PHYSICAL FITNESS QUALITIES OF PROFESSIONAL VOLLEYBALL PLAYERS: DETERMINATION OF POSITIONAL DIFFERENCES

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ABSTRACT

Marques, MC, van den Tillaar, R, Gabbett, TJ, Reis, VM, and González-Badillo, JJ. Physical fitness qualities of professional volleyball players: Determination of positional differences. J Strength Cond Res 00(0): 1–6, 2009—The purpose of this study was to investigate the anthropometric and strength characteristics of elite male volleyball athletes and to determine if differences exist in these characteristics according to playing position. A group of 35 professional male team volleyball players (mean ± SD age: 26.6 ± 3.1 years) participated in the study. Players were categorized according to playing position and role: middle blockers (n = 9), opposite hitters (n = 6), outside hitters (n = 10), setters (n = 6), and liberos (n = 4). Height, body mass, muscular strength (4 repetition maximum bench press and 4 repetition maximum parallel squat tests), and muscular power (overhead medicine ball throw, countermovement jump) were assessed. Significant differences (p < 0.05) were found among the 5 positional categories. The results indicated that the middle blockers and opposite hitters were the tallest and heaviest players, whereas the libero players were the lightest. Differences were also found in bench press maximal strength, with the middle blockers and opposite players significantly stronger (p < 0.05) than the setters and liberos. The setter positional group had significantly poorer (p < 0.05) parallel squat performances than the outside hitter and opposite hitter groups. No other significant differences (p > 0.05) were found among groups for the strength and power parameters. These results demonstrate that significant anthropometric and strength differences exist among playing positions in elite male volleyball players. In addition, these findings provide normative data for elite male volleyball players competing in specific individual playing positions. From a practical perspective, sport scientists and conditioning professionals should take the strength and anthropometric characteristics of volleyball players into account when designing individualized position-specific training programs.

KEY WORDS anthropometric, specificity, strength, body mass

INTRODUCTION

Volleyball is a team sport played at all competitive levels (e.g., youth, Olympic, and professional) and places an emphasis on explosive movements such as jumping, hitting, and blocking (14,15). In addition to technical and tactical skills, it has been argued that muscular strength and power are the most important factors contributing to successful performance during elite competitions (15). A volleyball squad comprises 12 players with team positions broadly defined as setters, hitters (outside hitter/left side hitter and opposite hitter/right side hitter), middle blockers, and liberos. Each of these positions plays a specific role in a volleyball match (5).

Various investigations have been undertaken to ascertain specific physical and physiological profiles of athletes in a variety of sports. With respect to team sports, player profiling by position has been studied in volleyball (5,7), field hockey (3,8,9,16), basketball (1,2), netball (10), and soccer (21). In volleyball, the majority of the studies have reported the characteristics of women volleyball players or junior volleyball athletes of different positions (5–7). However, to our knowledge, no similar studies of professional male volleyball players are available. Despite the increase in professionalism, there is a paucity of research on performance characteristics of elite volleyball players (14,15), and...
to the authors’ knowledge, few data are available for professional players during an entire in-season. Research has predominantly compared the anthropometric and physiological profiles of volleyball players among playing positions (4,9,13) rather than on jumping ability, throwing performance, or maximal dynamic strength.

However, there still exists limited information concerning the differentiation of these parameters in volleyball players according to their playing position. If significant differences exist among playing positions, it may provide insight into the physical qualities important for that position. Thus, the main aim of this study was to investigate the anthropometric and strength characteristics of elite male volleyball athletes and to determine if differences exist in these characteristics according to playing position.

METHODS

Experimental Approach to the Problem
The present study used a cross-sectional experimental design to compare the anthropometric and strength characteristics of elite male volleyball athletes according to their playing position. It was hypothesized that significant differences in anthropometric characteristics and muscular strength and power qualities would be detected among playing positions in elite male volleyball players. This research was a longitudinal project completed over 3 professional competition in-seasons. All players competed in 2–3 matches per week, combined with volleyball practice sessions and the strength and conditioning regimen. The athletes were familiar with all the testing and training exercises, as they had completed a preseason training routine before the initiation of the current in-season study. Consequently, the athletes were in good overall physical condition and were adequately familiarized with all experimental procedures.

