An Analysis of Playing Positions in Elite Men's Volleyball: Considerations for Competition Demands and Physiologic Characteristics

Jeremy M. Sheppard,[1,2,3] Tim J. Gabbett,[4] and Luiz-Claudio Reeberg Stanganelli[5]

[1]*Queensland Academy of Sport, Nathan, Australia;* [2]*Australian Volleyball Federation, Canberra, Australia;* [3]*School of Exercise, Biomedical, Health, and Exercise Sciences, Edith Cowan University, Joondalup, Australia;* [4]*Brisbane Broncos Rugby League Club, Brisbane, Australia; and* [5]*State University of Londrina, Londrina, Brazil*

Abstract

Sheppard, JM Gabbett, TJ, and Reeberg Stanganelli, L-C. An analysis of playing positions in elite men's volleyball: considerations for competition demands and physiologic qualities. *J Strength Cond Res* 23(6): 1858–1866, 2009—The purpose of this study was to investigate the physiologic demands, physiologic characteristics, and jumping ability of different playing positions in elite male volleyball players. The first investigation involved an analysis of 16 international men's volleyball matches. The second investigation involved an analysis of the anthropometric and jump performance characteristics of 142 Development National Team (DNT) and Senior National Team (SNT) international volleyball players. Mean ($\pm SD$) frequency of block jumps for Middles (11.00 ± 3.14) was significantly greater than for Setters (6.25 ± 2.87, $p < 0.001$) and Outsides (6.50 ± 3.16, $p < 0.001$). Attack jumps were performed more frequently by Middles (7.75 ± 1.88), and this was found to be significantly more than for Setters (0.38 ± 1.06, $p < 0.001$) and Outsides (5.75 ± 3.25, $p < 0.01$). Middles were taller than Outsides and Setters ($p < 0.001$). Consequently, Middles had a significantly higher reach and greater body mass than Outsides ($p < 0.001$, $p < 0.003$) and Setters ($p < 0.001$, $p < 0.001$). Both Middles and Outsides had superior countermovement vertical jump (CMVJ) and spike jump (SPJ) scores compared with Setters ($p < 0.001$). Position-specific comparisons between DNT players and SNT players demonstrated that the SNT players were superior in relative CMVJ and SPJ scores ($p < 0.05$), with a large magnitude of effect ($d > 0.99$). The results of this study highlight the large jumping and landing demands placed on the taller and heavier players in the middle position. In addition to establishing the magnitude of difference in jumping ability between junior and senior national team players, the results also provide a comprehensive data set that may assist with talent identification and talent development for aspiring male volleyball players.

Key Words jump, spike, block, time-motion

Address correspondence to Jeremy M. Sheppard, physicalpreparation@yahoo.com.

23(6)/1858–1866

Journal of Strength and Conditioning Research

Introduction

Volleyball is a sport comprised of many explosive efforts, characterized by multiple short bouts of high-intensity exercise, interspersed with brief rest periods (11,26). The high-intensity exercise and short recovery periods, with a total match duration of 60 to 90 minutes, would suggest that volleyball players require well-developed creatine phosphate and glycolytic energy systems as well as reasonably well-developed oxidative capabilities (4,22,23,25,26).

Considerable demands are placed on the neuromuscular system during the multidirectional court movements (e.g., sprints, dives, jumps) that occur repeatedly during competition (4). As a result, it could be logically assumed that volleyball players require well-developed speed and muscular power because skilful court movement and vertical jumping are considered the most important player capabilities by coaches and sport scientists (12,13,14,18,20,21). In addition, volleyball players require the ability to perform these repeated maximal efforts with limited recovery for the duration of the match (22). Considering the specialized role of the various positions in volleyball and the specific tasks involved, it is likely that differences exist in the physiologic characteristics among the playing positions, but this is not well understood.

The volleyball time-motion analysis (TMA) studies that have been published have generally been performed on competition before several rule changes (1999), which include player substitution rules and a major change from service scoring to rally-point scoring (4,11,25). Furthermore, anecdotally, many coaches believe that the player substitution rule changes (particularly the addition of the defensive specialist "libero" position) and evolving tactical play strategies have led to an increase in the specialization of player positions, which logically would impact upon the specialized nature of the physiologic profiles among these player positions.

With this in mind, the present study had 2 primary aims. The first aim was to evaluate the activity demands in elite men's volleyball with a particular focus on examining any differences in competition demands that may exist among player positions. The second aim was to examine the physiologic characteristics of elite male volleyball players of differing player positions. The first investigation was thought to be worthwhile to elucidate information such as the skill demands, jumping and landing stress, and other physiologic considerations to assist with training load management and tactical understanding. The second investigation was conducted to provide a comparison between the competition demands and the physiologic characteristics of the involved playing group. This was thought to be worthwhile to provide insight into the value of anthropometric and physiologic data for talent identification.

