SHORT REPORT

Anthropometric and physiological characteristics of junior elite volleyball players

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Objectives: To investigate the anthropometric and physiological characteristics of junior elite volleyball players.
Method: Twenty five national level volleyball players (mean (SD) age 17.5 (0.5) years) were assessed on a number of physiological and anthropometric variables. Somatotype was assessed using the Heath-Carter method, body composition (% body fat, % muscle mass) was assessed using surface anthropometry, leg strength was assessed using a leg and back dynamometer, low back and hamstring flexibility was assessed using the sit and reach test, and the vertical jump was used as a measure of lower body power. Maximal oxygen uptake was predicted using the 20 m multistage fitness test.
Results: Setters were more ectomorphic ($p<0.05$) and less mesomorphic ($p<0.01$) than centres. Mean (SD) of somatotype (endomorphy, mesomorphy, ectomorphy) for setters and centres was 2.6 (0.9), 1.9 (1.1), 5.3 (1.2) and 2.2 (0.8), 3.9 (1.1), 3.6 (0.7) respectively. Hitters had significantly greater low back and hamstring flexibility than opposites. Mean (SD) for sit and reach was 19.3 (8.3) cm for opposites and 37 (10.7) cm for hitters. There were no other significant differences in physiological and anthropometric variables across playing positions (all $p>0.05$).
Conclusion: Setters tend to be endomorphic ectomorphs, hitters and opposites tend to be balanced ectomorphs, whereas centres tend to be ectomorphic mesomorphs. These results indicate the need for sports scientists and conditioning professionals to take the body type of volleyball players into account when designing individualised position specific training programmes.

An athlete's anthropometric and physical characteristics may represent important prerequisites for successful participation in any given sport.[1] Indeed, it can be assumed that an athlete's anthropometric characteristics can in some way influence his/her level of performance, at the same time helping to determine a suitable physique for a certain sport.[2 3] However, although studies have examined the anthropometric and physiological profiles of athletes from a variety of sports,[3–6] it appears that few studies have examined the anthropometric or physiological profile of volleyball players, particularly in relation to their positional role within the sport.[1]

Somatotype analysis may be useful in terms of talent identification or development of training programmes, as somatotypes, as well as other physical characteristics, differ between sports and as a result of positional role and differences in requirements of play within particular positions.[2] It has also been suggested that somatotyping is superior to linear anthropometric measures in differentiating between different competitive sport populations, as it combines adiposity, musculoskeletal robustness, and linearity into one rating.[2] Previous research has also reported a range of differences in physiological and anthropometric variables as a result of playing position in a variety of sports.[3 5 7] Likewise, an awareness of the physiological characteristics of elite level athletes in a given sport may be beneficial in terms of optimising training programmes specific to the requirements of particular sports. They may also provide the athlete with information as to where training may be directed to compensate for areas where he/she may be below average in their specific sport.[4 6]

With regard to volleyball, previous work with senior Italian players has indicated that setters tend to have the highest endomorphic and mesomorphic values, and centres have the lowest endomorphic and highest ectomorphic scores.[1] Furthermore, hitters and opposites tend to have somatotype values intermediate between those of setters and centres.[1] Mean somatotype values (endomorphy, mesomorphy, ectomorphy) for elite, male, Italian volleyball players reported by Gualdi-Russo and Zaccagni[1] were 2.4, 4.5, 2.8 (balanced mesomorphs) for setters, 2.0, 4.0, 3.5 (ectomorphic mesomorphs) for centres, 2.2, 4.3, 3.0 (ectomorphic mesomorphs) for hitters, and 2.2, 4.3, 3.1 (ectomorphic mesomorphs) for opposites. However, it seems that anthropometric and/or physiological profiles of elite junior volleyball players have not been previously reported. An understanding of the anthropometric and physiological profiles of junior athletes may be important for talent identification within sports and accurate distribution of resources within a team.[1] Therefore the aim of this study was to examine positional differences in the anthropometric and physiological profiles of elite junior volleyball players between setters, hitters, centres, and opposites.

