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Somatotype and body composition of volleyball players and untrained female students – reference group for comparison in sport

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Abstract: There is substantial evidence that somatotype and success in sport and physical performance are positively related. Existing somatotype data on athletes are useful as guidelines for sport selection and choice of training appropriate to the enhancement of desired somatotype characteristics. Updated somatotype data from non-athlete reference groups complement comparative analysis applied in assessing the effects of the training process and selection. The aim of this study was to determine the somatotype of untrained girls studying at Warsaw University of Technology in 2011, in order to create a current reference group for comparison, and to investigate the difference in body build of female volleyball players compared with the non-athlete group. Twelve Second Division female volleyball players (age 21.6±1.5 years, body height 177.3±6.2 cm, body mass 71.0±6.5 kg, training experience 8.4±3.4 years) and 150 female untrained students of the University of Technology in Warsaw (age 20.0±6.4 years, body height 166.5±6.4 cm, body mass 59.7±8.4 kg) participated in a study carried out in 2011. Somatotype was determined using the Heath-Carter method. The volleyball players were a little older and were significantly taller and heavier than female students ($p<0.05$). Significant differences between the groups were found in breadth of the elbow, breadth of the wrist, biacromial diameter, arm circumference and crus circumference ($p<0.05$). The mean somatotype of the volleyball players was 4.5-3.4-2.8. (4.5±1.0–3.4±1.2–2.8±1.3), whilst that of the untrained students was 5.1–3.6–2.8. (5.1±1.4–3.6±1.1–2.8±1.3); the groups did not differ significantly in somatotype. The groups were significantly different in body composition (F [kg] and LBM [kg]), as estimated by BIA and anthropometric methods ($p<0.05$). No differences were observed between the groups in the skinfolds. Morphological characteristics of the female volleyball players depended on the competition level and performance. Somatic features of the bodies of the volleyball players were dominated by the height of the body and the associated magnitude of the constituent characteristics.

Key words: female students, reference group, somatotype, body composition, volleyball

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Introduction

Empirical and practical knowledge emerging from studies of the highest level volleyball players, such as their body composition, anthropometric dimensions and somatotype, aerobic profile, agility and speed, strength and power, allow determination of the complex physique profile of competitive male and female volleyball players. Research of the body build of volleyball players has indicated those anthropometric attributes that are required in this sport. It has suggested that somatotyping is superior to linear anthropometric measures for estimation of the body build of athletes, as it combines adiposity, musculoskeletal robustness, and linearity into one rating (Carter and Heath 1990). Somatotype analysis can provide better identification of the body build specification for athletes in various sports than can simple anthropometric characteristics, which strongly and positively correlate with body height (Malousaris et al. 2008). Somatotype analysis may be useful in terms of talent identification or development of training programs. Somatotype, as well as some other physical characteristics, differ between sports, but have the smallest diversity among sportspersons practicing the same sport and employing the same techniques (Carter and Heath 1990; Krawczyk et al. 1995). Existing somatotype data on athletes are useful as guidelines for sport selection and choice of training appropriate to the enhancement of desired somatotype characteristics. Updated data on somatotype of non-athlete reference groups complement comparative analysis applied in monitoring of the training process. Comparison of indicators of physical capacity and morphological body build in female volleyball player contestants with those of the untrained should allow identification of required directions of development and the effect of training on the predictors. Also body composition is an important factor of physical fitness for volleyball players, as excess body fat acts as a ballast against the body's ability to perform a number of movements, for example the vertical jump. Literature on the subject indicates that the body fat percentage of female volleyball players is in the range of 11.7–27.1% (Malousaris et al. 2008; Viviani and Baldin 1993).

The population of not physically active men and women is the basis for the assessment of body building for athletes in different sports. Students from the Warsaw University of Technology are a particularly good point of reference for research on the body build of sportsmen; they possess the highest indices of biological development (body height and weight) (Pilicz 1963; Milicer et al. 1976; Piechaczek 1996), and since the 1960s they have been the reference group for Polish athletes (Marchocka and Smuk 1984; Piechaczek 1990; Krawczyk et al. 1995). An additional value of this sample as a control group resides in the fact that the majority of students are little engaged in sports activity. This means that their body build, unaffected by intensive sports training, is an excellent point of reference for evaluating the effect of training on somatic characteristics (Milicer et al. 1976). In previous studies the reference group for top Polish athletes in tennis (Jagiello and Jagiello 2009), in pentathlon (Jagiello et al. 2011), in combat sports (Jagiełło et al. 2007; Jagiełło and Kruszewski 2009) and for dancers (Pilewska et al. 2013) was a group of untrained students from the Warsaw University of Technology, who were tested

in 1994 (Piechaczek et al. 1996). In our study we present updated somatic data from randomly selected non-athlete female students to create the current reference group for comparison.