Subjects
A group of 35 full-time professional male team volleyball (indoor hard court) players (mean ± SD age: 26.6 ± 3.1 years) participated in the study. Players were categorized according to playing position and role. Players were categorized as middle blockers (n = 9), opposite hitters (n = 6), outside hitters (n = 10), setters (n = 6), and liberos (n = 4). The subjects included 13 Portuguese international players (some of whom played European Top Team league finals and one who had competed in the European Champion Title), 3 from the Australian first team, 2 U.S. players (both Olympic Champions 2008), 1 international Brazilian athlete, 1 Dutch international player, and 3 from the Canadian national team. Thus, 70% of the subjects were national first team players who played on European Champion, European league, World league, World Championship, and Olympic Game winning teams. All players represented the same club, which has been rated as one of the best elite volleyball teams in Portugal. Before commencing the study, players had a physical examination by the team physician and each was cleared of any medical disorders that might limit full participation in the investigation. No players were taking exogenous anabolic-androgenic steroids or other drugs or substances expected to affect physical performance or hormonal balance during this study. All the subjects gave their informed consent and volunteered to participate in the study, which had the approval of the Academy’s Ethical Advisory Commission. All participants were fully informed about the nature and demands of the study and the known health risks. They completed a health history questionnaire and were informed that they could withdraw from the study at any time.

Training History
Apart from standard technical and tactical practice sessions (3–4 h·d⁻¹) and competitions, the subjects completed a resistance training regimen that included upper- and lower-body exercises targeting strength and power. Briefly, the resistance program was performed twice per week during the 12-week in-season, with each session lasting approximately 50 minutes. The principal resistance exercises were the bench press and parallel back squat. Subjects performed 3 sets of 3–6 repetitions (reps) for each exercise in the range of 50–85% of their predetermined 4 repetition maximum (4RM), with the loads adjusted throughout the season. Subjects also completed upper- and lower-body power exercises (loaded and unloaded vertical jumping activities and medicine ball throwing).

Testing Procedures
A detailed description of the muscular power testing procedures can be found elsewhere (15). All testing was carried out at the completion of the second period of in-season training. During this initial preparatory phase, the subjects performed 3 sets of 8 reps using moderate loads for the bench press and squat exercises plus unloaded jumping drills and medicine ball throws. Consequently, all the subjects were familiarized with the testing procedures and exercises. Maximal strength and explosive tests were separated by a 2-day period. These were tests that could be rapidly administered and were highly specific to volleyball team (15).

Anthropometric Measurements
The anthropometric variables of height and body mass were measured in each subject. Height and body mass measurements were made on a leveled platform scale (Año Sayol, Barcelona, Spain) with an accuracy of 0.001 m and 0.01 kg, respectively.

Countermovement Jump
Countermovement jump (CMJ) height was measured using a trigonometric carpet (Ergo jump Digitime 1000, Digitest, Finland) by the methods described previously (15). Subjects began from a standing position and performed a crouching action followed immediately by a jump for maximal height. Each subject completed 3 attempts with 2 minutes of rest allowed between trials. The hands were on the hips throughout the entire jump. The average of the 2 best trials
was used for analysis. The unloaded CMJ had an intraclass correlation coefficient (ICC) of 0.98 and a coefficient of variation (CV) of 3.4%.

**Overhead Medicine Ball Throw**

An overhead medicine ball throw was used to evaluate the upper-body muscular power. While standing, subjects held a 3-kg medicine ball in both hands in front of the body with arms relaxed. The athletes were instructed to throw the ball over their heads as far as possible. A backward counter-movement was allowed during the action. Five trials were performed with a 1-minute rest between each trial. An average of the best 4 throws was subsequently used for analysis. The distance of the throw was recorded to the nearest 1 cm. The ball throwing distance (BTd) showed an ICC of 0.93 and a CV of 6.4%.