Methods

Experimental Approach to the Problem

This project was conducted in 2 parts. The first investigation involved a comprehensive TMA of matches from the 2004 Olympic Games and from senior international men's volleyball competition from the 2006 international season. The second investigation involved an analysis of the physiologic characteristics of several men's national teams in the preparatory period before the 2008 Olympic Games.

Investigation 1: Time-Motion Analysis

Time-motion analysis of international volleyball matches was performed to obtain an accurate estimate of the demands of the 3 major front-row position categories in the sport. Eight matches from the men's competition of the 2004 Olympic Games and 8 international test matches were analyzed for frequency of all major activities performed (spike jumps [SPJ], block jumps, dives, and jump serves). A variety of teams were included in the analysis because player competency and opponent tendencies have a large effect on offensive and defensive demands (i.e., Setter's attacking options), which would in turn bias the demands of each position observed in this investigation.

The primary purpose of this component of the study was to evaluate potential differences in physiologic demands among the attacking positions of play: Middles, Outsides, and Setters. In addition, a comparison between winning teams and losing teams was conducted to determine whether the physiologic demands for each position differ under conditions of success and defeat.

Investigation 2: Physiologic Characteristics of Player Positions

Subjects. One hundred forty-two subjects (mean ± *SD*, age, height, and mass, 20.9 ± 2.6 yr, 198.9 ± 5.6 cm, and 91.9 ± 9.3 kg, respectively) participated in this study. The subjects were from the male indoor national volleyball teams of Argentina (world ranked 6th), Australia (world ranked 11th), Canada (world ranked 16th), Australia Under-21, Brazil Under-19, and Brazil Under-21. Testing was in accordance with and approved by institutional ethics, and written consent for testing was obtained in the athlete's scholarship holder's agreement.

Depending on the part of the world, player position nomenclature differs somewhat. For the purposes of the analyses involved in this study, players were classified as Outsides, Middles, or Setters. The group of Outsides (termed wing-attack in some countries) constituted opposites (i.e., right side) and passer-hitters, the Middles group comprised middle blockers, and the Setters group comprised only the Setters. Libero players (defensive specialists who do not play in the front row) were not included in this investigation.

For additional analysis, the players were also divided into Senior National Team (SNT) and Development National Team (DNT). Players were deemed SNT if they had competed in an official Fédéracion International del Volleyball-sanctioned competition (international test match, World League, Olympic Games, etc.) as a member of their countries' SNT (the athletes were not considered part of the SNT if they had played in a senior "B" national team match). DNT group players comprised athletes who were involved in their countries' age group national team program (e.g., U-21, U-19) and had competed internationally in age-group competition (e.g., Continental Age-group Championships).

Procedures. In the 24-hour period before performing the tests, the subjects refrained from activity that was considered unduly fatiguing in regard to vertical jump. Because the subjects involved in this study were "full-time" athletes, typically training more than 25 hours per week, this was accomplished by testing the athletes the day after a complete rest day.

All of the subjects were national program scholarship holders with at least 1 year of previous experience in the program and were free from injury at the time of testing. Therefore, all subjects had multiple exposures to the tests involved in this study in advance of data collection, and the population-specific repeatability of measures has been previously established (16). Subjects were given up to 4 trials on each jump, with 1 minute between jump test trials. The subjects were all tested during the international season (i.e., outside of domestic and professional competition), during the latter stages of the preparation period, and before the international competition period.

As per the normal testing protocol for this group, the subjects completed their typical practice warm-up before testing sessions. This warm-up includes 10 minutes of general activity (walk, jog, light stretching), followed by 10 minutes of dynamic activity that increased in speed and intensity (skips, leg swings, arm swings), 10 minutes of 2-person volleyball skill rally (i.e., "pepper drill"), followed by 3 to 5 minutes of rest before beginning the testing session. Subjects were refamiliarized with the testing protocol by way of 2 to 5 submaximal practice attempts.

Vertical Jump Assessments. Subjects were tested on their standing reach height before they performed a maximum effort countermovement vertical jump (CMVJ) as well as a SPJ (with approach) using a vaned jump and reach apparatus, which allowed for recording of the maximum height reached to the nearest centimeter (Yardstick, Swift Systems, Lismore, Australia). The measurement of the standing reach height allowed for a calculation of the relative jump heights on each of the jumping tasks (absolute jump height [cm] – standing reach height [cm] = relative jump height). In the CMVJ, no horizontal approach was allowed, whereas in the SPJ, an approach ranging from 3 to 4 steps was used based on the athlete's preference. In general, for testing, Middles and Setters perform a 3-step approach, and Outsides perform a 4-step approach because this is typical of their competitive environment. The population-specific intraclass correlation coefficients (ICC) (%Typical Error in parenthesis) of the height of the CMVJ and SPJ was 0.98 (2.5%) and 0.97 (3.2%), respectively (12,17).

