Chapter II

REVIEWS OF RELATED LITERATURE

The need for related literature has been widely recognized in the world of research. It provides researcher a broad and deep understanding of published research work of the related field and also helps to avoid duplication.

The researcher came across several books, periodicals and journals and published thesis, while searching for relevant facts and finding that were related to the present study.

Gaurav & Singh\(^1\) (2014) conducted a study to find out the differences in anthropometric characteristics of volleyball players in relation to their performance level (i.e., inter-university and inter-college). For this study, two hundred and forty (N=240) male volleyball players (inter-university level, N1=120, inter-college level, N2=120) of age ranging from 18-25 years were selected as subjects from various colleges and universities of North India. The purposive sampling technique was used to select the subjects. All subjects were assessed for height, weight, lengths, circumference and diameters. The independent samples t-test revealed that inter-university volleyball players had significantly higher height (p<0.05), weight (p<0.05), leg length (p<0.05), lower leg length (p<0.05) than inter-college volleyball players. However, inter-college volleyball players had significantly greater forearm length (p<0.05). The inter-university volleyball players also had significantly greater upper arm circumference (p<0.05), forearm circumference (p<0.05), thigh circumference (p<0.05) and calf circumference (p<0.05) than inter-college volleyball players. The inter-university volleyball players had significantly wider elbow diameter (p<0.05), shoulder diameter (p<0.05) and lesser hip diameter (p<0.05) than inter-college volleyball players. It is concluded that there were significant differences between inter-university and inter-college volleyball players with regard to anthropometric characteristics. Inter-university players showed better anthropometric measurements as compared to inter-college volleyball player.

\(^1\) Vishaw Gaurav., & Amandeep Singh (2014). Anthropometric characteristics of Indian volleyball players in relation to their performance level. Turkish Journal of Sport and Exercise, 16(1), 87-90.
Martín-Matillas et al. (2014) conducted a study to describe morphological characteristics of elite female volleyball players from the highest Spanish league, with special focus on differences by performance level and playing positions. Nearly all female players playing in the highest Spanish volleyball league during season 2003/2004 participated in this study (N=148 elite players, 92% of the total). Anthropometric, body composition and somatotype parameters according to performance and playing positions were analyzed. The players' characteristics were as follows; body mass 72.3 ± 8.4 kg; stature 179.8 ± 7.1 cm; body fat 24.0 ± 3.1% and skeletal muscle mass 27.3 ± 2.9 kg. Mean somatotype was 3.1 ± 0.7; 3.4 ± 0.9; 3.1 ± 0.9 characterized as central with a tendency to balanced mesomorph. Top level players (whose teams were better classified in the team performance ranking) were taller, had higher skeletal muscle mass and ectomorphy, and had a lower level of adiposity markers, compared with lower level players. Players selected for their respective National teams (individual performance) were taller, heavier, had higher muscle mass and lower endomorphy than non-selected players. Differences according to playing positions were found. This study provides a complete set of reference data on anthropometry, body composition and somatotype of elite female volleyball players. Morphological differences have been identified according to performance level and playing position.

Fattahi, Ameli & H. Sadeghi (2013) conducted a study to find out the Relationship between Anthropometric Parameters with Vertical Jump in Male Elite Volleyball Players Due to Game's Position. Vertical jump is one of the necessary components in performing spike and block skills in volleyball. Recent study was performed to determine relationship between anthropometric properties with vertical jump on 40 male elite volleyball players (27.93±3.92 years old and 8±1.53 years sport history) which at least played for 4 years in Iran premier league. Individual satisfaction and information forms were completed. 42 anthropometric parameters were measured. In order to decrease parameters covering the same measurements among 42 anthropometric properties, multiple correlation were applied and


parameters with coefficient higher than 0.8 were selected for further analysis, so number of parameters decreased to 17. Using principle component analysis method on 17 parameters, three main components including 70% of data variance were extracted. In the main components, parameters with coefficient more than 0.7 including weight, seated height in fixture, shank length, foot length, torso circumference at hip level, maximum calf circumference, abdomen fat, middle tight circumference and tight length were used for further analysis. The difference in distance between the standing reach height and the jump height was measured as the vertical jump records. To determine differences between vertical jump records and also relationship between anthropometric properties with vertical jumps, one way variance analysis (F-Test) and regression coefficients were used. Results show that spikers and liberos have the highest and the lowest vertical jump. There are significant differences between vertical jump of spikers and liberos, also between setters and liberos, but there are no significant differences between vertical jump of spikers and setters. According to the study, there is significant relationship between vertical jumps with shank length, maximum calf circumference, foot length for spikers and setters, also tight circumference and weight for liberos. Considering anthropometric parameters as well as training methods due to game's position seems to be necessary for volleyball players to perform spike and block successfully.

