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Comparison of Morphological Profiles
and Performance Variables Between Female Volleyball Players
of the First and Second Division In Portugal

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Knowledge of players' anthropometric profiles may contribute to a better understanding of the differences between their performance levels. For example, vertical jump height, which is a major indicator of a volleyball player's performance, is influenced by favorable anthropometric variables. This study's aim was to describe anthropometric profiles of elite female volleyball players competing in the 1st and 2nd divisions in Portugal and to link these profiles with performance skills such as jump height obtained during blocking and spiking actions. Fifty-nine volleyball players were analyzed according to their competitive level, forming three independent groups: GA (n = 20, A1 division, ranked first), GB (n = 21, A1 division, ranked last) and GC (n = 18, A2 division). Anthropometric data collected included body mass and height, arm span, seven skinfolds (triceps, biceps, subscapular, suprailiac, abdominal, thigh and calf), four body perimeters (relaxed brachial, contracted brachial, thigh and calf), and two body diameters (humeral and femoral). Performance data included the height obtained during block and spike actions. Significant differences were found between groups (GA/GB from A1 and GC from A2). Players in the GA had the highest body mass (68.05 ± 6.62 kg, p < 0.05), body height (176.35 ± 6.21 cm, p < 0.05), arm span (177.59 ± 6.09 cm, p < 0.05), lean mass (53.51 ± 4.94 kg, p < 0.05) and vertical jump heights (block: 0.36 ± 0.06 m and spike: 0.43 ± 0.05 m, p < 0.05). As expected, the fat mass percentage of GA players was the lowest (21.30 ± 2.61%). The results suggest that anthropometric profiles of volleyball players may vary according to the competitive level. The higher body mass, body height, arm span, and lean mass presented by GA players in comparison with GC players suggest these variables are important for top-level performance, since these athletes also exhibited higher jump heights. Variables such as height and arm span have a considerable genetic influence and could be important for early talent identification in volleyball. Other variables such as body mass, lean mass and vertical jump performance are more complex, since they also reflect the effects of environmental and training conditions.

Key words: anthropometric characteristics, volleyball, somatotype, vertical jump.

Introduction

Volleyball is one of the most popular sports in the world, played in many countries (more than 200 nations are member of FIVB), particularly in African, American, Asian and European nations (www.fivb.org). Volleyball is an intermittent sport that requires performance of frequent high-intensity and short-duration activities interspersed with low-intensity periods (Chamari et al., 2001; Driss et al., 1998; Gabbett and Georgieff, 2007). Successful participation in

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this and many other sports requires a high level of technical and tactical skills, which should reflect the influence of training and suitable anthropometric characteristics (Fields et al., 2017; Gaurav et al., 2010). Skills such as the block and spike require a high capacity to perform vertical jumps and are major determinants in volleyball games. Approximately 80% of game points are obtained when performing these skills (Voigt and Vetter, 2003). Improving them requires regular training (Ciccarone et al., 2007), which should be based on muscular strength and power exercises (Buśko, 2009; Smith et al., 1992). Vertical jump performance is, however, influenced by anthropometric variables that also reflect genetic characteristics (Chatterjee et al., 1999). The available literature shows, for example, that body fat content in female volleyball players generally ranges from 11.7 to 27.1% (Geladas and Maridaki, 1996; Hassapidou and Mastrantoni, 2001; Papadopoulou et al., 2002; Viviani and Baldin, 1993). As a result, the typical volleyball player somatotype is reported as being mesomorph-endomorph (Malousaris et al., 2008). Data comparing morphological characteristics of female volleyball players with players of other sports (Bayios et al., 2006) from different countries (Ayan et al., 2012; Cabral et al., 2008; Duncan et al., 2006; Milic et al., 2012), and for different competition levels and playing positions (Carvajal et al., 2012; Gualdi-Russo and Zaccagni, 2001; Malousaris et al., 2008) are available in the literature.

Although there are some studies involving Portuguese male volleyball players (Marques and Marinho, 2009), there is no data for Portuguese female elite volleyball players comparing anthropometric characteristics with performance data. Therefore, the main goals of this research were to analyze differences in the frequency of each somatotype category between less and more successful female senior volleyball players and to find differences in key performance variables, such as the vertical jump, in relation to the competition level.