Anthropometric Assessments. All subjects were assessed for height, mass, and standing reach. The height and mass assessments were conducted using a recently calibrated stadiometer and scale. Standing reach was assessed using the same vaned jump and reach apparatus used for vertical jump assessments. For the standing reach, while wearing their normal volleyball footwear, the subjects stood underneath the vanes of the apparatus and were encouraged to fully extend their dominant arm to displace the highest vane possible to determine their maximum standing reach height. The ICC and %TE for height, mass, and standing reach were 0.99 (1.5%), 0.99 (1.2%), and 0.98 (2.0%), respectively.

Statistical Analyses

A one-way analysis of variance (ANOVA) with a Games-Howell post hoc test was used to determine whether and where differences existed in the frequency of ballistic activities (attack jumps, blocks jumps, dives, jump serves) between positions during the international competitions. Paired *t*-tests were used to assess for differences in the frequency of these activities for each position between winning and losing teams. Data were analyzed per game, rather than total match, because matches are best to 3 and can vary in length between 3 to 5 games.

A one-way ANOVA with Tukey's post hoc test was used to assess the differences in physiologic characteristics between the positions of play among the entire player group. Independent *t*-tests were used to assess for difference in physiologic characteristics of each position between DNT and SNT groups. Cohen's effect size statistics (Cohen's d) were calculated to determine the magnitude of any differences observed based on the criteria of $d < 0.30$, small; $d = 0.31$ to 0.70, moderate; $d > 0.71$, large (1, 8). An alpha level of $p < 0.05$ was applied as the criterion for statistical significance.

Results

Time-Motion Analysis

Activities by Position. The mean frequencies of jumps performed per game within player positions are illustrated in Figure 1. Significant differences were revealed among Middles, Outsides, and Setters for the frequency of block jumps and attack jumps ($p < 0.001$ for both) but not jump serves ($p > 0.05$) or dives ($p > 0.05$). A Games-Howell post hoc test identified that the mean frequency of block jumps for Middles (11.00 ± 3.14) was significantly different from Setters (6.25 ± 2.87, $p < 0.001$) and Outsides (6.50 ± 3.16, $p < 0.001$). There was no difference between Outsides and Setters for frequency of block jumps ($p > 0.05$). Attack jumps were performed more frequently by Middles (7.75 ± 1.88), and this was found to be significantly different from Setters (0.38 ± 1.06, $p < 0.001$) and Outsides (5.75 ± 3.25, $p < 0.01$). Outsides performed attack jumps more regularly than Setters ($p < 0.001$).

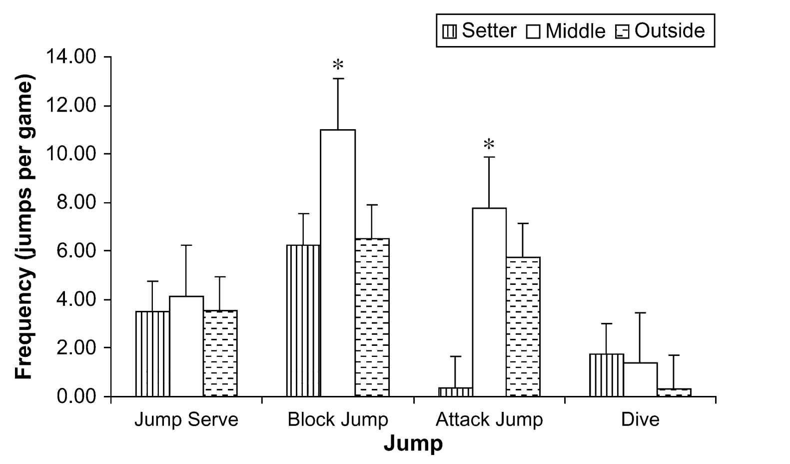

Figure 1. TMA of different positions in elite mens' volleyball.

