to record all the technical data of the game and subsequently to determine the index of the players' technical skill and performance. The anthropometric characteristics were found to be significantly correlated with the five basic skills of the game, determining the players' performance at a rate of 32-83%. Stronger correlation among the technical skills revealed spike, block and fake movement, while among the anthropometric parameters, body height and weight, circumference of torso and of the upper and lower limbs referred considerable correlation.

The anthropometric parameters and technical skills in young basketball players 12-14 years old were also studied (Karalejic *et al.,* 2011). The aim of the research was to describe the anthropometric characteristics and technical skills of young players and furthermore, to detect the relationship between anthropometric characteristics and technical skills. For this purpose, 118 young basketball players were measured in 18 anthropometric parameters and 4 technical skill tests (speed spot shooting, passing for speed and accuracy, obstacle dribble and defensive sliding). The results of the study demonstrated moderately negative influence of some anthropometric parameters to certain field tests in 14 years old players.

However, despite the plethora of research regarding the relationship of anthropometric characteristics and handgrip strength with technical skills performance, very few studies exploring the relationship of handgrip strength and the technical characteristics of the basketball players have been published. Researchers aimed to determine the influence of long term training in soccer sport (including handgrip strength training), on interlimb coordination of soccer players (Cortis *et al.,* 2009). The results of the study indicated that handgrip strength did not provide increments in the explained variance. On the contrary, in a recent study (Massuca and Fragoso, 2013) researchers argued that body height, 30 m sprint, vertical jump, sit ups and handgrip strength are strong predictors of the game performance in team handball.

In conclusion, review of the literature revealed apparent correlation among anthropometric characteristics and handgrip strength and enough regarding anthropometric characteristics and technical skills of various team sports. However, big gap in literature exists regarding the relationship of anthropometry including handgrip strength, with the technical characteristics, as well as the performance of basketball players. Consequently, the purpose of the present study was twofold: i) to confirm the relationship among anthropometric characteristics, handgrip strength and technical skills and ii) to investigate the predictability of these anthropometric characteristics and handgrip strengths' on the technical performance of ball handling, in young basketball players, using a simple prediction model, aiming to facilitate the trainers and coaches work to classify the players on the playing positions.

Material and methods

Participants

In total 106 young basketball players of four different clubs, aged 13-14 years old with minimum training experience of two years, participated in the study. All of them participated voluntary in the study after

their parents informed and signed a consent form, and they could drop out any time they wanted to. The study conducted in compliance with Helsinki Declaration and following approval from the School's Ethics Committee.

Measurements

Anthropometric measurements

Anthropometric measures were taken according specific procedure (Lohman *et al.,* 1988). In particular, body height (cm) was measured with precision of 0.1 cm with a stadiometer (SECA, model 220, UK). Body mass (kg), with light, indoor clothing without shoes, was recorded with a scale (Bilance Salus, Italy) to the nearest 100 g. Body mass index (BMI) was calculated according the equation BMI=Body mass X Standing height^2 (kg $*$ m^2). Stretched arms length was measured with a tape measure from the tip of the right middle finger to the tip of the left one when subject was in standing position face to the wall, with extended arms parallel to the ground. Upraised arms height was measured with a tape measure from the floor to the tip of the middle fingers, when subject was in standing position, face to the wall with upraised arms. The upper arm's length was measured from the top of the arm to the elbow and the forearm's length from the elbow to the wrist proximal starting point, with a tape measure to the nearest 0.1 cm. Digital radiograph of dominant hand was taken for the measurement of circumference and it was measured as the perimeter of the wrist proximal starting point to the thump tip, to the forefinger tip, to the middle finger tip, to the ring finger tip, to the pinkie tip, and finally again to the wrist (figure 1), (Vinsapuu and Jurimae, 2007).

Fig.1. Measured circumference of the dominant hand.

Measurement of Handgrip Strength

Maximal handgrip strength of the dominant hand was measured with a specific hand dynamometer in kilograms and then was converted to Newtons by multiplying the index by 9.81 (Gerodimos, 2012). For the 13 years old players the dynamometer was set at 5.0 cm and for the 14 years old at 6.0 cm. The players were standing and held the dynamometer without touching their trunk, in a downward direction. They performed two trials and the best was used.

Field Tests

Field tests were performed under stable environmental conditions (ambient temperature 20-22^0 C and relative humidity 40-50%) in an indoor terrain.

(a) The 20 m speed dribble. Its purpose was to evaluate the skill of dribbling the ball with maximal speed. Performance was determined with photocells using an electronic timing system (OMEGA, Switzerland) at the start and the finish line and time was determined in seconds and hundreds of seconds. Each player was allowed two trials and the total time was used.

