Acta of Bioengineering and Biomechanics
Vol. 19, No. 2, 2017

Original paper
DOI: 10.5277/ABB-00678-2016-02

Somatotype variables related to strength and power output in male basketball players

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Purpose: The purpose of this study was to investigate the relationship between somatotype, muscular strength, power output measured in maximal cycle ergometer exercise bouts, and maximal power output and height of rise of the body mass centre (jump height) measured in akimbo counter movement jump (ACMJ), counter movement jump (CMJ) and spike jump (SPJ), in male basketball players. *Methods*: Thirteen male basketball players (second division, age 19.4 ± 0.8 years, body height 192.9 ± 5.6 cm, body mass 88.8 ± 8.6 kg, training experience 9.3 ± 0.8 years) participated in the study. Somatotype was determined using the Heath-Carter method. Maximal joint torques were measured under static conditions. Power output was measured in 2 maximal cycle ergometer exercise bouts, 10 seconds each, with increasing external loads equal to 7.5 and 10.0% of the body weight (BW). All jump trials (ACMJ, CMJ and SPJ) were performed on a force plate. *Results*: The mean somatotype of basketball players amounted to: 2.8–4.2–3.2. The sum of the joint torques for left and right lower extremities (0.613), trunk (0.631) and all six measured muscle groups (0.647) were significantly correlated ($p < 0.05$) with the mesomorphic component. Endomorphic, mesomorphic and ectomorphic components were correlated insignificantly with values of maximal power and height of jump during ACMJ, CMJ and SPJ trials. The power output measured in maximal cycle ergometer exercise bouts with increasing external loads was significantly correlated ($p < 0.05$) with mesomorphy and ectomorphy. *Conclusion*: It can be assumed that basketball players' anthropometric characteristics can influence their level of performance but it is not a decisive factor.

Key words: *male, basketball, Somatotype, strength, power, vertical jump*

1. Introduction

Motor abilities, morphological and physiological characteristics play an important role in determining the success of a sportsperson. Competitors representing the highest level in their sport disciplines show great similarity in morphological traits and motor abilities as a result of selection and adaptation to physical effort, developed in the course of specific training [3]. Those traits of athletes achieving highest results in particular sport discipline create a specific "model" – the somatic and physical pattern for that discipline.

Physical effort in basketball consists of various portions of aerobic and anaerobic workloads. Observations of basketball matches indicate that efficiency in this sport depends on the ability of the athletes to make short explosive efforts (starts, stops, jumps). Planning of the training program for basketball should not concern merely the applied training loads, but it should also focus on the athletes' physical abilities [21]. Research on the body structure of basketball players has identified the anthropometric attributes desirable in this sport. The basketball players of the Polish national team had significantly greater bone length and musculoskeletal robustness parameters

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Received: June 23rd, 2016
Accepted for publication: August 5th, 2016

compared with the student population [13]. These morphological parameters are an essential part of the evaluation and selection of basketball players and should be integrated and applied to annual training programs for players in this discipline.

It has been suggested that somatotyping is superior to linear anthropometric measures during estimating the body–build of athletes, as this combines adiposity, musculoskeletal robustness and linearity into one rating [3]. In fact, for various other sports, somatotype analysis can provide a better identification of body–build specification than simple anthropometric characteristics, which strongly, positively correlate with body height [8], [21]. Somatotype analysis may be useful both in terms of talent identification and in the development of training programs. Somatotype, as well as some other physical characteristics, can differ between sports, but has the smallest diversity among sportspeople practicing the same sport, and employs the same techniques [1], [6]. Ostojic et al. [11] showed that a strong relationship exists between body composition, aerobic fitness and anaerobic power.

Measurements of maximal muscle torques taken under static conditions [1], [2], [18], [21] and power output in vertical jumps on a force plate [2], [14], [20] are routine methods used for determination of muscle strength and power in laboratory testing. The relationship between strength, power and somatotype components has been documented by several investigators [2 (volleyball)], [7 (judo)], [16]–[17 (rugby athletes)]. Although similar investigations are needed and useful for basketball players, we couldn't find any results of such research in the literature. There are numerous of studies either on morphological traits or motor features and physiology tests of basketball competitors, but there is lack of research linking these characteristics and studying correlations between them.

The aim of this study was to investigate the relationship between components of somatotype, muscle torques, maximal power and height of rise of the body mass centre measured in akimbo counter movement jump (ACMJ), counter movement jump (CMJ) and spike jump (SPJ), and power output measured in maximal cycle ergometer exercise bouts in male basketball players.