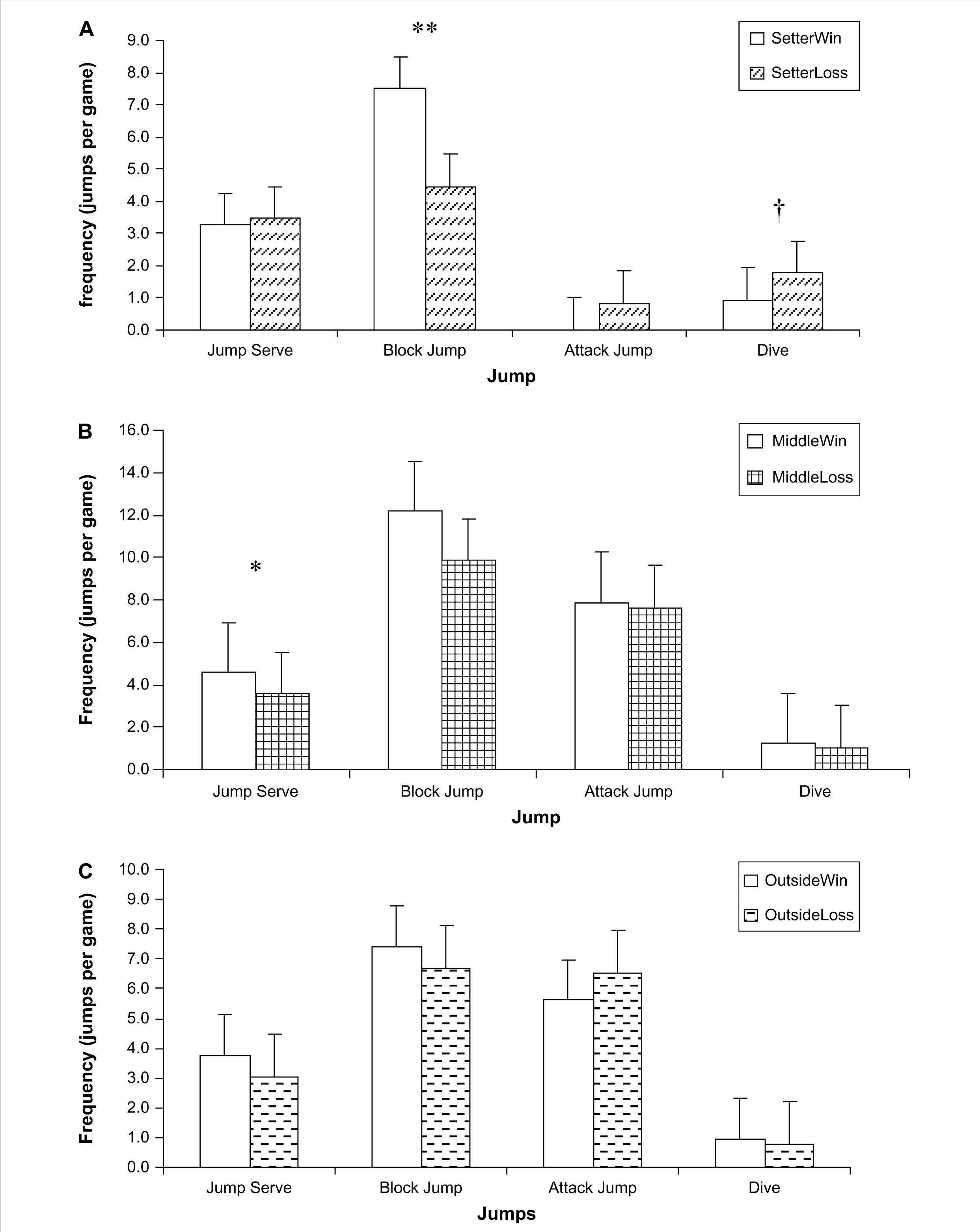

Figure 2. Differences in movement between positions from winning and losing sides. A) Setters B) Middles C) Outsides. **Values are significantly different from losing side, $p < 0.01$. *Values are significantly different from losing side, $p < 0.05$. †Values are significantly different from winning side, $p < 0.05$.

Table 1. Mean ± *SD* and *p* values reflecting differences between player position groups for anthropometric and jump variables for middle ($n = 49$), setter ($n = 22$), and outside ($n = 71$) player positions in national team volleyball players.

	Position	Mean	*SD*	Comparison	*p*
Height	Middle	203.1	3.9	O vs. S	0.001
	Setter	192.90	4.20	M vs. S	0.001
	Outside	197.8	4.6	M vs. O	0.001
Body mass	Middle	96.3	8.4	O vs. S	0.007
	Setter	84.6	9.0	M vs. S	0.001
	Outside	91.1	8.5	M vs. O	0.003
Standing reach	Middle	268.1	6.6	O vs. S	0.001
	Setter	254.2	9.6	M vs. S	0.001
	Outside	262.3	8.4	M vs. O	0.001
CMVJ	Middle	324.0	9.2	O vs. S	0.001
	Setter	308.5	11.5	M vs. S	0.001
	Outside	319.8	10.0	M vs. O	0.060
Relative CMVJ	Middle	55.9	8.7	O vs. S	0.361
	Setter	54.4	9.4	M vs. S	0.799
	Outside	57.4	9.5	M vs. O	0.632
Spike	Middle	343.2	8.7	O vs. S	0.001
	Setter	328.1	10.4	M vs. S	0.001
	Outside	341.3	9.1	M vs. O	0.516
Relative spike	Middle	75.1	7.8	O vs. S	0.038
	Setter	73.9	7.8	M vs. S	0.841
	Outside	79.1	9.2	M vs. O	0.038

*O = outside; S = setter; M = middle; CMVJ = countermovement vertical jump.
†Height, standing reach, CMVJ, and spike jump are in centimeters. Mass expressed in kilograms.

Table 2. Mean ± *SD*, *p* value, and effect size reflecting differences between Development National Team (DNT, $n = 13$) and Senior National Team (SNT, $n = 9$) for setter position.