(b) The obstacle dribble test (AAHPERD, 1984). Its purpose was to assess the skill in handling the ball while running and changing directions through obstacles. An obstacle course (3.6 m $*$ 5.8 m) marked by six cones was set up in the free throw lane of the court. On the signal, the subject started dribbling while passing the cones and changing hands. Players were instructed to cover the distance of 17.9 m as fast as possible, maintaining the control of the basketball (figure 2). Each subject was allowed two test trials (one for each hand) and then another two trials (one for each hand) and time was recorded. The mean time of the two trials was used.

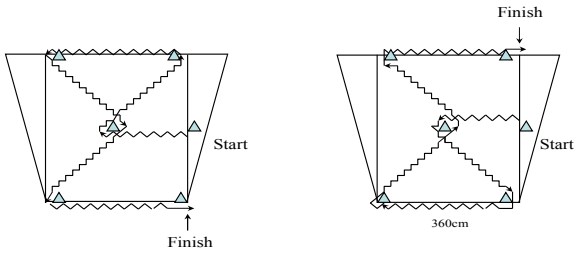

Fig. 2. Obstacle dribble basketball test (AAHPERD, 1984).

(c) The speed spot shooting test (AAHPERD, 1984). Its purpose was to assess the performance in speed and accurate shooting, under time restriction, with agility and ball handling. Five spots 3.66 m distance from the basket (according AAHPERD's instructions for the ages of 13-14 y) were marked (figure 3). The subject started behind a marked spot and on the signal shot the ball, run to get the rebound and repeat to the next spot for 60 sec. During the trial, subjects could perform four lay-ups and the score was calculated as the sum of the successful shots * 2 points, plus the missed shots * 1 point. Subjects were allowed one test trial and another two trials. The total score was the sum of the two trials.

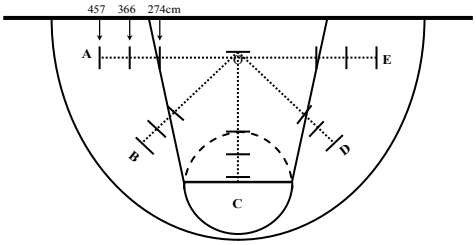

Fig. 3. Speed spot shooting basketball test (AAHPERD, 1984).

(d) The free throws test (AAHPERD, 1984). Its purpose was to assess the performance in free throws shooting. The subjects performed 20 free throw shots behind the free throw line in four sets of five shots, with at least one minute break between sets. The subjects were allowed one trial and the total score was the sum of the successful free throw shots. It is useful to be noticed that passing skill test was used in the study, because research findings indicate that none of the established reflects the players' ability on the specific skill (Sachanidi *et al.,* 2013).

Statistical analysis

Means and standard deviations were applied for all the measured variables. For the data analysis were conducted: i) Pearson correlation analysis for the control of the relationship between the measured variables, ii) step by step regression analysis for the predictability control of selected anthropometric characteristics and handgrip strength (independents) against the selected basketball technical skills (dependent), and iii) a canonical correlation analysis for the establishment of a simple prediction model including to the 1st part the stronger predictors between the anthropometric characteristics (including handgrip strength), and to the 2nd part the most predictable (by the above characteristics) between the measured technical skills. For the statistical treatment SPSS 21.0 was used and statistical significance for all the analyses was accepted at $p<0.05$ level.

Results

Means and standard deviations of the measured anthropometric parameters and the athletes' performance in selected technical skills are presented in table 1.

Table 1. Anthropometric parameters, handgrip strength and technical characteristics of young basketball players (*M* ± *SD*).

Variable	(N = 106)
Standing height (cm)	165.9 ± 0.09
Body mass (kg)	60.0 ± 12.77
Arms length (cm)	169.1 ± 0.12
Arms height (cm)	214.0 ± 0.14
Upper arm length (cm)	33.2 ± 2.68
Forearm length (cm)	25.8 ± 2.09
Hand circumference (cm)	54.1 ± 4.57
Handgrip strength (N)	288.4 ± 75.44
Speed dribble (s)	8.45 ± 0.78
Shooting performance	39.4 ± 8.20
Free throws	8.2 ± 2.61
Obstacle dribble (s)	3.79 ± 0.39

Correlations between all of the measured variables are presented in the below table 2. Strong correlations (Pearson) were observed between all the anthropometric parameters with handgrip (r = 0.55 to 0.79). However, significant but moderate correlations were observed between body height, extended arms length and arms height, with the technical skills of speed and obstacle dribble, as well as between handgrip and the technical skills of speed dribble, obstacle dribble and speed spot shooting, while non significant correlation was observed between handgrip and free throws performance.

Table 2. Pearson correlations between all the measured variables.