**Maximal Dynamic Strength**

Upper- and lower-body maximal strength tests were carried out using a 4 repetition maximum bench press (4RM-BP) and a 4 repetition maximum parallel squat (4RM-PS). The 4RM-BP test was conducted on a standard bench and required the subject to perform an eccentric-concentric action. Beginning with the arm fully extended, the athletes lowered the bar toward the chest reaching 90° abduction of the shoulder joint and 90° flexion of the elbow before returning to the start position. Reps performed incorrectly were not included in the count. The protocol began with 50 kg and increased 10, 5, and 2.5 kg during subsequent sets until 4 complete reps could not be performed. All subjects performed 5–6 reps for each warm-up set. The rest time between sets was 3 minutes. In the 4RM-PS, the bar was placed across the trapezius at a self-chosen location and the starting position of knee angle was set at 180° (full leg extension). The squat was performed to the parallel position, that is, when the greater trochanter of the femur was lowered to the same level as the knee. Two researchers monitored the correct position. The subject then lifted the weight until his knees were fully extended. Each player started with identical weights of 90 kg, performing on command a series of 4 complete parallel squats. Subsequently, the weight was increased by 10 kg increments until the subject was unable to reach full leg extension. The last bearable load was determined as being 4RM. Five-minute rest intervals separated the 4RM-BP and 4RM-PS tests. The 4RM-BP showed an ICC of 0.96 and a CV of 5.6%. The 4RM-PS reported an ICC of 0.92 and a CV of 5.7%.

### Statistical Analyses

A one-way analysis of variance was used to determine significant differences among positions in physical and performance characteristics. Statistical power varied from 0.75 to 1.0 for the different tests. According to the literature, a statistical power of 0.5 or greater is considered adequate for sport science research with statistical power of 0.8 or greater considered very high (19). Relationships between the subjects’ physique (height and body mass), muscular strength and power performance, and playing position were examined using the Pearson product-moment correlation coefficient. The level of significance was set at \( p \leq 0.05 \), and all data are expressed as mean \( \pm SD \).

### Results

#### Anthropometric Characteristics

Tables 1 and 2 show the anthropometric strength and power results for each positional group. Significant effects of body mass and height together with differences in the 2 strength parameters were found among the groups \( ( p < 0.05 ) \). Post hoc comparison indicated that height and body mass differed significantly among most groups; however, no significant differences were found between the outside hitters and setters \( ( p = 0.27 ) \) for height. In addition, no significant differences \( ( p > 0.05 ) \) were detected between the middle blockers and opposite hitters \( ( p = 0.83 ) \) and between liberos and setters \( ( p = 0.21 ) \) for body mass. The middle blockers and opposite hitters were the tallest and heaviest players, whereas the libero players were the lightest (Table 1).

#### Muscular Strength and Power

Significant differences were also found in maximal bench press strength, with the middle blockers and opposite players lifting more weight than the setters and liberos. The setter positional group had significantly poorer \( ( p < 0.05 ) \) parallel

### Table 1. Anthropometric characteristics of individual playing positions in professional male volleyball players.*

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Height (cm)</th>
<th>Body mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle blockers</td>
<td>25.7 ± 3.6</td>
<td>203 ± 0.04</td>
</tr>
<tr>
<td>Opposite hitters</td>
<td>28.7 ± 3.1</td>
<td>200 ± 0.04</td>
</tr>
<tr>
<td>Outside hitters</td>
<td>27.6 ± 2.3</td>
<td>191 ± 0.02‡</td>
</tr>
<tr>
<td>Setters</td>
<td>27.7 ± 3.5</td>
<td>190 ± 0.05‡</td>
</tr>
<tr>
<td>Liberos</td>
<td>25.3 ± 2.1</td>
<td>182 ± 0.04</td>
</tr>
</tbody>
</table>

*Data are expressed as mean \( \pm SD \). Middle blockers \( ( n = 9 ) \), opposite hitters \( ( n = 6 ) \), outside hitters \( ( n = 10 ) \), setters \( ( n = 6 ) \), and liberos \( ( n = 4 ) \).