	Group	Mean	*SD*	*p*	Effect size
Height	DNT	193.6	3.6	0.419	0.35
	SNT	192.0	5.4		
Mass	DNT	81.3	8.3	0.035	0.99
	SNT	89.4	8.1		
Standing reach	DNT	254.9	11.2	0.677	0.19
	SNT	253.1	7.1		
CMVJ	DNT	304.3	10.1	0.033	0.99
	SNT	314.7	10.8		
Relative CMVJ	DNT	49.4	7.4	0.001	1.65
	SNT	61.5	7.3		
Spike jump	DNT	324.0	9.7	0.023	1.08
	SNT	333.9	8.6		
Relative Spike	DNT	69.1	5.1	<0.001	2.29
	SNT	80.8	6.1		

*CMVJ = countermovement vertical jump.
†Height, standing reach, CMVJ, and spike jump are in centimeters. Mass expressed in kilograms.

Activities by Position: Winners vs. Losers. The mean frequencies of jumps and dives of the different player positions within winning and losing sides are illustrated in Figure 2. Setters on the winning side ($n = 12$) performed block jumps more frequently than the losing side ($n = 13$) (7.50 ± 2.61 winners, 4.46 ± 2.37 losers). A paired *t*-test found this to be significantly different ($p < 0.01$). Losing Setters had a higher ($p < 0.05$) mean frequency of dives than the winning Setters (1.77 ± 1.01 losers, 0.92 ± 0.80 winners). There were no significant differences in jump serves or attack jumps between winning and losing sides. No significant differences were found between winning Outsides ($n = 36$) and losing Outsides ($n = 24$) ($p > 0.05$ for all jumps). Middles playing for the winning side ($n = 24$) performed jump serves more frequently ($p < 0.01$) than Middles from the losing side ($n = 24$) (4.58 ± 1.53 winners, 3.54 ± 1.18 losers). Block jumps were also significantly different between winning and losing sides ($p < 0.05$), with winners having a higher mean frequency than losers (12.21 ± 3.36 winners, 9.83 ± 4.27 losers).

Player Characteristics

Table 1 presents the anthropometric and jumping characteristics of the subjects. Middles were taller than Outsides and Setters, and Outsides were taller than Setters ($p < 0.001$). Consequently, Middles had a significantly higher standing reach and greater body mass than Outsides ($p < 0.001$, $p < 0.01$) and Setters ($p < 0.001$ for both), and Outsides had a higher standing reach than Setters ($p < 0.001$).

Both Middles and Outsides had a higher CMVJ than Setters

Table 3. Mean ± *SD*, *p* value, and effect size reflecting differences between Development National Team (DNT, $n = 30$) and Senior National Team (SNT, $n = 19$) for the middle position.

	Group	Mean	*SD*	*p*	Effect size
Height	DNT	203.9	4.0	0.064	0.58
	SNT	201.7	3.6		
Mass	DNT	94.0	9.5	0.013	0.82
	SNT	100.0	4.1		
Standing reach	DNT	270.0	6.7	0.010	0.80
	SNT	265.1	5.5		
CMVJ	DNT	322.0	8.9	0.055	0.57
	SNT	327.1	9.1		
Relative CMVJ	DNT	52.0	6.8	<0.001	1.37
	SNT	62.0	7.8		
Spike jump	DNT	342.4	9.7	0.417	0.25
	SNT	344.5	6.8		
Relative spike	DNT	72.4	7.5	0.002	1.01
	SNT	79.4	6.3		

*CMVJ = countermovement vertical jump.
†Height, standing reach, CMVJ, and spike jump are in centimeters. Mass expressed in kilograms.

Table 4. Mean ± *SD*, *p* value, and effect size reflecting differences between Development National Team (DNT, $n = 48$) and Senior National Team (SNT, $n = 23$) for outside position.

	Group	Mean	*SD*	*p*	Effect size
Height	DNT	196.9	4.2	0.017	0.60
	SNT	199.6	4.8		
Mass	DNT	89.2	8.9	0.007	0.75
	SNT	94.9	6.1		
Standing reach	DNT	262.9	6.6	0.191	0.34
	SNT	260.8	5.8		
CMVJ	DNT	316.6	9.2	<0.001	1.08
	SNT	326.2	8.5		
Relative CMVJ	DNT	53.7	7.9	<0.001	1.51
	SNT	65.3	7.5		
Spike jump	DNT	339.4	9.3	0.007	0.74
	SNT	345.5	7.1		
Relative spike	DNT	76.4	8.6	<0.001	0.99
	SNT	84.6	7.9		

*CMVJ = countermovement vertical jump.
†Height, standing reach, CMVJ, and spike jump are in centimeters. Mass expressed in kilograms.

($p < 0.001$), but when expressed relative to standing reach (relative CMVJ), no differences existed between the groups of setter, middle, and outside players. Both Middles and Outsides had a higher SPJ than Setters ($p < 0.001$). When expressed relative to standing reach (relative SPJ), Outsides were superior to Setters ($p < 0.05$) and to Middles ($p < 0.05$).

