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Discriminant effect of morphology and range of attack on the performance level of volleyball players

Efeito discriminante da morfologia e alcance de ataque no nível de desempenho em voleibolistas

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Abstract – The aim of this study was to identify the discriminant effect of morphology and range of attack-related variables on the performance level of under-17 female volleyball players. The sample consisted of young volleyball players (n=40) divided into two groups: players of the Brazilian national team (n=21) aged 15.86 ± 0.36 years, body weight of 68.11 ± 8.73 kg, and height of 181.61 ± 6.11 cm, and players of the state team of Rio Grande do Norte (n=19) aged 15.16 ± 0.88 years, body weight of 60.54 ± 7.60 kg, and height of 170.52 ± 7.97 cm. The somatotype was assessed using the Heath & Carter method. A modified Sargent test was used to assess vertical jump height and maximum attack height. The measures were compared between the two groups using the Student t-test for independent samples. Discriminant function analysis was applied to predict group allocation using the measures obtained as independent variables. The two groups differed significantly in terms of body weight, fat mass, height, maximum attack height, range of attack, and somatotype. Discriminant function analysis identified the somatotype measures (endomorphy, ectomorphy, and mesomorphy) with correlation coefficients below 0.30. The canonical correlation coefficient obtained with this function was 0.856. In conclusion, somatotype or vertical jump ability does not seem to distinguish elite athletes from non-elite athletes in under-17 female volleyball players, and height is the main morphological determinant to achieve elite level performance.

Key words: Volleyball; Performance; Morphology.

Resumo – *O estudo teve como objetivo identificar o efeito discriminante de variáveis morfológicas e de variáveis relacionadas com o alcance de ataque no nível de desempenho de voleibolistas da categoria infanto-juvenil do sexo feminino. A amostra incluiu voleibolistas da categoria infanto-juvenil (N=40), divididas em dois grupos: Seleção Nacional Brasileira (n=21) com idade = 15,86 ± 0,36 anos, massa corporal = 68,11 ± 8,73 kg, estatura = 181,61 ± 6,11 cm; e Seleção Estadual do Rio Grande do Norte (n=19) com idade = 15,16 ± 0,88 anos, massa corporal = 60,54 ± 7,60 kg, estatura = 170,52 ± 7,97 cm. Para identificar o somatotipo utilizou-se o protocolo de Heath & Carter. Para determinação da altura máxima de ataque e da impulsão vertical, foi utilizado o Sargent Test adaptado. As medidas dos dois grupos foram comparadas através do teste t de student para amostras independentes. Foi aplicada a função discriminante tendo como variáveis independentes as medidas recolhidas e como variável dependente o nível de prestação (grupo). Verificaram-se diferenças entre os dois grupos na massa corporal, massa gorda, estatura, altura máxima de alcance, alcance de ataque e somatotipo. A função discriminante identificou que as variáveis caracterizadoras do somatotipo (endomorfia, ectomorfia e mesomorfia) não apresentavam coeficiente de correlação modular superior a 0.30. Nesta função, o coeficiente de correlação canônica foi de 0.856. Conclui-se que em voleibolistas infanto-juvenis do sexo feminino, o somatotipo e a impulsão vertical não permitem diferenciar jogadoras segundo o nível de prestação e que a estatura é a medida morfológica mais determinante para chegar ao alto rendimento.*

Palavras-chave: *Voleibol; Rendimento; Morfologia.*

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INTRODUCTION

The advances in modern sport have led researchers in the area of sport sciences to investigate what characterizes sporting excellence. Brazilian volleyball, which is currently among the world elite, is experiencing marked technological advances that provide better training conditions due to the constant research in this area, as well as a renewal process in base selection. In addition, it has one of the best and exclusive training centers in the world.

Each sport modality presents particular characteristics specific to its needs that can to vary according to the specificity of the sport studied. These characteristics include anthropometric and biomotor variables. Studies in the area of kinanthropometry permit to identify, at different levels and stages, the reference standards and profile of future athletes of different modalities and to evaluate variables that interfere with high performance[1,2]. Morphological factors influence sport performance and somatotype analysis permits to evaluate body components that interfere with the achievement of high performance[3].

Analysis of the different characteristics of an elite athlete shows the importance of anthropometry and physical tests for the development of reference values. However, studies in the area of volleyball investigating these variables in initial competitive categories are scarce due to a strong tendency to study adult players[4].

Several studies have demonstrated the importance of anthropometric parameters and motor performance for to achieve high performance, with these variables being able to support training monitoring in an attempt to minimize possible errors. Specific characteristics such as height are considered to be essential to achieve high performance in volleyball[4].