†Middle blockers and opposite hitters are not significantly different \( ( p > 0.05 ) \) for body mass.

‡Outside hitters and setters are not significantly different \( ( p > 0.05 ) \) for height.

§Setters and liberos are not significantly different \( ( p > 0.05 ) \) for body mass.
squat performances than the outside hitter and opposite hitter groups (Table 2). No other significant differences ($p > 0.05$) were found among the groups for the strength and power parameters (Table 2). Significant correlations were only found between bench press performance and body mass ($r = 0.53; p = 0.0012$) and height ($r = 0.46; p = 0.0052$).

**Discussion**

The aim of this study was to investigate the anthropometric and strength characteristics of elite male volleyball athletes and to determine if differences exist in these characteristics according to playing position. If significant differences exist among playing positions, it may provide insight into the physical qualities important for that position so that appropriately structured resistance training programs can be designed for individual positions. In agreement with our experimental hypotheses, the results demonstrated that there were important differences with respect to anthropometric characteristics and muscular strength and power test scores of players based on their specific position on a team.

Despite several studies on male athletes in team sports, there are relatively few published research studies on male team volleyball players (15,18). Thus, relatively little objective information is available on strength performance characteristics of male volleyball players, and no studies have documented if strength values differ by playing position in male volleyball athletes. Analyses revealed significant differences among individual playing positions for the following tests: 4RM-BP, 4RM-PS, and overhead medicine BTdL.

The significant differences in bench press results among groups can be explained by the geometric scaling paradigm (17). According to this paradigm, strength is directly related to muscle cross-sectional area, which increases with increases in body height. This indicates that a taller person would perform better in activities with a significant strength component. In the present study, this theory is supported by the significant positive correlation between height, body mass, and bench press performance ($r = 0.46$ and $r = 0.53$, respectively). Given that the middle blockers were significantly taller than the liberos and setters, this could explain the differences in bench press performance. When the strength was expressed according to relative strength (i.e., expressed as force per kg of body mass), the differences among groups and the positive correlation were no longer evident ($r = 0.23; p = 0.17$). It is commonly accepted that taller athletes can throw faster and further distances than shorter athletes (11,20). As expected, the libero position had significantly poorer upper-body power performances than all other positions. This finding may be attributed to the lack of upper-body-specific activities during competition in these players. Finally, no significant differences were found between liberos and setters for throwing and bench press performance. Given that height differences were observed between these 2 positions, differences in throwing distance values may be expected. The finding of similar upper-body strength and power between liberos and setters most likely reflects the limited upper-body involvement during competition. Indeed, neither position is required to spike during volleyball matches.

No significant relationship was detected between parallel squat and body height. These findings most likely reflect the fact that increased absolute leg strength is reduced in taller athletes because they are required to lift their own weight further when performing squats. The present results found significant differences in parallel squat performances between