Comparisons of DNT and SNT for setter, middle, and outside positions are presented in Tables 2, 3, and 4, respectively. In all positions, the SNT group exhibited superior relative jumping (relative CMVJ and SPJ) ability to the DNT group. For both Setters and Outsides, SNT players were superior to DNT players in absolute jumping ability (Tables 2 and 4), but absolute jumping ability was not different between DNT and SNT Middles (Table 3).

Discussion

This study had 2 primary aims. The first aim was to evaluate the activity demands in elite men's volleyball to highlight any differences in competition demands that may exist among player positions and between winning and losing teams. The second aim was to examine the physiologic characteristics of elite male volleyball players of differing player positions. The first investigation was thought to be a worthwhile study to elucidate information such as the skill demands, jumping and landing stress, and other physiologic considerations to assist with training load management and tactical understanding. The second investigation was conducted to provide a comparison between the competition demands and the physiologic characteristics of elite players. This second component was thought to be worthwhile to provide insight into talent identification information for anthropometric and physiologic data and to allow a comparison for setting training targets for the DNT members aspiring to be involved in the SNT.

The results of the TMA analysis revealed that the greatest blocking demand is placed on the Middles in comparison with Setters and Outsides, with Setters and Outsides involved in similar blocking demands. In addition, Middles performed more SPJs than both Setters and Outsides, with Outsides performing a greater volume of SPJs than Setters. These findings indicate that the spike and block jumping and landing demands of Middles are greatest of all positions. This cannot be assumed to equate to the highest total physiologic stress because, on nearly all teams, the middle player is removed from the majority of back-court play by the defensive specialist libero position. This significantly reduces the total physiologic load of the middle player. However, practitioners should consider the significant neuromuscular stress imposed by the large jump and land demands of the taller and heavier middle position players. This has implications for the monitoring of training load, in that Middles likely encounter the greatest neuromuscular stress from maximal jumping and landing.

It should also be recognized that a Setter can perform 20 or more submaximal jumps as "jump sets" per game (17,19). Although Setters had a modest maximal jumping demand compared with Middles and Outsides, their total jump demands during match conditions is actually highest when submaximal jump sets are included in the analysis. For the elite playing level, coaches and sport scientists should consider that a typical match (and therefore match-like training conditions) likely imposes the greatest stress from maximal jumping on middle players but that the setter performs a very large volume of submaximal jumping.

This finding also has implications in regard to the lateral movement demands to perform block jumps, particularly for middle positions players, but also for the Outsides and Setters. Middles not only perform block jumps in a middle-net position but must often move a large distance, very rapidly, to the left or right side to assist Outsides with blocking duties toward the sideline. Conversely, Outsides must often move rapidly to the middle-net position to assist Middles with blocking tasks. Therefore, it is not only the jump and land stress that must be considered in regard to match demands but also the rapid lateral movement that is often a component of a blocking task, and this is a particularly large component for middle blockers and outside position players (11). Injury rates as a whole, and to a lesser extent, its etiology, in volleyball players has received reasonable research attention (2,3,9,10). However, future research is needed to examine the injury incidence, severity, and etiology among the specific playing positions in volleyball to elucidate whether these differences in competition load manifest differences in injury state among the playing positions.

Although all front-court positions in volleyball require rapid lateral movement and blocking tasks, it appears as though the largest demand is placed on the taller and heavier (Table 1) middle blockers. This finding has important implications for the implementation of appropriate technique and physical training for middle players (in particular) while also emphasizing the need for effective decision-making training to correctly identify where to move for specific offensive movements. In addition, these cognitive and physical skills must be trained such that the Middles are highly efficient and fatigue resistant because they are required to execute the many blocking and attack jumps typically in a fatigued state.

Some coaches and sport scientists believe that taller, heavier athletes, such as those who are encouraged to be middle players, are inherently slower at rapid movements. Taller athletes will tend to have slower limb movement because their limbs are longer. However, if effective movement patterns are taught, their height advantage can easily be translated into superior movement speed in comparison with shorter athletes (12). In other words, tall athletes take large steps, allowing them to move laterally at the net faster than shorter athletes (12), and this lateral movement at the net is a particularly large component of total movement for middles (11). On the basis of the demands of elite match conditions and the physiologic characteristics of elite players, the results of this study suggest that volleyball coaches and sport scientists should aim to select taller athletes with well-developed (or seemingly trainable) speed characteristics to play in the middle. It is suggested that those practitioners interested in talent identification for volleyball should consider height, but also jumping and speed ability, as essential components, particularly for elite middle position players (5,6,12,19,18,22,24).

The blocking demands of Middles and Setters were greater in winning teams compared with losing teams. It could be suggested that the Middles and Setters in superior teams are more skilful at being involved in blocking tasks, allowing for more involvement in double- and triple-person blocks in comparison with less successful teams. It is often the Setter's blocking role to assist Outsides and Middles with their primary blocking task (offence to the outside or middle court, respectively), whereas it is also often the Middles' blocking role to assist Outsides with their primary blocking task (offence to the outside court on either side). It could also be suggested that more successful teams serve consistently, and consistently well, which thereby stresses the passers on the opposing team, reduces passing quality, and limits the ability of the setter to set diverse offenses. This could potentially allow the opposing team to more readily create a double- or triple-person well-formed block and in part explain the larger blocking contributions by Middles and Setters from winning teams.