METHODS

Subjects

Twenty five elite junior volleyball players participated in this study after approval by the college ethics committee and after providing written informed consent. The study was carried out at a summer training camp held by the English Volleyball Association. Participants were aged 16–19 years (mean (SD) 17.5 (0.5)) and all were members of the England men's junior volleyball squad.

Procedure

All measures were conducted on the same day and were completed in the standardised order described below. Height and body mass were assessed using a Seca stadiometer and weighing scales (Seca Instruments Ltd, Hamburg, Germany). Percentage body fat was assessed using skinfold measures of four sites using Harpenden skinfold callipers (Holtain Ltd, Crosswell, Crymych, UK) and using the Durnin and Womersley[8] skinfold equation. Muscle mass was also estimated using anthropometric methods using skinfolds and girths and the Martin *et al*[9] muscle mass equation.

Table 1 Summary of results in relation to playing position

Measure	Setters	Hitters	Centres	Opposites
Height (m)	1.91 (5.0)	1.93 (4.5)	1.87 (3.6)	1.90 (5.9)
Body mass (kg)	71.2 (9.3)	77.9 (8.4)	77.6 (5.9)	71.3 (9.2)
Leg strength (kg)	162.5 (33.3)	182.2 (22.7)	172.8 (37.9)	155.4 (28.6)
Sit and reach (cm)	26.1 (6.9)	37 (10.7)	34.5 (9.4)	19.3 (8.3)*
Vertical jump (cm)	42.8 (8.1)	49.0 (5.7)	47.2 (5.1)	42.0 (5.1)
Estimated $\dot{V}O_2$ (ml/kg/min)	46.9 (4.9)	51.1 (3.7)	50.4 (3.7)	48.3 (6.7)
Muscle mass (kg)	43.4 (5.2)	50.9 (7.1)	49.6 (4.4)	44.5 (5.2)
% body fat	12.9 (3.4)	12.5 (2.4)	11.5 (2.2)	11.8 (3.5)
Endomorphy	2.6 (0.9)	2.4 (0.5)	2.2 (0.8)	2.3 (0.8)
Mesomorphy	1.9 (1.1)	2.6 (0.6)	3.9 (0.4)†	2.5 (1.0)
Ectomorphy	5.3 (1.2)	4.6 (0.8)	3.6 (0.7)‡	5.1 (1.1)

Values are mean (SD).
Post hoc test results: *significantly different from hitters ($p<0.01$); †significantly different from setters ($p<0.01$); ‡significantly different from setters ($p<0.05$).

Somatotypes were calculated using the Heath-Carter method.[2] Leg strength (kg) was assessed using a leg dynamometer (Takei Instruments Ltd, Tokyo, Japan), low back and hamstring flexibility was assessed using the sit and reach test, and vertical jump was assessed using a digital jump mat (Newtest Systems, Oulu, Finland). Three tests were completed by all participants, with the best effort of each test being used for analysis. Maximal oxygen uptake was also estimated from the multistage fitness test.[10]

Analysis
After completion of the tests, univariate analysis of variance with Bonferroni adjustments was used to examine any differences in anthropometric and physiological variables according to playing position. Descriptive statistics were also calculated. SPSS version 11.0 was used for all analyses.