It was hypothesized that players from different divisions would exhibit differences in their anthropometric profiles and in the vertical jump height in agreement with observations made in previous studies involving athletes of other nationalities.

Methods

Participants

Fifty-nine female volleyball players were analyzed according to their competitive level, forming three independent groups: GA (n = 20, A1 division, from clubs ranked 1st to 4th in the A1 division), GB (n = 21, A1 division, from clubs ranked 9th to 12th in the A1 division) and GC (n = 18, competing in the second National League or A2 division). All participants were evaluated during the 2005/06 season. This protocol was approved by the ethics committee of the Sports Sciences, Health and Human Development Research Center (Portugal), and was in accordance with the latest revision of the Declaration of Helsinki.

Anthropometric measures

The players' body mass, body height and arm span were measured, along with seven skinfolds (triceps, biceps, subscapular, suprailiac, abdominal, thigh and calf), four body perimeters (relaxed brachial, contracted brachial, thigh and calf), and two body diameters (humeral and femoral). After that, the three somatotype classifications (ectomorphy, mesomorphy and endomorphy) were assessed by tracing out the respective somatotype letter (Carter and Heath, 1990).

The body fat percentage was calculated using the Siri equation (Siri, 1961) (Eq. 1)

Percentage of body fat = (495 / Body density) − 450 (Eq.1)

Body density was calculated using Eq. 2 (Forsyth and Sinning, 1973):

Body density = 1.02415 − (0.00169 * α) + (0.00444 * β) − (0.0013 * μ) (Eq.2)

α: subscapular skinfold (mm); *β*: height (cm); *μ*: abdominal skinfold (mm)

Fat mass (FM) was estimated using Eq. 3.

Fat mass = Body Weight * (Fat Percentage / 100) (Eq.3)

Lean body mass (LBM) was calculated by subtracting fat mass from body mass.

Jump performance

The height (m) achieved during the block

and spike was measured using an *ergojump* device (Globus Ergo tester, Italy). The participants were instructed to perform each test with accuracy. Additionally, key feedback was provided during the tests to ensure a proper jump technique. In the event of a clear error, the test was disregarded, and another attempt was allowed. The vertical jump protocol consisted of three countermovement jumps (block) and three countermovement jumps using arms, with individual technique and coordination (spike). Three-minute rest intervals were given between the two sets of different jumps.

Procedures

The measurements were conducted in the last third of the competition season (during the play-offs phase) by experienced technicians. To analyze the morphological profiles, anthropometric measurements were collected in accordance with previous literature (Heyward and Stolarczyk, 1996). Height was measured to the nearest 0.1 mm using a SECA 213 stadiometer. Body mass (kg) was measured to the nearest 50 g using a SECA 769 digital scale.

The seven skinfolds were assessed using a Harpenden skinfold caliper with a constant pressure of 10 g/mm², allowing readings with accuracy of 0.1 mm. Breadths were measured using a small (Campbell 10) and a large (Campbell 20) sliding caliper from Rosscraft Innovations Inc., (Vancouver, Canada), with 0.1 mm accuracy. The four body perimeters were estimated using an inelastic anthropometric tape with accuracy of 0.1 cm. Each variable was measured three times on the right hemisphere. The mean of all the measurements was considered the final value. All evaluations were performed by the same experienced researcher, assisted by a recorder.

Statistical analysis

For a comparative analysis of somatotypes between groups, the Somatotype Attitudinal Distance (SAD) interpretative model was used, defined as the spatial distance between two somatopoints, along with the somatotype attitudinal mean (SAM), defined as the average of the SADs of each somatopoint from the mean somatopoint (S) of a sample (Carter and Heath, 1990).

Descriptive statistics and analysis of variance (two-way ANOVA) were used to compare mean values of each measure between A1 (GA and GB) and A2 (GC) competition levels. The Bonferroni post-hoc test was used to assign specific differences in the ANOVA when a significant F-value was computed. The probability of type I error (alpha) was set a priori at 0.05. All procedures were performed using SPSS 21.0 statistical software (SPSS Inc., Chicago, IL, USA).