Taware et. al. (2013) conducted a study to assess flexibility, muscular endurance, power and cardio-respiratory endurance of volleyball players and to compare the results with age matched controls. Also, to compare the findings of the volleyball players with that of the international norms from the available literature and to make some suggestions for the improvement in their performance level. The study was carried out in 40 male volleyball players aged between 17 to 26 years and 40 ages matched male controls. Physical fitness parameters namely flexibility, muscular endurance, power and cardio-respiratory endurance were measured; data was analyzed using unpaired 't'-test. It was observed that all physical fitness parameters were significantly more in players as compared to their aged-matched controls but when values of the subjects were compared to international standards; our subjects were behind the recommended norms for the elite volleyball players. The volleyball

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players have more advantage of flexibility muscular endurance, power and cardio-respiratory endurance.

**Aouadi et al.** (2012) conducted a study to examine the association between physical and anthropometric profiles and vertical jump performance in elite volleyball players. Thirty-three elite male volleyball players (21±1 y, 76.9±5.2 kg, 186.5±5 cm) were studied. Several anthropometric measurements (body mass, stature, body mass index, lower limb length and sitting height) together with jumping height anaerobic power of counter movement jump with arm swing (CMJarm) were obtained from all subjects. Forward stepwise multiple linear regression analysis was performed to determine if any of the anthropometric parameters were predictive of CMJarm. Anaerobic power was significantly higher (P<0.05) in the tallest players relative to their shorter counterparts. A significant relationship was observed between CMJarm and lower limb length (r²=0.69; P<0.001) and between the lower limb length and anaerobic power obtained with CMJarm (r²=0.57; P<0.01). While significantly correlated (P≤0.05) with CMJarm performance, stature, lower limb length/stature and sitting height/stature ratios were not significant (P>0.05) predictors of CMJarm performance. This study demonstrates that lower limb length is correlated with CMJarm in elite male volleyball players. The players with longer lower limbs have the better vertical jump performances and their anaerobic power is higher. These results could be of importance for trained athletes in sports relying on jumping performance, such as basketball, handball or volleyball. Thus, the measurement of anthropometric characteristics, such as stature and lower limb length may assist coaches in the early phases of talent identification in volleyball.

**Dopsaj et al.** (2012) conducted a study to define a practical multidimensional model for assessing the general level of jumping performance relative to playing positions in elite female volleyball players, successful competitors at top international levels. The present study undertook the task to determine whether there were differences related to jumping performance in elite female volleyball players in relation to their playing position in the game (Correction, Receiver, Setter, Opposite, Libero).

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Blocker, Setter and Libero). A set of 7 variables was used to assess the jumping levels, with 6 variables covering the space of vertical jumping while 1 variable covered horizontal jumping skills. Standardized field tests (Abalakov method and standing long jump) were used for all measurements. The data were processed by the multivariate statistical method. The results indicated that there were no general statistically significant differences between jumping skill levels in elite female volleyball players relative to playing positions (Wilks' Lambda Value = 0.135, F relation = 1.281, p = 0.204) measured by the method applied. According to the descriptive results for the general jumping score (JUMPscore), the elite female volleyball players at Receiver positions had the highest jumping scores with 66.58 ± 9.18 score points, while Setters scored the lowest, 54.52 ± 10.34.