The aim of this study was to: determine somatotype and body composition of untrained girls studying at Warsaw University of Technology in 2011 to create a current reference group for comparison, and investigate the difference in somatotype and body composition between female volleyball players and untrained students of University of Technology in Warsaw.

Material and methods

The study was approved by the Senate Ethics Committee of the Josef Pilsudski University of Physical Education in Warsaw. All participants were informed about the aim and the course of the study, and about the possibility of immediate withdrawal from the study without giving a cause. All subjects agreed to conditions that were presented in written form. The study was performed in accordance with the Declaration of Helsinki. Twelve Second Division female volleyball players (age 21.6±1.5 years, body height 177.3±6.2 cm, body mass 71.0±6.5 kg, training experience 8.4±3.4 years) and 150 female untrained students in the first and second years of the University of Technology in Warsaw (age 20.0±6.4 years, body height 166.5±6.4 cm, body mass 59.7±8.4 kg) participated in the study during November and December 2011.

The research group of female students from the Warsaw University of Technology was randomly selected according to the methodology used since the 1960s as a reference group for comparison particularly of body building athletes. The female students from the Warsaw University of Technology were drawn from students of all faculties as follows: names were drawn from lists of individual faculties, the number of respondents from each faculty was proportional to the participation of students in the faculty compared to the total number of students in the given year of study, the students selected were not practicing any sport professionally, and all the students had Polish nationality and were Caucasians.

Anthropometric examinations considered the following variables: height and body mass, six skinfolds (triceps, biceps, subscapular, supraspinale, medial-calf, abdominal), arm girth relax and tensed (with forearm flexed at 90° and with biceps tensed), girths (waist, hip and calf), breadths of (wrist, bicondylar humerus and femur, biacromial and bicristal diameters).

Body height was determined using a SiberHegner anthropometer (Switzerland), skinfolds were measured using a Harpenden skinfold caliper, girth measurements were acquired with a steel measuring tape and wrist girth, and bicondylar diameters of femur and humerus were measured using a small spreading caliper (SiberHegner, Switzerland). Measurements of body mass and body composition were carried out using a Model TBF–300 body composition analyzer (Tanita, Japan) adjusted for STANDARD. Body composition by use of the anthropometric method was estimated by Piechaczek's method (Piechaczek 1976). Total body fat F (kg, %) and total lean body mass LBM (kg, %) were then calculated. All measurements were taken by the same investigator, applying standard anthropometrical methods according to the procedure of the International

Biological Programme (Weiner and Lourie 1969). BMI and WHR (waist/hip ratio) indexes were calculated and corrected by skinfolds, arm girth (tensed and corrected by triceps and biceps skinfolds) and calf girth (corrected by calf skinfold).

Somatotype was calculated by the Heath-Carter method. Endomorphy was calculated based on the sum of three skinfolds (triceps, subscapular, supraspinale) Σ3SKF [cm] and corrected for height by multiplying this sum by 170.18/height in cm Σ3SKFcorrected [mm] (Carter and Heath 1990).

The measurements were conducted at the turn of November and December 2011. All measurements were performed in the morning.

Statistical analysis

Significance differences between the groups were assessed using the one-way analysis of variance (ANOVA) with the post hoc Scheffé's test. The effect size (ES) in ANOVA was assessed by eta square and interpreted as follows: $0.01 \leq \eta^2 < 0.06$ small, $0.06 \leq \eta^2 < 0.14$ medium and $\eta^2 \geq 0.14$ large (Cohen, 2013). Distribution of all the investigated variables was assessed by the Kolmogorov-Smirnov test and all of them had normal distribution.

For comparisons of the whole somatotype among groups SAD (somatotype attitudinal distance) analysis were used. Significance differences between mean somatotypes SAM (somatotype attitudinal mean) were assessed using the t-test for two independent groups (Carter, 2002). The level of statistical significance was set at $p<0.05$. All statistical calculations were performed using the Statistica program (v. 12.0, StatSoft) and MS Excel.