	BH	BM	AL	AH	UA	FA	HC	HG	SD	SH	FT	OD
BH	1,00	0.62 **	0.92 **	0.92 **	0.77 **	0.74 **	0.64 **	0.73 **	-0,30 **	0.16 ns	-0,23 ns	-0,30 **
BM		1,00	0.63 **	0.64 **	0.54 **	0.57 **	0.61 **	0.55 **	-0,06 ns	0.11 ns	-0,07 ns	0.06 ns
OA			1,00	0.93 **	0.74 **	0.75 **	0.59 **	0.80 **	-0,32 **	0.18 ns	0.04 ns	-0,33 **
HA				1,00	0.76 **	0.82 **	0.58 **	0.73 **	-0,27 **	0.13 ns	0.05 ns	-0,27 **
UA					1,00	0.79 **	0.46 **	0.55 **	-0,16 ns	0.11 ns	0,00 ns	-0,10
FA						1,00	0.51 **	0.57 **	-0,15 ns	0.08 ns	0.09 ns	-0,08
HC							1,00	0.62 **	-0,15 ns	0.11 ns	-0,03 ns	-0,25 *
HG								1,00	-0,45 **	0.20 *	0.00 ns	-0,48 **
SD									1,00	-0,41 **	-0,20 *	0.44 **
SH										1,00	0.43 **	-0,21 *
FT											1,00	-0,23 *
OD												1,00

Note. BH = body height; BM = body mass; AL = stretched arms' length; AH = upraised arms' height; UA = upper arm; FA = forearm; HC = hand circumference; HG = handgrip; SD = speed dribble; SH = speed spot shooting; FT = free throws performance; OD = obstacle dribble.

* = $p<0.05$; ** = $p<0.01$; ns = non significant correlation.

Step by step regression analyses revealed significant prediction ability of the anthropometric parameters (independent): i) body height against speed dribble and obstacle dribble, (ii) extended arms length against speed dribble and obstacle dribble, iii) arms height against speed dribble and obstacle dribble, and iv) handgrip against speed dribble, speed spot shooting and obstacle dribble. None of the independent variables referred predictability on free throws shooting performance (table 3).

Table 3. Stepwise regression analysis of anthropometric characteristics against technical skills.

Independent variables	Dependent variables	R^2 X 100	F	p
Body height	Speed dribble	29.6	9.52	0.003
	Speed spot shooting	2.4	2.36	0.13
	Free throws	2.3	0.05	0.82
	Obstacle dribble	8.8	9.57	0.003
Stretched arms' length	Speed dribble	10.3	11.34	0.001
	Speed spot shooting	3.4	3.30	0.072
	Free throws	0.1	0.13	0.72
	Obstacle dribble	11.2	12.44	0.001
Upraised arms' height	Speed dribble	7.2	7.71	0.007
	Speed spot shooting	1.7	1.66	0.20
	Free throws	0.3	0.24	0.62
	Obstacle dribble	7.2	7.72	0.007
Handgrip strength	Speed dribble	20.5	26.06	0.000
	Speed spot shooting	4.0	4.01	0.05
	Free throws	0.0	0.00	0.95
	Obstacle dribble	23.2	30.52	0.000

Canonical correlation analysis yielded one significant function with eigenvalue of 0.485 and squared correlation (R_c^2) of 0.327, verifying the relationship between anthropometric variables and basketball skills. Collectively, the full model across the function was statistically significant using the Wilks' $\lambda = 0.673$ criterion, $F_{(8, 188)} = 5.15$, $p<0.001$). Because Wilks' λ represents the variance unexplained by the model, 1- λ yields the full model effect size in an r^2 metric. Thus for the set of the canonical function, the r^2 effect size was 0.327, indicating that the full mode explained a substantial proportion, about 33% of the variance shared between the variable sets. The predictor variables set of handgrip strength, body height and arms height, were the primary contributors to the predictor synthetic variable, with secondary contribution by extended arms length. Regarding the criterion variable set, obstacle dribble and speed dribble skills performed satisfactory loadings (table 4).

Table 4. Canonical solution for anthropometric parameters predicting technical skills for function 1.

Variable	*Coefficient*	r_s	r_s^2 (%)
SD	.533	.805	64.80
OD	.652	.875	76.56
Rc^2			32.70
BH	.517	.613	37.58
AL	.219	.686	47.06
AH	.505	.563	31.70
HG	.931	.975	95.06

Note. Structure coefficients (r_s) greater than |.30| are underlined. Coefficient = standardized canonical function coefficient; r_s= structure coefficient; r_s^2= squared structure coefficient; SD = speed dribble; OD = obstacle dribble; BH = body height; AL = stretched arms length; AH = upraised arms height; HG = handgrip strength.