Polluveer et al.7 (2012) conducted a study to find if the players who play in different positions in Estonian top female teams can be differentiated by their body build and psychophysiological characteristics. The study involved four female teams of the Estonian league: Viimsi Spa, Viljandi Metall, Tallinn University and the Junior National Team. In total, 41 female volleyballers were studied; they were divided as follows: first tempo attackers - 13, setters - 8, diagonal attackers - 6, second tempo attackers - 9, liberos - 5. Twelve anthropometric measurements were taken and eight indices were calculated from the measurement results. Psycho physiological tests were conducted, using the computer program Win Psycho, on all the 41 subjects three times during the season. Psychophysiological studies consisted in measuring simple and complex reaction times and anticipation time. Anthropometric and psycho physiological variables were statistically analyzed according to the players’ positions on the court. The mean values of variables of the four participating teams were also analyzed. Anthropometric data – both basic characteristics and indices – show great individual variability. However, there were statistically significant differences between the groups of players only in height, weight and horizontal arms spread. The results of psychophysiological tests did not differ statistically significantly between players in different positions. Still, the reaction times shortened towards the end of the

season. The analysis of volleyballers' mean reaction times according to teams showed that the reaction times of three teams improved during the season. Tallinn University was the only team whose reaction times worsened. Viljandi Metall was statistically significantly better compared to Viimsi Spa. Both of them were also the strongest clubs during the 2011/2012 season. Consequently, psychophysiological tests reflect the intensity and level of coaching in the teams.

Sattler et al. (2012) conducted a study to determine the reliability and factorial validity of 2 volleyball-specific jumping tests, the block jump (BJ) test and the attack jump (AJ) test, relative to 2 frequently used and systematically validated jumping tests, the countermovement jump test and the squat jump test and (b) to establish volleyball position-specific differences in the jumping tests and simple anthropometric indices (body height [BH], body weight, and body mass index [BMI]).

The BJ was performed from a defensive volleyball position, with the hands positioned in front of the chest. During an AJ, the players used a 2- to 3-step approach and performed a drop jump with an arm swing followed by a quick vertical jump. A total of 95 high-level volleyball players (all men) participated in this study. The reliability of the jumping tests ranged from 0.97 to 0.99 for Cronbach's alpha coefficients, from 0.93 to 0.97 for interitem correlation coefficients and from 2.1 to 2.8 for coefficients of variation. The highest reliability was found for the specific jumping tests. The factor analysis extracted one significant component, and all of the tests were highly intercorrelated. The analysis of variance with post hoc analysis showed significant differences between 5 playing positions in some of the jumping tests. In general, receivers had a greater jumping capacity, followed by libero players. The differences in jumping capacities should be emphasized vis-a-vis differences in the anthropometric measures of players, where middle hitters had higher BH and body weight, followed by opposite hitters and receivers, with no differences in the BMI between positions.

Wiliam et. al.⁹ (2012) conducted a study to describe the kinanthropometric profiles of Cuban women Olympic volleyball champions during 1992–2000 and compare these by position played. Measurements were taken of body composition, somatotype, proportionality and several anthropometric indicators in 41 Cuban women volleyball players, grouped by playing position. All were members of the national team that participated in the Summer Olympic Games in Barcelona (1992), Atlanta (1996) and Sydney (2000). Mean and standard deviations were calculated for all study variables. Analysis of variance was used to compare means for different positions for the variables weight; height; percent adipose, muscle and bone mass; body mass index; and muscle-to-bone ratio. Discriminant analysis was performed to identify anthropometric dimensions differentiating playing positions (center, spiker and setter), using p<0.05 as significance threshold. Centers presented greater absolute size and higher average adipose (22.8±1.7 kg) and bone (7.1±0.6 kg) mass. The mean somatotype of all volleyball players was balanced mesomorphic (2.7–3.6–2.9). Classified by position, centers (2.9–3.4–3.4) and spikers (2.8–3.6–2.9) presented an average mesomorphic–ectomorphic somatotype, and setters (2.6–3.7–2.6) were balanced mesomorphic. On assessing Somatotype Attitudinal Mean (SAM), centers and spikers showed more intrapositional homogeneity than that of setters. Centers were significantly taller (187.1±2.5 cm) than players in other positions. Centers’ percent adipose tissue mass (28.9±2.7%) was significantly higher than that of setters (24.3±2.7%), who were leanest of all positions. The kinanthropometric profile of Cuban women Olympic volleyball champions was defined by considerable muscular skeletal development, with a predominantly mesomorphic somatotype and low endomorphy. Height and body composition varied significantly by playing position.