Results

The body composition characteristics are summarized in Table 1. The competition level had a significant effect on body height and arm span ($p < 0.05$), with players from the A1 (GA and GB) and A2 (GC) divisions presenting the highest and the lowest values, respectively. Significant differences were also found in all skinfolds, except for suprailiac. Regarding skinfolds, A1 players (GA and GB) had the lowest values, while A2 players (GC) obtained the highest values. No differences were found in the perimeter variables between groups.

Table 2 shows significant differences in the sum of three, five and seven skinfolds and the percentage of body fat between groups. GA and GB presented the lowest values in the sum of skinfolds, which resulted in a lower body fat content. A2 players presented higher values in the sum of the skinfolds and the percentage of body fat. In relation to lean body mass, GA and GC players had the highest and lowest values, respectively.

The somatoplot (Figure 1) shows the mean values of the players' somatotypes. Generally, all players were characterized as balanced endomorphs. However, A1 players were leaner than A2 players. Both GA and GB groups were identified as endomorph-ectomorphs (4.3-2.7-3.1 and 4.5-2.3-3.3, respectively). In the A2 division, players (GC) were classified as endomorph-mesomorphs (7.3-3.3-1.9).

The results regarding performance obtained from specific vertical jumps (block and spike) are summarized in Table 3. The mean values of the jumps show that GA players achieved higher results in both jumps, with the only statistically significant difference being between the GA and the GC for the spike jump.

Table 1

Anthropometric characteristics of Portuguese female volleyball players
from the A1 (GA and GB) and A2 (GC) divisions (Mean ± SD).

	GA	GB	GC
Number of players	**20**	**21**	**18**
Body height (cm)	176.35 ± 6.12 [a]	174.95 ± 8.39 [b]	168.17 ± 7.49 [a,b]
Body mass (kg)	**68.05 ± 6.62**	**64.48 ± 7.59**	**66.39 ± 8.43**
Arm span (cm)	177.65 ± 6.09 [a]	174.19 ± 7.07	169.39 ± 8.49 [a]
Skinfolds (mm)			
Triceps	15.55 ± 3.97 [a]	15.86 ± 4.16 [b]	35.89 ± 6.68 [a,b]
Biceps	8.95 ± 3.25 [a]	9.05 ± 3.64 [b]	25.44 ± 4.51 [a,b]
Subscapular	9.80 ± 2.17 [a]	9.81 ± 1.97 [b]	19.17 ± 6.95 [a,b]
Suprailiac	19.60 ± 6.81	21.19 ± 5.40	23.89 ± 8.34
Abdominal	15.50 ± 4.52 [a]	14.95 ± 5.29 [b]	31.83 ± 9.54 [a,b]
Thigh	22.05 ± 5.53 [a]	23.57 ± 5.62 [b]	47.78 ± 9.12 [a,b]
Calf	18.40 ± 5.34 [a]	20.05 ± 4.54 [b]	39.00 ± 7.62 [a,b]
Diameters (cm)			
Humeral	6.03 ± 0.38	5.72 ± 0.35 [b]	6.07 ± 0.40 [b]
Femoral	9.11 ± 0.56	8.88 ± 0.39 [b]	9.46 ± 0.68 [b]
Perimeters (cm)			
Brachial relaxed	26.55 ± 1.54	25.60 ± 1.68	26.36 ± 1.75
Brachial contracted	28.03 ± 2.74	27.67 ± 1.75	28.28 ± 2.18
Thigh	51.70 ± 4.51	50.57 ± 3.45	53.28 ± 4.86
Calf	37.21 ± 2.35	36.31 ± 2.30	37.03 ± 2.87

[a] *significant difference (p < 0.05) between GA and GC divisions (A1 first and A2)*
[b] *significant difference (p < 0.05) between GB and GC divisions (A1 last and A2)*

Table 2

Body composition indices and somatotype variables of Portuguese female
volleyball players from the A1 (GA and GB) and A2 (GC) competition levels (Mean ± SD).