In addition to knowledge about the specific profile of each sport modality, the rapid advances in elite sports require professionals to understand the specific physical characteristics in different playing positions or functions within the same modality in an attempt to increase training efficiency and to provide better specific training guidance[5]. Within this context, somatotype analysis adds information to common anthropometric measures (height, body weight, skinfolds, etc.) and is used to identify the existence of specific morphological types in each sport modality and playing position. The importance of this parameter has been demonstrated in studies investigating the ideal physical profile in different modalities[3,6-10]. Some studies have used somatotype analysis to establish the ideal physical profile of volleyball players in each playing position in order to facilitate training programs[3,6,11,12]. Studies regarding somatotype in volleyball conducted in different countries concluded that teams of the same category and qualification level tend to present a similar somatotype profile, whereas other studies found in the same category homogeneity of the somatotype profile in different playing positions for both male and female athletes[5,11,13-15].

Studies on Brazilian volleyball have classified the somatotype of female athletes into levels of trainings[16], as well as of the Brazilian under-17 male team[15,]. The importance of the somatotype of elite athletes in relation to different playing positions and performance levels has been reported in studies conducted in different countries[2,11-13].

Volleyball requires a broad repertoire of jump skills in different situations of the game. Vertical jump is of the utmost importance in volleyball and is mainly used during serving, setting, attacks and blocks, which are essential for scoring a point. Studies investigating the morphofunctional characteristics of volleyball players have focused on vertical jump height[5,11,17-22], although today the maximum range of attack of the player during jumping and not his vertical jump height has become more important. Marques et al[5] demonstrated the existence of different types of physical fitness and anthropometric profiles in male volleyball as a function of the specific position of the players.

The present study is relevant since it permits the identification of parameters that define the profile of elite athletes, contributing to the process of talent selection, a challenge for researchers and sport professionals. Therefore, the objective of this study was to identify the discriminant effect of morphological variables and variables related to range of attack on the performance level of female under-17 volleyball players.

METHODOLOGICAL PROCEDURES

Sample

The sample consisted of 40 female athletes aged 15 and 16 years divided into two groups: 21 athletes were invited to participate in the under-17 Brazilian team and 19 were invited to participate in the under-17 team of the State of Rio Grande do Norte. The two groups were in the initial basic period of training at the time of the study.

Procedures

Data from the Brazilian team were collected at the training center in Saquarema, Rio de Janeiro, and data from the Rio Grande do Norte team at the Laboratory of Physical Activity and Health of Universidade Federal do Rio Grande do Norte. Before data collection, the athletes received information about the study and signed an informed consent form together with their legally responsible persons. The study was conducted in accordance with the ethical guidelines of the National Health Council (Resolution 196/96) and was approved by the Ethics Committee of Universidade Federal do Rio Grande do Norte (protocol 119/05).

Protocols

Body weight was measured with an anthropometric scale (Filizola, Brazil) to the nearest 100 g, with the subjects wearing as little clothing as possible and standing on the center of the platform, with weight evenly distributed across both feet. Height was measured with a stadiometer, with the subjects standing barefoot, the arms extended along the body and the head in the Frankfurt plane, according to the protocol of Marfell-Jones et al.[23].

Somatotype was evaluated by the Heath-Carter method[24]. The measures necessary for somatotype analysis: body weight; height; triceps (TR), subscapular (SB), supraspinale (SE) and medial calf (PM) skinfold thickness; humerus and femoral bone diameter, and circumference of the leg and arm contracted, were obtained as described by Marfell-Jones et al.[23]. Fat mass was evaluated based on triceps and subscapular skinfolds using the protocol described by Slaughter et al.[25]. Skinfold thickness was measured with a plicometer (Sanny, Brazil) and bone diameter and body circumference were measured with a caliper and metric tape, respectively (Sanny, Brazil).

For analysis and comparison of the somatotype data of the athletes, the somatotype dispersion distance (SDD) suggested by Ross and Wilson[22], somatotype attitudinal distance (SAD)[23], somatotype dispersion index (SDI), and somatotype attitudinal mean (SAM) were calculated. An SDD ≥ 2 and an SAD ≥ 1 were used as criteria to determine the presence or absence of differences between groups.

A modified protocol of the Sargent Jump test described by Bulingin [26] was used for the evaluation of vertical jump height and range of attack. Total height is taken with the subject standing perpendicular to the tape and the dominant arm extended. The subject then runs approximately 2 or 3 steps oblique to the wall (with an individually chosen angle of 30 to 45 degrees). After an impulse from both feet, the subject performs a maximum vertical jump using the dominant arm. Three jumps were performed at an interval of 3 min and the best score for the maximum range of attack was considered. A centimeter-graded ruler fixed to the wall 2 m above the floor was used for the measurement. The wall had been constructed above a slab in order to permit preparatory movements in an open space.