RESULTS
Table 1 shows results from statistical tests and mean (SD) of all values according to playing position. The results indicate that the only measures influenced by playing position were the sit and reach test and the mesomorphic and ectomorphic components of somatotype. Sit and reach scores were significantly ($p<0.01$) different between opposites and hitters, with hitters having significantly higher scores than opposites. Mean (SD) for sit and reach was 19.3 (8.3) cm for opposites and 37 (10.7) cm for hitters. With regard to somatotype, the results indicate a significant difference in mesomorphic scores ($F_{3,24} = 5.458$, $p<0.01$) and ectomorphic scores ($F_{3,24} = 3.293$, $p<0.05$). Bonferroni adjustments indicated that setters were significantly less mesmorphic than centres ($p<0.01$) but significantly more ectomorphic than centres ($p<0.05$). Mean (SD) of somatotype (endomorphy, mesomporphy, ectomorphy) for setters and centres was 2.6 (0.9), 1.9 (1.1), 5.3 (1.2) and 2.2 (0.8), 3.9 (1.1), 3.6 (0.7) respectively. Classification of somatotypes according to the Heath-Carter method[2] revealed that setters were classed as endomorphic ectomorphs, hitters and opposites were balanced ectomorphs, and centres were classified as ectomorphic mesomorphs.

DISCUSSION
These findings support previous research with senior volleyball players[1] that also found the greatest differences in somatotype between setters and centres in elite adult volleyball players. However, unlike that research, centres in the present study were more mesomorphic than players in any other position. These differences may be related to the different technical and tactical demands placed on players in different positions. Although high ectomorphy scores may be advantageous because of the nature of game play in volleyball, in centres, endurance of the opposing attack is the primary concern, whereas setters require more speed and agility in terms of attack organisation. Therefore greater mesomorphy may be advantageous in sustaining opposing attacks for centres, but, as speed of movement and agility are more essential in the role of setter, high mesomorphy scores would not be advantageous. The somatotype scores of hitters and opposites tend to be intermediate between centres and setters in the present study, supporting previous research.[1] There appears to be no clear explanation for the differences in low back and hamstring flexibility found in the present study, and additional research is needed to explain why opposites may have lower levels of low back and hamstring flexibility than hitters. Other than somatotype and sit and reach scores, no significant differences were found in the anthropometric or physiological profile of these volleyball players according to playing position. This may indicate that similar levels of leg strength, explosive leg power, estimated maximal oxygen uptake, muscle mass, and percentage body fat are required for elite volleyball irrespective of playing position. Overall, such information may be useful for talent identification, sport selection, and planning specific training programmes that correctly consider the physical traits and

What is already known on this topic

- Few studies have examined the anthropometric and physiological profiles of elite volleyball players; however, somatotype and physiological values have previously been reported for adult athletes
- Both characteristics have been linked with playing position and level of competition

What this study adds

- This study evaluates the anthropometric and physiological characteristics of a group of elite junior volleyball players and provides an insight into these characteristics with respect to playing position
- It also highlights the need to consider anthropometric and physiological differences when selecting playing position, allocating resources, or creating strength and conditioning programmes for junior volleyball players

abilities of the athlete. Further research examining the role that anthropometric and physiological factors play in volleyball performance specific to playing position would be desirable.

These findings imply that somatotypes differ as a function of positional role in volleyball and that sports scientists, coaches, and strength and conditioning professionals need to be aware of the specific positional requirements in volleyball in terms of body type. Consideration of an athlete's body type when allocating resources, selecting playing position, and within conditioning programmes may be beneficial in increasing the effectiveness of players within a team.

In addition, examination of the physiological profile of elite level athletes may provide a basis for position specific training programmes and provide the athlete with information on where training may be directed or to compensate for areas where the athlete may be below average in their specific sport.

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COMMENTARY

Volleyball is a very specialised sport, with both anthropometric and physiological characteristics being unique at the various positions. This study helps to identify the anthropometric differences between positions and illustrate that adiposity, musculoskeletal robustness, and linearity are each specific among the various positions. This said, I would expect that there would be greater differences in physiological characteristics between positions given the different physiological and performance demands necessary for success at the various positions. Future studies should look at the physiological and performance characteristics that differentiate successful players at each position. I would agree with the authors' assessment that there are distinguishing anthropometric differences between positions, but would also expect that the physiological and performance characteristics would also distinguish between positions in some manner. In addition, how would starters compare with back ups, and how would those who made the final squad compare with those who did not?

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