	GA	GB	GC
Sum of 7SKFS (mm)	111.29 ± 21.77 [a]	113.06 ± 23.59 [b]	198.61 ± 38.66 [a,b]
Sum of 5SKFS (mm)	86.57 ± 16.51 [a]	89.29 ± 16.57 [b]	148.27 ± 28.89 [a,b]
Sum of 3SKFS (mm)	45.21 ± 11.38 [a]	47.36 ± 10.07 [b]	71.52 ± 20.18 [a,b]
Body fat (%)	21.30 ± 2.61 [a]	21.80 ± 2.32 [b]	27.29 ± 2.71 [a,b]
Fat mass (kg)	14.54 ± 2.67 [a]	14.11 ± 2.63 [b]	18.13 ± 2.93 [a,b]
Fat free mass (kg)	53.51 ± 4.94 [a]	50.36 ± 5.57	48.26 ± 6.40 [a]
Endomorphy	4.26 ± 0.88 [a]	4.51 ± 0.91	7.28 ± 1.62 [a,b]
Mesomorphy	2.71 ± 1.00	2.25 ± 0.92 [b]	3.33 ± 1.24 [b]
Ectomorphy	3.08 ± 0.88 [a]	3.29 ±1.06 [b]	1.90 ± 1.31 [a,b]
Somatotype Category	endomorph-ectomorphs	endomorph-ectomorphs	endomorph-mesomorphs

[a] *significant difference (p < 0.05) between GA and GC divisions (A1 first and A2)*
[b] *significant difference (p < 0.05) between GB and GC divisions (A1 last and A2)*

Table 3

Technical vertical jump performances of Portuguese female volleyball players
from the A1 (GA and GB) and A2 (GC) competition level (Mean ± SD).

	GA	GB	GC
N	**20**	**21**	**18**
Blocking height (m)	0.36 ± 0.06	0.35 ± 0.06	0.33 ± 0.05
Spiking height (m)	0.43± 0.05 [a]	0.42 ± 0.06	0.37 ± 0.05 [a]

[a] *significant difference (p < 0.05) between GA and GC divisions (A1 first and. A2)*
[b] *significant difference (p < 0.05) between GB and GC divisions (A1 last and A2)*
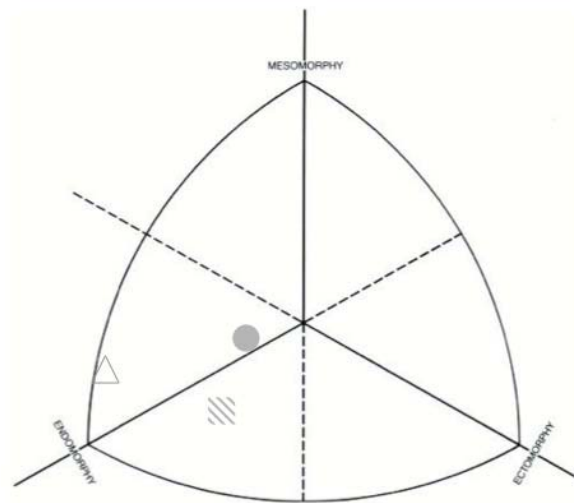
Figure 1
Somatochart of Portuguese female players from different competition levels.
(⬤ mean of GA; ▨ mean of GB; △ mean of GC)

Discussion

The results of this study show that Portuguese female volleyball players competing in the first and second divisions present different body composition and somatometric values.

Body height and vertical jump height values appear to be key factors in determining volleyball performance. As expected, differences were found in body height values between the two divisions (GA, A1 players 176.4 ± 6.12 cm and A2 players 168.17 ± 7.49 cm). Similar results were found in Greek international elite players (177.1 ± 6.5 cm) (Malousaris et al., 2008). However, volleyball players can be even taller, for example, Chinese female players (183.6 ± 5.8 cm) in the top eight teams of the 2007-2008 national championship. These differences in body height

seem to be a determining factor for success in elite volleyball performance. For example, from 1992 to 2002, the number of female volleyball players taller than 190 cm increased rapidly (Gao, 2006). This trend confirms the importance that coaches attribute to this variable when selecting the most talented players. These changes in anthropometric profiles can be confirmed in the height indices of the top six female volleyball teams: the mean increased by 0.03 cm from 1.81 to 1.84 m between the 26th to the 29th Olympic Games (Gao, 2006; Zhang, 1998). Moreover, body height and the arm span, which also display significant differences between the GA and GC groups, appear to have a high level of heritability (Chatterjee et al., 1999), which supports their use for talent detection.