Results

The students were younger than the volleyball players. The volleyball players were significantly taller and heavier than the female students ($p<0.05$) Significant differences between the groups were found in the breadth of the wrist, bicondylar humerus and biacromial diameters (associated size of the constituent characteristics), and arm and calf circumference (indicators of muscle mass) (Table 1).

The groups were also significantly different in body composition (F [kg] and LBM [kg]) as estimated by BIA and anthropometric methods (Table 3). No differences were observed between the groups in the skinfolds (Table 2).

The mean somatotype of the volleyball players was: 4.5–3.4–2.8 (values for endomorphy 4.5±1.0, mesomorphy 3.4±1.2 and ectomorphy 2.8±1.3 respectively) (Fig. 1). The somatotype spread was very large on the somatochart. The greatest diversity was recorded in the ectomorphy component (range from 0.5 to 5.0). The lowest ectomorphy and highest endomorphy were characteristic for liberos and setters. The highest ectomorphy and the lowest endomorphy and mesomorphy were most common in hitters and opposites. Differentiation of the mesomorphy and endomorphy component was also very large (range of 2.1–5.6 and 3.0–6.0, respectively).

The mean somatotype of untrained students was 5.1–3.6–2.8 (values for endomorphy 5.1±1.4, mesomorphy 3.6±1.1, and ectomorphy 2.8±1.3) and featured slightly greater participation of endomorphy. Differentiation of the endomorphy, mesomorphy and ectomorphy components was very large (ranges of 2.5–8.5, 1.5–7.0 and 0.5–6.0, respectively).

Table 1. Anthropometrical characteristics of volleyball players and students of Warsaw University of Technology.

Variables	WUT (n=150)	Volleball (n=12)	F	*p*	η^2
	Mean±SD	Mean±SD			
Age (years)	20.0±1.1	21.6±1.5	19.33	0.000	0.108
Training (years)	–	8.4±3.4			
Body height (cm)	166.50±6.37	177.27±6.24	31.84	0.000	0.166
Bicondylar humerus breadth (cm)	6.06±0.27	6.39±0.36	16.26	0.000	0.092
Wrist breadth (cm)	5.05±0.28	5.28±0.21	7.18	0.008	0.043
Bicondylar femur breadth (cm)	8.99±0.50	9.27±0.30	3.51	0.063	0.022
Biacromial breadth (cm)	36.46±1.67	39.17±0.97	30.95	0.000	0.162
Bicristal breadth (cm)	28.68±1.85	29.59±1.73	2.72	0.101	0.017
Arm girth relaxed (cm)	26.74±2.83	26.90±2.32	0.035	0.851	0.000
Arm girth flexed and tensed (cm)	27.06±2.43	29.04±2.13	7.490	0.007	0.045
Arm girth corrected (cm)	24.58±1.82	26.93±1.86	4.52	0.035	0.028
Waist girth (cm)	70.06±5.59	73.27±4.66	3.741	0.055	0.023
Hip girth (cm)	95.70±6.39	98.88±3.31	2.88	0.092	0.018
WHR index	0.73±0.04	0.74±0.04	0.66	0.419	0.004
Calf girth corrected (cm)	34.55±2.22	35.96±2.10	4.52	0.035	0.028
Calf girth (cm)	36.17±2.46	37.27±2.21	2.25	0.136	0.014
Σ3SKF(cm)	5.10±1.65	4.59±1.02	1.13	0.290	0.007
Σ3SKFcorrected (mm)	52.26±17.03	44.21±10.37	2.60	0.109	0.016
Body mass (kg)	59.71±8.44	70.98±6.49	20.41	0.000	0.113
BMI index	21.53±2.75	22.63±2.53	1.81	0.181	0.011

WUT – Warsaw University of Technology.

Table 2. Skinfold thickness comparison between volleyball players and students of Warsaw University of Technology.

Variables	WUT (n=150)	Volleball (n=12)	F	p	η^2
	Mean±SD	Mean±SD			
Triceps skinfold (cm)	1.70±0.57	1.42±0.36	2.68	0.104	0.017
Biceps skinfold (cm)	0.78±0.30	0.69±0.23	1.186	0.278	0.007
Subscapular skinfold (cm)	1.52±0.62	1.28±0.39	1.679	0.197	0.010
Suprailiac skinfold (cm)	1.89±0.63	1.89±0.44	0.000	0.989	0.000
Medial-calf skinfold (cm)	1.62±0.57	1.31±0.39	3.480	0.064	0.021
Abdominal skinfold (cm)	2.12±0.67	2.31±0.67	0.954	0.330	0.006
Sum of 6 skinfolds (cm)	9.63±2.85	8.90±1.82	0.752	0.387	0.005

WUT – Warsaw University of Technology.