2. Materials and methods

The study was approved by the Ethics Committee of the Institute of Sport – National Research Institute in Warsaw. All participants were informed about the aim and course of the study, and about the possibility of immediate resignation without giving a cause. All subjects agreed to the presented conditions in written form. Thirteen male basketball players (second division) from the Warsaw Sports Club Polonia (age 19.4 ± 0.8 years, body height 192.9 ± 5.6 cm, body mass 88.8 ± 8.6 kg, training experience 9.3 ± 0.8 years) volunteered to participate.

The maximal joint torques of six muscle groups: flexors and extensors of the hip, knee and trunk were measured under static conditions using a torque meter type TBK2-PM (JBA, Zbigniew Staniak, Poland). Technical characteristics of the torque meters were described by Buśko et al. [2]. Measurements of joint torque were performed according to the generally accepted principles [2]. The measurements of joint torque taken for the knee flexors and extensors were carried out on subjects in a sitting position. The hip and knee joints were bent at 90°. The subjects were stabilized at the level of anterior superior iliac spines and thighs, with the upper extremities resting on the chest. The subjects were laying face up during the measurements of hip flexors and extensors. Subjects were stabilized at the level of anterior superior iliac spines. The hip joint angle remained at 90° during the measurement. The maximal, physiological extension of the knee and hip joints was accepted as 0°. The joint axis of rotation during joint torque measurements corresponded to the axis of rotation of the torque meter. The joint torques of the right and left limb were measured separately, always in the flexion-extension order. The participants performed a maximum voluntary contraction (MVC) under static conditions of flexors and extensors of the hip joint, knee joint and trunk for 3 s each. The rest time between the measurements were 1–2 minutes.

The force-velocity (F–v) and power-velocity (P–v) relationships were determined by means of a test performed on a Monark 874 E cycloergometer (Sweden) connected to a PC, using the MCE 4.0 software package („JBA" Zb. Staniak, Poland). After adjusting the ergometer saddle and handlebars, each subject performed the tests in a stationary position, without lifting their body off the saddle, with his feet strapped onto the pedals. Each player performed two 10-second maximal cycloergometer tests with increasing external loads amounting to 7.5 and 10.0% of body weight (BW), respectively. There were 2-minute breaks between the tests. The standard procedures of exercise performance were followed and the subjects were verbally encouraged to achieve and maintain the maximal pedaling velocity as quickly as possible. With the use of MCE, the maximal power output at a given load (P_i; i – load value) and velocity (v_i) necessary to achieve P_i were determined [2].

Power output of lower extremities and the height of rise of the body mass center during vertical jumps were measured on a force plate PJS-4P80 („JBA" Zb. Staniak, Poland) for counter-movement jumps (CMJ), akimbo counter-movement jumps (ACMJ) and spike jumps (SPJ). The MVJ v 3.4. software package („JBA" Zb. Staniak, Poland) was used for taking the measurements. In the physical model applied, the subject's body mass bouncing on the plate was reduced to a particle affected by the vertical components of external forces: the body's gravity force and the vertical component of the ground reaction force. The maximal power and maximal height of rise of the body mass center (h) were calculated from the registered reactive force of the plate [5]. Each subject performed nine vertical jumps with maximal effort on the force plate: three counter-movement jumps (CMJ), three akimbo counter-movement jumps (ACMJ) and three spike jumps (SPJ). There were 5-second breaks between each jump in CMJ and ACMJ trials, and 1-minute breaks between the SPJs. A jump with the highest elevation of the body's center of mass was taken for statistical analysis, for each type of jump.

Anthropometric examinations consisted of the following variables: body height, body mass, four skinfolds (triceps, subscapular, supraspinale, medial-calf), biceps girth (with forearm flexed at 90° and with biceps tensed), standing calf girth, bicondylar femur breadth and bicondylar humerus breadth [3]. Body height was determined using the Siber-Hegner anthropometer (Switzerland), body mass was measured on an electronic weighing machine Tanita TBF 300 (Japan), skinfolds were measured using a Harpenden skinfold caliper, girth measurements were acquired with a steel measuring tape and bicondylar diameters of femur and humerus were measured using a small spreading caliper (Siber-Hegner, Switzerland). Somatotype was calculated by the Heath-Carter method [3].