Statistical analysis

The results are reported as means and standard deviations. Application of the Shapiro-Wilk test showed a normal distribution of the data. Anthropometric variables and the results of the jump test were compared between teams by the Student t-test for independent samples. The SAD was used for the comparison of somatotypes, with an SAD ≥ 1 indicating differences between groups. The discriminatory function was constructed using all measures obtained in this study as independent (predictive) variables. The two groups (teams) were the dependent variable. The SPSS 16.0 program was used for statistical analysis and $p<0.05$ indicated statistical significance.

RESULTS

Table 1 shows the mean and standard deviation of body weight, height, fat mass, maximum height, vertical jump height for attack, and maximum range of attack. Only age and vertical jump height did not differ significantly between groups. The national team was superior in terms of all other variables, except for fat mass.

The following numerical values were obtained for the three somatotype components: endomorphy (3.08 ± 0.85), mesomorphy (2.26 ± 1.07) and ectomorphy (3.81 ± 1.29) for the national team, and endomorphy (3.94 ± 1.0), mesomorphy (2.27 ± 1.1) and ectomorphy (3.33 ± 1.14) for the team from Rio Grande do Norte. The somatotype ratings were endo-ectomorph and Ecto-endomorph, for athletes of national and state selections, respectively. The SDD was 2.25, demonstrating a difference between the value studied and the reference value. The SAD was 1.0, confirming the difference between somatotypes. Calculation of SDI (0.025) and SAM (0.03) values close to zero shows the homogeneity of the subjects in relation to the average of the sample.

Table 1. Comparison of body weight, height, fat mass, maximum height, vertical jump height, and maximum range of attack between under-17 female volleyball players of the national team and a state team.

	National team (N=21)		State team (N=19)	
	Mean	SD	Mean	SD
Age (years)	15.86	0.36	15.16	0.88
Body weight (kg)	68.11*	8.73	60.54*	7.60
Height (cm)	181.61*	6.11	170.52*	7.97
Fat mass (%)	20.07*	3.55	23.21*	3.95
Maximum height reached with extended arm (cm)	238.21*	6.37	221.68*	10.24
Vertical jump height (cm)	43.58	5.32	44.47	3.67
Maximum range of attack (cm)	281.79*	8.55	266.16*	12.15

Values are the mean and standard deviation (SD).
* Significant difference between teams ($p<0.05$).

Application of the discriminant function showed that 8 of the 9 variables had entered the function as predictors of performance levels, although only 6 of these variables presented a modular correlation coefficient higher than 0.30. The canonical correlation coefficient in this function was 0.776 (Table 2).

Table 2. Structural matrix of canonical correlation and the other results of the discriminant function.

Variables of the function	Correlation coefficient
Height	0.855
Maximum height	0.810
Range of attack	0.622
Body weight	0.452
Endomorphy	-0.350
Fat mass	-0.308
Ectomorphy	0.172
Vertical jump height*	0.082
Mesomorphy	-0.024
Wilk lambda	0.398
Chi-square	29.456
P	0.000
Eigenvalue	1.511
Canonical correlation	0.776

* Variable not used in the analysis because it did not pass the tolerance test.

DISCUSSION

The objective of the present study was to identify the discriminant effect of morphological variables and variables related to range of attack on the performance level of under-17 female volleyball players. The two groups studied differed in terms of body weight, fat mass, height, maximum attack height, range of attack, and somatotype. However, the discriminant function showed that the modular correlation coefficient of two of the somatotype components (ectomorphy and mesomorphy) did not exceed 0.30. The canonical correlation coefficient in this function was 0.776.

In the present study, the difference in height, and consequently in maximum height reached with arm extended, determined the distinction between high and intermediate performance, in agreement with the literature. As a consequence, in addition to genetic variables, physical qualities and training strategies, height is currently considered to be a fundamental element to achieve a high performance level in volleyball.

The evolution of height in world volleyball can be illustrated by old data from the female Brazilian team, which was not ranked in world volleyball at that time, and the Japanese team, an olympic and world champion. The mean height of these teams was 174.29 ± 3.91 and 175.54 ± 3.31 cm, respectively[28], compared to the current mean height of 181.61 ± 6.11 cm. In a study involving elite volleyball players from Greece[12], the mean height of adult teams was 177 cm, with a mean of 179.6 cm for athletes from the 1st division and of 174.7 cm for athletes from the 2nd division. These values are below the height of the national Brazilian team and much higher than that of the state team studied. These data demonstrate that the higher the performance level, the taller the players. Studying young female volleyball players, Stamm et al[29] concluded that height is a significant factor

in the performance of game elements, particularly for attack and block (71-83%).