The groups did not differ significantly in the whole somatotype. Mean somatotype SAM was 1.862±0.835 and 1.895±1.063 for volleyball players and untrained students, respectively. The difference was not significant (t=–0.047, p=0.962).

Table 3. Body tissue composition of the female volleyball players and students of Warsaw University of Technology.

Variables	WUT (n=150)	Volleball (n=12)	F	*p*	η^2
	Mean±SD	Mean±SD			
Body mass (kg)	59.71±8.44	70.98±6.49	20.41	0.000	0.113
FAT_{ANT} (kg)	15.44±3.57	18.13±2.91	6.435	0.012	0.039
LBM_{ANT} (kg)	44.27±5.19	52.86±3.95	31.37	0.000	0.164
FAT_{ANT} (%)	25.59±2.73	25.42±2.15	0.045	0.832	0.000
LBM_{ANT} (%)	74.41±2.73	74.58±2.15	0.04	0.833	0.000
FAT_{BIA} (kg)	13.92±5.75	14.68±3.12	0.20	0.649	0.001
LBM_{BIA} (kg)	45.80±3.29	56.31±4.22	108.84	0.00	0.405
FAT_{BIA} (%)	22.47±6.53	20.52±3.10	1.038	0.310	0.007

Legend: ANT – the anthropometric method; variable calculated by Piechaczek's formula (Piechaczek 1976), BIA – variables measured by bioelectrical impedance analysis.
WUT – Warsaw University of Technology.

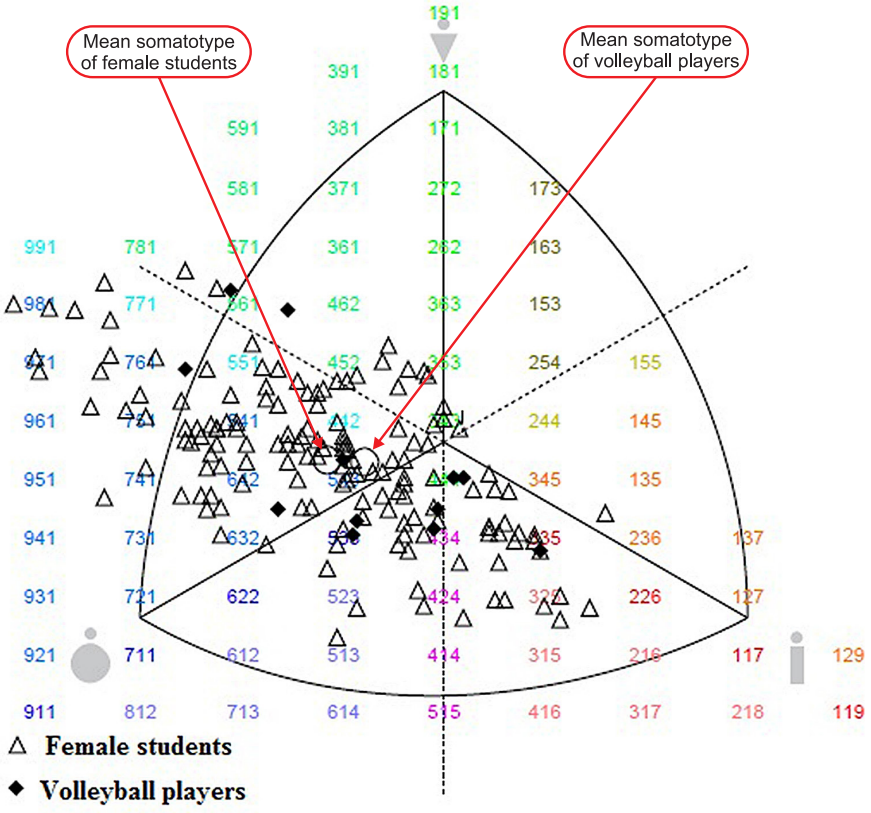

Fig. 1. Somatochart of the female volleyball players (n=12) and students of Warsaw University of Technology (n=150). The circles indicate the mean values of somatotype

Discussion

The somatotype of athletes is most often compared to the somatotype of players of the highest level or reference groups – untrained subjects. In most sports top level athletes are more mesomorphic and less endomorphic than the non-athlete reference group (Gualdi-Russo and Zaccagni 2001; Jagiełło et al. 2007: Malousaris et al. 2008; Jagiełło and Kruszewski 2009: Pietraszewska et al. 2015). In our study the mean somatotype of untrained students was 5.1–3.6–2.8 and showed slightly greater participation of endomorphy, but non-athletes and volleyball players did not differ significantly in the contributions of the three somatotype components to somatotype. Morphological characteristics of female volleyball players depend on the competition level and performance.