All the measurements were made on one day (2013-10-21) and were performed in the following order: anthropometry, strength, vertical jumps and maximal efforts on a cycle ergometer. Before vertical jump testing and muscle torque measurement, the participants performed a 5-minute warm-up consisting of light exercise (i.e., running, circulation of the arms, hips and trunk, squats followed by stretching exercises). Before performing of the maximal efforts on a cycle ergometer, the participants performed a 2-minute submaximal warm-up on a cycle ergometer (Monark 874 E, Sweden). They were instructed to cycle at 50–60 rpm and to maintain a power output of approximately 150 W. Distribution of all the investigated variables was assessed by the Shapiro –Wilk test. Relationships between the joint torques, power output, height of jumps and the components of somatotype were assessed by calculating the Pearson's correlation coefficients. The level of statistical significance was set at $p < 0.05$. All statistical calculations were performed using the Statistica^{TM} software (v. 10.0, StatSoft 2011).

3. Results

The mean somatotype of basketball players amounted to: 2.8–4.2–3.2 (values for endomorphy 2.8 ± 1.0, mesomorphy 4.2 ± 0.9 and ectomorphy 3.2 ± 1.2, respectively (Fig. 1). The somatotype spread was very large on the somatochart. The largest diversity was observed in endomorphy (ranged from 1.5 to 5.0), mesomorphy (ranged from 2.5 to 6.0) and ectomorphy (ranged from 1.0 to 5.5).

Results of the strength measurements and relationships between the muscle torques and components of somatotype are presented in Table 1. The values of sum of the joint torques for left and right lower limb, trunk and all the six muscle groups was significantly correlated with mesomorphic component (0.576, 0.639, 0.631, 0.647, respectively). The correlations between endomorphy, ectomorphy and the sums of joint torques were not significant expect the ectomorphy and sum of the maximal joint torque for right lower extremity (SLER) relation.

Absolute power outputs obtained for a force-velocity relationship (mean values ± SD) are presented in Table 2. The power output measured in maximal cycle ergometer exercise bouts with increasing external loads equal to 7.5 and 10.0% of BW was strongly correlated with mesomorphy (positively) and ectomorphy (negatively). No significant correlations were found between power output and endomorphic components.

Mean (±SD) values of the maximal power output (P_{max}) and height of rise of the body mass center measured in ACMJ, SPJ and CMJ jumps are presented in Table 3. No significant correlation was found between maximal power, jump height measured in ACMJ, CMJ and SPJ jump and the somatotype components.

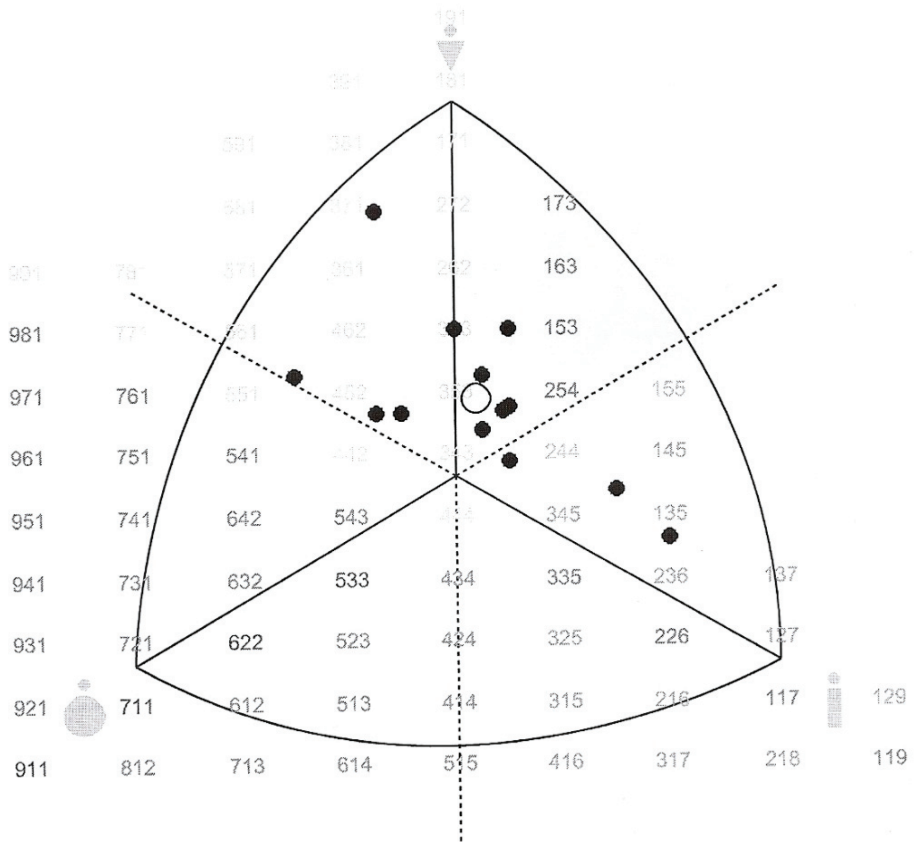

Fig. 1. Somatochart of baskeball players (n = 13). The circle is the mean value of somatotype