A significant difference in body weight was also observed in the present study, which was higher in the national team compared to the team from Rio Grande do Norte. This result is expected as a consequence of the greater height of the former, in addition to a higher muscle mass due to more rigorous nutritional monitoring and higher training volume of professional athletes. Although muscle mass or lean mass was not directly quantified in the present study, the estimated fat mass and total body weight indicate a higher amount of lean mass in athletes of the national team.

Explosive strength of the lower limbs, which was quantified indirectly by vertical jump height, did not differ between the two groups. However, the maximum range of attack was higher in the national team, probably because of the greater height and maximum height reached with extended arm observed for these athletes ($p<0.001$). These results suggest that jumping power may not be an important variable for athlete selection, or that it is at least less important than anthropometric characteristics, especially height. As a consequence, tall athletes can develop this physical quality with training, whereas short athletes will not reach the same attack height as tall elite athletes, irrespective of training volume.

Somatotype analysis showed a higher endomorphy rating compared to the mesomorph value for the under-17 category. The same trend has been reported in the study of Silva et al [4]. Gualdi-Russo and Zaccagni[13], studying adult Italian elite volleyball players, obtained somatotype values of 3.0 ± 0.8, 3.3 ± 1.0 and 2.9 ± 0.9 for endomorphy, mesomorphy and ectomorphy. The authors concluded that the somatotype varies according to performance levels and playing position. Duncan et al[11], also studying junior elite female volleyball players, observed that setters were more ectomorphic and less mesomorphic than centers. Mean somatotype values (endomorphy, mesomorphy and ectomorphy) were 2.6 ± 0.9, 1.9 ± 1.1 and 5.3 ± 1.2 for setters, and 2.2 ± 0.8, 3.9 ± 1.1 and 3.6 ± 0.7 for centers. In a study involving adult Greek volleyball players of different performance levels, Malousaris et al[12] observed differences in the first and third component according to performance level for athletes of the 1st division (3.2 ± 0.8, 2.4 ± 1.1 and 3.2 ± 0.9) and of the 2nd division (3.6 ± 0.7, 2.9 ± 1.0 and 2.7 ± 1.0).

Bayios et al[7], comparing the somatotype of Greek elite female volleyball, handball and basketball players, observed that volleyball players were taller. Variations in somatotype according to competitive level have been reported in the literature, with teams at low competitive levels showing higher endomorphy and lower mesomorphy, whereas the opposite is observed for elite teams. The balance between the mesomorphic and ectomorphic components reflects the tendency of world volleyball, i.e., strong and tall athletes with a long slender body.

Analysis of the somatochart of the Brazilian national team showed that the data were more normally distributed and concentrated in the ectomorph region when compared to the state team, a finding indicating a better balance between height and total body weight. This is probably an important characteristic for the selection of volleyball athletes.

Taken together, the literature data and the results of the present study demonstrate the need for a more accurate definition of the profiles of different positions and levels of qualification in volleyball.

However, the simple comparison of the values obtained for the two teams does not permit to conclude whether it is more or less likely that an athlete belongs to an elite group based on his/her morphological profile or maximum range. Therefore, discriminant analysis was performed in the present study. Using discriminant analysis, Leone, Lariviere and Comtois[1] showed the existence of anthropometric and motor characteristics in adolescent athletes aged 12 to 17 years that distinguish volleyball players from tennis players or skaters. Similarly, Sampaio et al[6] used the same approach to differentiate basketball players from three different leagues according to their technical-tactical skills.

In the present study, discriminant analysis supported the results (differences) obtained by the comparisons mentioned above and permitted to exclude ectomorphy, mesomorphy and jumping ability (vertical jump height) as predictors of participation in an elite group (Brazilian national team). In this respect, the results suggest that body height and maximum height reached with extended arm, as well as variables resulting directly from these parameters (range of attack), permit to distinguish elite and non-elite athletes. However, the present study has limitations such as its cross-sectional design. Only longitudinal studies will permit to determine the existence of other training adaptations, over the years, will ultimately determine the specific characteristics of adult selections.

CONCLUSIONS

The two teams differed significantly in terms of height, body weight, fat mass and range of attack, with athletes of the national team showing higher mean values for all of these variables. Somatotype analysis classified the national Brazilian team as endo-ectomorphic and the team from Rio Grande do Norte as ecto-endomorphic. The results suggest that somatotype or vertical jump height does not permit to distinguish elite athletes from non-elite athletes in young female volleyball players, and that height is the main morphological determinant to achieve elite level performance

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