### Table 2. Performance characteristics of individual playing positions in professional male volleyball players.*

<table>
<thead>
<tr>
<th>Playing Position</th>
<th>4RM-BP (kg)</th>
<th>4RM-PS (kg)</th>
<th>CMJ (cm)</th>
<th>TD (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle blockers</td>
<td>96.11 ± 12.19†</td>
<td>132.50 ± 16.69</td>
<td>42.90 ± 5.37‡</td>
<td>11.53 ± 0.35§**</td>
</tr>
<tr>
<td>Opposite hitters</td>
<td>94.00 ± 18.51†</td>
<td>146.00 ± 15.17‡</td>
<td>41.91 ± 2.57‡</td>
<td>12.50 ± 1.75**</td>
</tr>
<tr>
<td>Outside hitters</td>
<td>86.50 ± 13.13</td>
<td>149.00 ± 25.58§</td>
<td>46.67 ± 4.34‡</td>
<td>12.19 ± 1.31#</td>
</tr>
<tr>
<td>Setters</td>
<td>78.33 ± 11.25†</td>
<td>123.33 ± 13.65‡</td>
<td>47.01 ± 3.39‡</td>
<td>11.33 ± 1.58</td>
</tr>
<tr>
<td>Liberos</td>
<td>76.25 ± 8.54†</td>
<td>127.50 ± 17.08</td>
<td>44.44 ± 0.99‡</td>
<td>10.88 ± 0.18§**</td>
</tr>
</tbody>
</table>

**4RM-BP = 4RM bench press; 4RM-PS = 4RM parallel squat; CMJ = countermovement jump; TD = throwing distance.

*Data are expressed as mean ± SD. Middle blockers ($n = 9$), opposite hitters ($n = 6$), outside hitters ($n = 10$), setters ($n = 6$), and liberos ($n = 4$).

†Middle blockers are significantly stronger than liberos and setters ($p < 0.05$).

‡No differences were noted for CMJ between all groups ($p > 0.05$).

§Outside hitters have significantly greater lower-body strength than setters ($p < 0.05$).

§Middle blockers and opposite hitters throw significantly further than liberos ($p < 0.05$).
hitters and liberos. In contrast, no significant differences were observed among playing positions for CMJ performances. Although these results are difficult to reconcile, it is possible that the similar CMJ performances, despite some differences in parallel squat performances, may reflect the fact that stretch-shortening cycle movement patterns (e.g., digging a ball) are performed in all volleyball positions.

Unique body types and proportions may constitute important prerequisites for successful participation in volleyball. The results of this study demonstrate that significant differences exist among elite volleyball players of different playing positions for height, body mass, muscular strength, and upper-body muscular power. However, no differences were found among playing positions for lower-body muscular power. In volleyball, teams compete by manipulating skills of spiking and blocking high above the head. Given that volleyball competition requires handling the ball above the head, height could be considered the most important physical attribute. This is supported by the fact that the mean heights of volleyball players rank among the highest in international teams (18, 21). Some authors have suggested that height is an important predictor of volleyball talent (7, 21), and the presence of tall players is an indispensable element for success as a team.

Given the similarities in jumping movements and physical stature between sports, a logical comparison can be drawn between the present study and previous studies of basketball players. Recent research on elite male basketball players has illustrated a trend toward an increase in height and significant differences in height and body mass among positions (12, 21). In our study, we found that middle blockers and opposite hitters were significantly taller and heavier than the players from other positions. Because the game involves contact with the intention of blocking the ball in a net elevated 2.43 m above the ground level, physical attributes of middle blockers and opposite hitters could assist players to dominate close to the net. The shorter the middle blocker, the higher he has to jump in order to play successfully in this aerial zone. Conversely, the outside hitters and setters with the lower height and body mass are the most skillful players and are used to set up attacks that are sometimes completed by the taller players. These findings suggest that height offers a performance advantage for middle blockers and opposite hitters, whereas lower-body mass seems to be advantageous for outside hitters and setters.

**Practical Applications**

There are 3 important practical applications from this study. First, through appropriate in-season testing, a volleyball coach can use information about the players’ physical and performance characteristics to place them in specific positions with greater likelihood of high-level performance and team success. Second, this study provides normative data and performance standards for elite and subelite volleyball players competing in specific individual playing positions. Finally, the principle of specificity is critical for program design and implementation in complex activities such as team sports. Consequently, the strength and conditioning specialist must determine what differences exist between playing positions and develop the training program accordingly. Significant differences exist among senior volleyball players of different playing positions for height, body mass, muscular strength, and upper-body muscular power. Coaches can use this information to determine the type of physical profile that is needed for specific positions and to design resistance training programs to maximize strength and power development for individual athletes.

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