Body fat and fat free mass are also two important variables for elite volleyball players. In

fact, these variables are strongly correlated with the ability to increase muscular strength, which contributes to better performance. Differences were found between the groups, with A1 players showing less fat mass and greater fat free mass. The mean of the sum of 3, 5 and 7 skinfolds of the A1 division players presented lower values of fat mass and higher values of fat free mass compared with A2 division players.

The body fat percentages for A1 players (GA: 21.3 ± 2.61% and GB: 21.80 ± 2.32%) were similar to the values reported by Papadopoulou et al. (2002) in a study with Greek female volleyball players from the national team (22.4 ± 4.7%) and the A1 (21.3 ± 5.5%) division. Another study by Malousaris et al. (2008), also with female volleyball players in the A1 Greek National League, presented similar results (22.7 ± 2.9%). However, in general, the A2 Portuguese female players had higher body fat percentages compared to other volleyball players of different ages and competition levels (Geladas and Maridaki, 1996; Hassapidou and Mastrantoni, 2001; Papadopoulou et al., 2002).

The negative correlation between the body fat percentage and performance is well documented (Nikolaidis, 2013). In fact, Table 2 confirms the above-mentioned trend, with GA and GB players presenting lower values than GC players, while also exhibiting higher vertical jump heights, especially for spike actions.

Regarding the somatotype, significant differences were found between A1 and A2 players in the endomorphy and ectomorphy components, with A1 players presenting lower values in endomorphy and higher values of ectomorphy, as expected. The somatoplot (Figure 1) shows that, in general, all players were characterized as balanced endomorphs. Yet A1 players were leaner than A2 players. Both groups (GA and GB) from the A1 division were identified as endomorph-ectomorphs (4.3-2.7-3.1 and 4.5-2.3-3.3, respectively), while players from the A2 division (GC) were characterized as endomorph-mesomorphs (7.3-3.3-1.9). Nevertheless, the first component (endomorph) of A2 division players presented higher values than A1 players. Compared to the A2, the morphology of A1 players was characterized by higher ectomorphy and lower endomorphy. These results are similar to those found by Malousaris et al. (2008) in a study with Greek female players that were characterized as endomorph-ectomorphs (3.2-2.4-3.2) and balanced endomorphs (3.6-2.9-2.7) in the A1 and A2 divisions, respectively. Also, in a study with Italian A1 and A2 volleyball leagues (Gualdi-Russo and Zaccagni, 2001), differences were observed between the two somatotypes (2.9-3.1-3.0 and 3.1-3.5-2.7), with A1 players having lower endomorphy and higher ectomorphy than A2 players, whereas the mesomorphy was the main component. This trend was also confirmed in a study involving elite Chinese female volleyball players (3.7-2.9-4.0), whose main component was ectomorphy.

With respect to morphological characteristics, these profiles reflect the genetic make-up of the athletes, but also the level of training, probably one of the main reasons for the differences found between A1 and A2 players. A2 players had high values of endomorphy, which reflects the lack of elite training and lower performance quality in this division. The results of the A1 division are closer to the values found in studies with other international elite players but are still at a lower level. Together with physical profiles, these morphological variables seem to be key elements for coaches when selecting and detecting talents who may reach elite levels in volleyball.

Conclusion

The results of this study suggest that A1 players have a better morphological profile for high performance volleyball, since they had lower fat content and higher lean body mass. Regarding somatotype values, A1 players displayed the lowest endomorphy values and the highest ectomorphy values in comparison with A2 players. Players in the A1 division had morphological profiles and body composition values that are more suitable for high performance volleyball (i.e. lower fat percentage and higher values in body height and mass). This agrees with the volleyball ideal values for elite performance, suggesting a strong correlation with muscular strength and linearity.

Better performance among A1 players was also confirmed in spike height, suggesting that anthropometric and body composition indices as well as the somatotype could play an important role in specific volleyball performance-related skills. Since some anthropometric

variables are more likely to express the influence of heritability, future studies should analyze their relative contribution, along with environmental components, such as those introduced by nutritional aids or training.

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