Another characteristic separating winning from losing sides was the frequency of dives performed by Setters. Losing Setters performed more dives than winning Setters. It may be suggested that the losing team's blocking ability may be poorer, and that, when in the back row rotation, the Setters were diving more to dig the ball. It could also be that, on a losing team, the primary passers from service receive might be less successful in their passing attempts, thereby requiring the Setters to move a greater distance (and potentially diving) to track down the ball for the second touch (the offensive setting task).

Considering that Outsides demonstrated similar jump scores to Middles yet are shorter and subsequently have a lower standing reach, Outsides tend to have superior relative jump ability for the SPJ (Table 1). These results imply that coaches and sport scientists should consider absolute jump heights as an important factor in judging the performance requirements of Outsides. In other words, a shorter opposite or pass-hitter (outside player) must make up for their lack of height and standing reach by exhibiting superior relative jump heights because the attacking and blocking demands of Outsides is high (Figure 1), and, at the elite level, Outsides have a similar absolute CMVJ and SPJ height to the taller Middles by exhibiting superior relative jump heights (Table 1).

SNT Middles were significantly heavier than DNT Middles, despite the DNT group possessing a significantly greater standing reach (Table 3). SNT Outsides were taller and heavier than the DNT Outsides (Table 4). SNT Setters were not taller and did not have a higher standing reach than DNT setters, but they were heavier ($p < 0.05$, $d = 0.99$). It could be suggested that DNT athletes have experienced the majority or all of their growth in height but are less massive than SNT players because of a lower strength and conditioning training age and because of normal growth and development considerations.

As outlined in Tables 2, 3, and 4, relative jumping ability in the SNT group was superior to that of the DNT group in all positions, with large magnitudes of effect ($d = 0.99$–2.29). These results demonstrate the importance of developing vertical jump ability in volleyball players, in both CMVJ and SPJ, given that they are important discriminators between higher and lower performers. Previous research has demonstrated the importance of vertical jump ability in discriminating between national team and non-national team players (22), but with scholastic level players, previous research has been inconsistent in establishing the discriminate validity of jumping tests for higher and lower performers (5,6,24).

The activity demands by position in the present study on international matches were similar to those found in lower-level domestic competition (11) and, in general, similar to those found in semiprofessional competition (4). However, the results of the SNT group in this study highlight several differences between current elite players and elite players from previous studies. The SNT group ($n = 51$) in this study, across all positions, were 199 (range, 182–211) cm and 95 (77–108) kg, with CMVJ and SPJ scores of 325 (295–349) cm and 343 (320–362) cm. It would appear that, throughout each position, elite players are considerably taller and are heavier and have greater standing reach heights than in the previous studies of national team and elite players (4,11,22). It also evident that the current SNT player group involved in this study posses far superior absolute and relative vertical jump abilities to national teams in previous studies (7,22).

The results of this study clearly demonstrate the importance of vertical jump ability in elite level players because this analysis was conducted on top national team players compared with developing national team players who did not differ greatly in anthropometry or in their daily training environment (therefore a reasonably homogenous group). Considering the importance of jumping ability and also movement speed (18,19) in volleyball, coaches and sport scientists should aim to develop movement speed and jumping ability as the primary physical components in volleyball players.

Practical Applications

Time-motion analysis and an evaluation of physiologic characteristics and jumping ability of player positions in volleyball reveal important differences in the playing demands (and therefore physical requirement and physical load of competition) and the player characteristics of each position. The taller and heavier Middles have the greatest requirement in comparison with Outsides and Setters in regard to jumping tasks. Outsides have similar absolute jumping abilities, but because of their lower height, accomplish this through greater relative jumping ability.

Practitioners should consider several points in light of these results. When performing talent identification for volleyball, taller athletes with good jumping and speed capabilities should be sought for all positions but in particular for the middle positions. Middles perform a great deal of lateral movement and blocking tasks, and it appears as though middle blockers on more successful teams are able to move at the net and perform more blocking tasks than players from less successful teams. Outsides have the greatest relative jump height, and their absolute jump height should be expected to be equivalent to their taller team mates playing in the middle.

Acknowledgments

The authors thank the coaches and support staff from the Argentina, Australian, Brazil, and Canadian national programs for their collaboration on this project. The authors also thank in particular Amy Lindh and Russell Borgeaud for their assistance in the preparation of this article.