Discussion

The aim of the present study was to investigate the influence of the anthropometric characteristics and hand grip strength's on the technical abilities of the young basketball players. Researchers attempted to measure general anthropometric characteristics, handgrip strength of the dominant hand and basketball technical skills, defining the ball handling ability, through established valid and reliable tests.

Regarding the relationship of anthropometric parameters and handgrip strength, the findings of recent literature are fully confirmed. In particular, the study revealed strong correlation of handgrip and general anthropometric parameters of body height, stretched arms length and upraised arms height. These results are in accordance with previous studies (Jurimae *et al.,* 2009; Semproli *et al.,* 2007), which supported the strong influence of body height on handgrip strength. Finally, body mass, arm's and forearm's lengths, and hand surface were also significantly correlated with handgrip strength, but less strongly than the previous mentioned, which findings are in agreement with some researchers (Semproli *et al.,* 2007), while others (Fallahi and Jadidian, 2011; Hewson *et al.,* 2010, Vinsapuu and Jurimae, 2007) argue that these dimensions are the strongest predictors of handgrip strength.

In recent years a plethora of confirmatory studies, concerning the influence of the anthropometric characteristics on handgrip strength of various sports athletes, have been accomplished. Researchers' efforts focused on general anthropometric parameters, arms and hands dimensions and handgrip, however with conflicting results. In the present study it was clearly confirmed that the general anthropometric characteristics of standing height and stretched arms length are the most important factors influencing handgrip strength, regardless of the hand's dimensions, for the specific group of young basketball players. In this point, the precise procedure of the hands dimensions measurement through the digital radiograph should be mentioned.

Regarding the second part of the investigation, an influence of the anthropometric characteristics including handgrip, on selected basketball skills, which verify the basketball handling, was confirmed. Specifically, body height, stretched arms length and upraised arms height revealed predictability on speed and obstacle dribble skills, while handgrip strength revealed predictability on speed dribble, obstacle dribble and speed spot shooting performance. All the other measured anthropometric characteristics, appeared to be weak predictors of the measured technical skills, while the free throws skill as dependent variable, could not be predicted from any of the prediction parameters. Researchers argue about the significance of the influence of the anthropometric parameters on skills' ability and game performance in various team sports. Specifically, researchers supported that handgrip cannot have any effect on soccer players' coordination (Cortis *et al.,* 2009) while others (Mssuca and Fragoso, 2013), referred that handgrip is effective on game performance of handball players. Additionally, it has been referred poor predictability of the anthropometry on the technical performance of handball players (Vinsapuu and Jurimae, 2009), while others (Stamm *et al.,* 2001) revealed a 32-83% correlation between anthropometry characteristics of body height, body mass, girth of torso, upper and lower limbs' length, with attack, block and change direction ability, in young female volleyball players. On the other hand, in a sample of 118 pre-pubertal basketball players (Karalejic *et al.,* 2001) was referred negative correlation between anthropometry and selected basketball skills.

From the above conclusions, it is obvious that when the sport or the procedure differs, then the results vary. Consequently, considering basketball game and the specific sample size and age, researchers decided to establish a simple prediction model. The 1st part of the model includes the stronger predictors between the anthropometric characteristics, and the 2nd part the most significant between the measured technical skills. Due to this purpose, a canonical correlation analysis was conducted using the four attachment anthropometric variables as predictors of the two skills test variables to evaluate the multivariate shared relationship between the two variable sets. The analysis yielded one significant function, verifying the relationship between anthropometry and handling the ball performance in basketball game. Regarding the predictor variable set, handgrip, body height and upraised arms length were the primary contributors to the predictor synthetic variable, with secondary contribution by stretched arms length. Regarding the criterion variable set, obstacle dribble and speed dribble skills performed satisfactory loadings compared to previous established norms. Conclusively, a significant proportion of the total variance of the criterion variables has been explained by the prediction ones. The most important anthropometric characteristics regarding the influence on the ball handling skill of the young basketball players are handgrip strength, standing height and upraised arms length, while the most significant skills defining ball handling are speed dribble and obstacle dribble.

Conclusions

Despite the plethora of researches concerning the relationship of anthropometric characteristics and handgrip strength, only few of them included skills of the game. In addition, very few studies have investigated basketball skills and anthropometry with conflicting results. The present study aimed to establish a simple prediction model, which confirmed the predictability of specific anthropometric characteristics on exact basketball handling skills. In basketball game the young players with strong hands, longer arms and high stature exhibit advantage in ball handling ability. Conclusively, coaches and trainers of pre-pubertal and adolescent male basketball players should take under consideration the specific characteristics of their players, aiming to facilitate the selection of most skilled and their classification on playing positions.

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