Table 1. Mean values (±SD) of the sums of the maximal joint torque (MT) for right (R) and left (L) lower extremity (SLE), trunk (ST) and all six muscle groups (TOTAL), and the Pearson's linear correlation coefficients between joint torque and endomorphy (ENDO), mesomorphy (MESO) and ectomorphy (ECTO)

Variables	MT [N·m]	ENDO	MESO	ECTO
SLER	1265.9 ± 220.2	–0.022	0.639*	–0.561*
SLEL	1237.7 ± 239.9	–0.105	0.576*	–0.464
SLE	2503.5 ± 455.4	–0.066	0.613*	–0.516
ST	762.5 ± 110.0	0.160	0.631*	–0.513
Total	3266.1 ± 538.6	–0.023	0.647*	–0.541

* – $p < 0.05$.

Table 2. Mean values (±SD) of power output (P) and the Pearson's linear correlation coefficients between power output and endomorphy (ENDO), mesomorphy (MESO) and ectomorphy (ECTO)

Load [% BW]	P [W]	ENDO	MESO	ECTO
7.5% BW	978.4 ± 113.8	0.258	0.776*	–0.676*
10.0% BW	1075.9 ± 126.4	0.131	0.766*	–0.579*

* – $p < 0.05$.

Table 3. Mean values (±SD) of the jump height (h), maximal power output (P_{max}) in akimbo counter-movement jump (ACMJ), counter-movement jump (CMJ) and spike jump (SPJ) performed on a force plate and the Pearson's linear correlation coefficients between power output and endomorphy (ENDO), mesomorphy (MESO) and ectomorphy (ECTO)

Variables		ENDO	MESO	ECTO
$P_{maxACMJ}$ [W]	2440.8 ± 439.9	–0.018	0.242	–0.138
h_{ACMJ} [m]	0.419 ± 0.040	–0.395	–0.422	0.408
P_{maxCMJ} [W]	3591.4 ± 787.9	–0.036	0.048	0.129
h_{CMJ} [m]	0.525 ± 0.051	–0.437	–0.354	0.382
P_{maxSPJ} [W]	4802.2 ± 748.8	–0.223	0.493	–0.288
h_{SPJ} [m]	0.600 ± 0.051	–0.529	–0.294	–0.338

* – $p < 0.05$.

4. Discussion

The main finding of the present study was the joint torques and power output developed on a cycle ergometer correlate significantly with the mesomorphic component in basketball players. Maximal power and height of rise of the body mass center measured for ACMJ, CMJ and SPJ trials are correlated insignificantly with values of the somatotype component. Anthropometrical characteristics are very important for basketball players, as the game entails physical contact in which greater muscle strength and power may provide an advantage. Physical characteristics of basketball players should be considered in the process of choosing players which will fulfill the game plan. It is believed that basketball players of the highest level of performance have a significantly greater musculoskeletal length and robustness in body build. The results of anthropometric measurements showed that the average length factor, bone width and musculature factor of tested basketball players are in accordance with a study about the type of body build of the Polish National League basketball players [13]. Considering the basic anthropometrical characteristics of body height and mass, no differences were found between Polish second division players and the Turkish team [5]. Different results regarding somatotype have been reported in a study by Viviani [19], concerning Italian basketball players at the same level of performance as our subjects. Thirty eight Italian athletes of medium class (B ad C) were characterized by lower values of endomorphy and mesomorphy and higher ectomorphy (2.2–3.2–3.8) than the equivalent values of our group (2.8-4.2-3.2). Male athletes examined by us had lower values of mesomorphy, as well as higher ectomorphy and endomorphy, when compared with Turkish basketball players of the same level (3.1–3.7–2.4) [12] and elite Greek athletes (3.7–4.0–2.9) [9]. These comparisons are supported by the fact that our players seemed to have greater musculoskeletal robustness in body build, which is a very desirable in a contact sport such as basketball. Such tendency was also pointed out in similar studies carried out on the Serbian national team [11].