In the study of Malousaris et al. (2008) the somatotype of female volleyball players of the Greek National League was 3.4–2.7–2.9. A similar result was reported by Gualdi-Russo and Zaccagni (2001), who investigated Italian elite female volleyball players (3.0–3.3–2.9). The female volleyball players from the A1 league were characterized by higher ectomorphy and lower endomorphy and mesomorphy in relation to their counterparts from the A2 league (Gualdi-Russo and Zaccagni 2001; Malousaris et al. 2008). Together with the decreasing level of sport in female volleyball teams, an increase in endomorphic and mesomorphic components and a decrease in the ectomorphic component were observed. Female volleyball players in our study had similar mean somatotype profiles (4.5–3.4–2.8) to the somatotype of the Greek second league players (4.2, 3.6, 3.3) (Nikolaidis et al. 2015) and to the somatotype of Italian amateur volleyball players (4.7–3.9–2.3) studied by Viviani and Baldin (1993). Female athletes examined by us had high values of endomorphy and mesomorphy as well as low ectomorphy when compared to the A1 league of female volleyball players from Greece (Malousaris et al. 2008; Nikolaidis et al. 2015) and from Italy (Gualdi-Russo and Zaccagni 2001). When tested, our volleyball players had similar meso- and ectomorphy and much higher endomorphy than the Polish first division competitors (3.1–3.9–2.9) described by Pietraszewska et al. (2015) and the elite female volleyball players from the highest Spanish league (3.1, 3.4, 3.1) examined by Martín-Matillas et al. (2014). The summarized comparison of somatotypes of female volleyball players confirms a variety of morphological build of athletes according to the level of competition.

Differentiation of somatotypes may also be the result of testing a different number of players playing in different positions on the pitch, although Pietraszewska et al. (2015) found no significant differences between volleyball players playing in different positions on the pitch.

Krawczyk et al. (1995) studied top class athletes representing various sports, and in the context of their body components found that volleyball players belong to the group of athletes characterized by relatively high fatness as compared to athletes in other sports disciplines.

On the other hand, investigations of top Polish volleyball players and untrained students conducted by Pietraszewska et al. (2015) found that the FAT of the competitors (27.8±3.4%) was higher than for the control group (25.5±3.2%).

In our study, the volleyball team did not differ significantly from the reference group (students of Warsaw University of Technology) in terms of total body fat and in the skinfolds. In the Malousaris et al. study (2008), players from the A2 division were characterized by a body fat content of 24.1±2.6%. Depending on player's position, the lowest body fat content was found among sweepers, at 21.4±3.1%, while the largest body fat content was found among receivers, at 25.7±3.4%. Although the body fat values obtained in our volleyball players seem to be similar, body fat percentage reported by Malousaris et al. (2008) was calculated by Siri's formula (Siri 1956), while this study used Piechaczek's formula (Piechaczek 1976). Currently, the most popular method for determining body composition is through bioelectrical impedance analysis (BIA). This method is considered to be simple, quick and noninvasive, and is used to monitor body composition of an athlete throughout an entire competitive or training season. Some authors (Wit et al. 1998, Buśko and Lipińska 2012) find that it provides accurate results of body fat percentage similar to those obtained by the anthropometric methods. In our work body composition was also estimated in this way, and the results obtained for total fat by the anthropometric method and BIA were similar and do not differ significantly for compared groups. Observed significant differences in body composition F [kg] and LBM [kg] and the somatic features of the volleyball players were dominated by the height of the body and the associated magnitude of the constituent characteristics.

Conclusions

Morphological characteristics of female volleyball players depend on the competition level and performance. The somatotype, total body fat and subcutaneous adiposity of Second Division players were similar to the untrained comparison group. The somatic features of the volleyball players were dominated by the height of the body and the associated magnitude of the constituent characteristics.

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Authors' contributions

AP collected the data, performed statistical analyses and interpreted the results, wrote the paper; KB performed statistical analyses, wrote and reviewed the manuscript; EK provided logistic support during data collection and collected the data.

Conflict of interest

The Authors declare that there is no conflict of interests.

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