References

1. Cohen, J. Statistical power analysis for the behavioral sciences (2nd ed). Hillsdale, NJ: L. Erlbaum Associates, 1988.
2. Cumps, E, Verhagen, EA, Duerinck, S, Deville, A, Duchene, L, and Meeusen, R. Effect of a preventative intervention programme on the prevalence of anterior knee pain in volleyball players. *Eur J Sport Sci* 8: 183–192, 2008.
3. Dufek, JS and Zhang, S. Landing models for volleyball players: A longitudinal evaluation. *J Sports Med Phys Fitness* 36: 35–42, 1996.
4. Dyba, W. Physiological and activity characteristics of volleyball. *Volley Tech J* 6: 33–51, 1982.
5. Gabbett, T and Georgieff, B. Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players. *J Strength Cond Res* 21: 902–908, 2007.
6. Gabbett, T, Georgieff, B, and Domrow, N. The use of physiological, anthropometric, and skill data to predict selection in a talent-identified junior volleyball squad. *J Sports Sci* 25: 1337–1344, 2007.

7. Heimer, S, Misogoj, M, and Medved, V. Some anthropological characteristics of top volleyball players in FSR Yugoslavia. *J Sports Med Phys Fitness* 28: 200–208, 1988.
8. Hopkins, WG. Probabilities of clinical or practical significance. *Sportscience* 2002. Available at: 6:sportsci.org/jour/0201/wghprob.htm. Accessed 2007.
9. Malliaras, P, Cook, JL, and Kent, PM. Anthropometric risk factors for patellar tendon injury among volleyball players. *Br J Sp Med* 41: 259–263, 2007.
10. Oystein, L, Refsnes, PE, Engebretsen, L, and Bahr, R. Performance characteristics of volleyball players with patellar tendinopathy. *Amer J Sports Med* 31: 408–413, 2003.
11. Polgaze, T and Dawson, B. The physiological requirements of the positions in state league volleyball. *Sports Coach* 15: 32–37, 1992.
12. Sheppard, JM and Borgeaud, R. Influence of stature on movement speed and repeated efforts in elite volleyball players. *J Australian Strength Cond* 16: 12–14, 2008.
13. Sheppard, JM, Chapman, D, Gough, C, McGuigan, M, and Newton, RU. The association between changes in vertical jump and changes in strength and power qualities in elite volleyball players over 1 year. In: *Proceedings of the National Strength and Conditioning Association Annual Conference*. Las Vegas, NV, 2008.
14. Sheppard, JM, Chapman, D, Gough, C, McGuigan, MR, and Newton, RU. Twelve month training induced changes in elite international volleyball players. *J Strength Cond Res*, In press.
15. Sheppard, JM, Cormack, S, Taylor, KL, McGuigan, MR, and Newton, RU. Assessing the force-velocity characteristics of well trained athletes: the incremental load power profile. *J Strength Cond Res* 22: 1320–1326, 2008.
16. Sheppard, JM, Cronin, J, Gabbett, TJ, McGuigan, MR, Extebarria, N, and Newton, RU. Relative importance of strength and power qualities to jump performance in elite male volleyball players. *J Strength Cond Res* 22: 758–765, 2007.
17. Sheppard, JM and Gabbett, T. The development and evaluation of a repeated effort test for volleyball. In: *Proceedings of the National Strength and Conditioning Association Annual Conference*. Atlanta, GA, 2007.
18. Sheppard, JM, Gabbett, T, and Borgeaud, R. Training repeated effort ability in national team male volleyball players. *Int J Sports Phys Perf* 3: 397–400, 2008.
19. Sheppard, JM, Gabbett, TJ, Taylor, KL, Dorman, J, and Lebedew, AJ. Development of a repeated-effort test for elite men's volleyball. *Int J Sports Phys Perf* 2: 292–304, 2007.
20. Sheppard, JM, Hobson, S, Chapman, D, Taylor, KL, McGuigan, M, and Newton, RU. The effect of training with accentuated eccentric load counter-movement jumps on strength and power characteristics of high-performance volleyball players. *Int J Sports Sci Coach* 3: 355–363, 2008.
21. Sheppard, JM, McGuigan, MR, and Newton, RU. The effects of depth-jumping on vertical jump performance of elite volleyball players: An examination of the transfer of increased stretch-load tolerance to spike jump performance. *J Australian Strength Cond* 16: 3–10, 2008.
22. Smith, DJ, Roberts, D, and Watson, B. Physical, physiological and performance differences between Canadian national team and Universiade volleyball players. *J Sports Sci* 10: 131–138, 1992.
23. Spence, DW, Disch, JG, and Fred, HL. Descriptive profiles of highly skilled women volleyball players. *Med Sci Sports Exerc* 12: 299–302, 1980.
24. Thissen-Milder, M and Mayhew, JL. Selection and classification of high school volleyball players from performance tests. *J Sports Med Phys Fitness* 31: 380–384, 1991.
25. Viitasalo, JT. Evaluation of physical performance characteristics in volleyball. *Int Volleyball Tech* 3: 4–8, 1991.
26. Viitasalo, JT, Rusko, H, Pajala, O, Rahkla, P, Ahila, M, and Montonen, H. Endurance requirements in volleyball. *Can J App Sport Sci* 12: 194–201, 1987.