Each position on the playground has its desirable characteristics related to players' motor skills and physiological features. Such characteristics should be taken into consideration trying to determine ideal body build of elite basketball player.

Knowledge about the relationship between body build characteristics and muscle strength, power and jumping ability provides the basis for successful sport selection and an effective, proper training program. Quarrie and Wilson [17] studied the relationships between anthropometrics, strength and power measures of rugby union forwards and their individual force production in the scrum. The body mass and somatotype of the players were significantly related to the force they applied in the scrum. Heavier players, and those who were more endo-mesomorphic, were capable of producing higher individual scrummaging forces than players who were lighter or more ectomorphic. All three components of somatotype (endomorphy, mesomorphy, ectomorphy) correlated significantly with scrum force of rugby players.

In the study of Lewandowska et al. [7] the values of sum of joint torques for right and left upper extremities (SUE), sum of joint torque of right and left lower extremities (SLE), the sum of joint torque of the trunk (ST) and the total torque sum in judo athletes were significantly correlated with mesomorphic component: r = 0.68, 0.80, 0.71 and 0.78, respectively. Ectomorphic component correlated significantly with the values of SUE, SLE, ST and TOTAL: r = –0.69, –0.81, –0.71 and –0.79, respectively. The correlations between endomorphy and the sums of joint torques were not significant. In the study of Buśko et al. [2] a statistically significant, positive correlation has been found in female volleyball players only between values of SUE, SUEL and mesomorphic component: r = 0.57 and r = 0.64, respectively. Correlations between endomorphy, ectomorphy and the sums of joint torques were not significant. In our study, a statistically significant, positive correlation has been found between the mesomorphic component and values of the maximal joint torques of the right (R) and left (L) lower extremity (SLE), trunk (ST) and all six muscle groups (TOTAL). Those observations are in accordance with the results of judoists in the study by Lewandowska et al. [7].

Ziv and Lidor [20], [21] suggest that good jumping ability is associated with achieving success in basketball and this information can also be used for talent detection and early development processes in basketball. In the study by Buśko et al. [2], mesomorphic and ectomorphic components correlated significantly with values of maximal power measured during ACMJ and CMJ jumps in female volleyball players. The maximal power and height of jump measured in ACMJ and CMJ trials did not correlate with somatotype components in judo athletes (unpublished data). In our study, somatotype components did not correlate with values of maximal power measured for ACMJ, CMJ and SPJ jumps in male basketball players, unlike in female volleyball players. This may suggests that you should pay attention not only to the anthropometric characteristics of players but also on the physical ability characteristics.

In female volleyball players, only the power output measured in maximal cycle ergometer exercise bouts at increasing external loads equal to 2.5, 5.0 and 7.5% of BW were strongly correlated with endomorphy (positively), mesomorphy (positively) and ectomorphy (negatively) [2]. No significant correlations were found between power output measured with external loads equal to 10.0 and 12.5% of BW and all the somatotype components. Power output measured with external loads amounting to 2.5, 5.0, 7.5, 10.0 and 12.5% BW was strongly correlated with both mesomorphy (positively) and ectomorphy (negatively) in judoists. In our study, power output measured with external loads equal to 7.5 and 10.0% of BW significantly correlated with mesomorphy (positively) and ectomorphy (negatively). Those findings may suggest that mesomorphy and ectomorphy are significantly linked with the power output measured in cycloergometer test. On the other hand, investigations on elite volleyball players conducted by Gualdi-Russo and Zaccagni [4] and Malousaris at al. [8] showed that somatotypes of competitors who achieved better results (A1 vs A2 league) were characterized by higher ectomorphy and lower endomorphy and mesomorphy. Contribution of mesomorphy in somatotype represents a lean body mass (LBM) level, while endomorphy reflects body fatness. Body composition was found to be a significant factor in determining the anaerobic power, aerobic capacity and sport results of athletes. Anaerobic power of Olympic weight lifters was found to be significantly correlated (positively) with LBM and negatively with body fat [15]. In our study, mesomorphy and ectomorphy were correlated significantly (positively and negatively, respectively) with anaerobic power too.

5. Conclusions

Presented results indicate that the joint torques and power output developed on a cycle ergometer correlate significantly with the mesomorphic component in basketball players. Maximal power and height of rise of the body mass center measured for ACMJ, CMJ and SPJ trials are correlated insignificantly with values of the somatotype component. It can be assumed that basketball players' anthropometric characteristics can influence their level of performance but it is not a decisive factor.

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