Trajkovic et. al.¹⁰ (2011) conducted a study to examine the positional differences in body composition and jumping performance of elite youth volleyball players. The research was conducted on a youth national team players of Serbia (n=28, average age=15.68±0.47 years). Players were categorized as middle blockers

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(n = 7), opposite hitters (n = 5), outside hitters (n = 8), setters (n = 6), and liberos (n = 2). The middle blockers and the opposite hitters are the tallest (201.57±4.92 cm; 203.00±4.41 cm) and the heaviest (86.14±6.79 kg; 91.60±6.69 kg) players in the team. The smallest value for body height and body weight was found among liberos. The results of % body fat have shown the smallest values among liberos (11.60±3.06) and the greatest among the opposite hitters (14.00±1.64). The results in jumping performance tests have shown similar values for all the positions in the team with no statistically significant difference. Statistically significant difference was found among positions for body height, body weight and standing reach height. It cannot be concluded that volleyball players develop distinctive performance characteristics at this age and level. Therefore, more researches must be conducted in order to understand better selection and training process that consider positional roles and demands.

Viswanathan & Chandrasekaran\(^\text{11}\) (2011) conducted a study to predict the role of a number of anthropometric characteristics in performance of Indian youth elite Basketball players with special reference to their playing positions. Two hundred and seventy six (age, 15.1 ± 1.3 years) youth elite male Basketball players from 23 states of India participated in the 26th Lakadawala Youth National Basketball Championship at Mastan YMCA, Mumbai from 9th to 16th May 2009, were selected as the subjects. The selected subjects were divided into three groups according to their playing positions namely Guard (GD = 72), Forward (FD = 126) and Centre (CR = 78). The selected anthropometric variables namely Body weight, Skinfold measurements (mm) - Biceps, Subscapular, Triceps, Supraspinale, Abdominal, Illiac Crest, Front Thigh and Medial Calf; Girth measurements (cm) - Arm girth relaxed, Arm girth flexed and Calf girth; Length measurements (cm) - Standing height, Arm span, Arm length, Leg length and Breadth measurements (cm) - Humerus breadth and Femur breadth as the independent variables were taken for this study. The data were collected by following standard testing protocol of International Society for the Advancement of Kin anthropometry (ISAK) during the competition by scientifically approved equipments. The criterion variable, playing ability of the selected Basketball players are assessed by three qualified Basketball coaches. To determine the

relationship between the selected anthropometric variables and the coaches rating on playing ability, the coefficient of correlation was used. Anthropometric variables that statistically correlated with performance were used to form respective linear predictive models (stepwise argument selection) with special reference to their playing positions for predictive equation development. The results revealed that there was a strong correlation (r = 0.9) exists between the playing ability versus height, weight, arm length, arm span, leg length and flexed arm girth among all the playing positions.

Fonseca et al.\textsuperscript{12} (2010) conducted a study to analyzed anthropometrical characteristics of Brazilian junior volleyball players. Sixteen male players were selected for 2006 South American Championship were evaluated, using Lohman protocols to access body fat, and Heath & Carter somatotype according to players position: setters, libero, middle, outside and opposite. Results indicated that the significant differences for body mass and height between middle and outside, and middle and opposite, were observed. However, no differences between player positions were observed for percentage of body fat and somatotype components. This result leads for athlete selection that looks for tall and linear players independent of player position. The only position that showed a difference was libero.

Gaurav et al.\textsuperscript{13} (2010) conducted a study to compare the anthropometric characteristics and somatotype of the Guru Nanak Dev University, Amritsar’s male basketball players and volleyball players. Sixty three players (volleyball=36 and basketball=27) of age group 18-25 years were selected. All the participants were assessed for height, weight, breadths, girths and skin fold thickness. Results showed that basketball players had significantly higher height, weight and body surface area as compared to volleyball players. The basketball players were also found to have significantly greater biceps and supraillia skin fold thicknesses, calf circumference, percent body fat, and total body fat, fat free mass and endomorphic component as compared to volleyball players. Volleyball players had significantly greater body density as compared to basketball players. The basketball and volleyball players of


this study were found to have higher percentage body fat with lower body height and body weight than their international counterparts.

Mridha\textsuperscript{14} (2010) conducted a study to investigate male and female sub-junior volleyball players from six states of India. Body composition of the two groups were understood by height, weight, body mass index, percentage body fat, fat mass, lean body mass and waist-to-hip ratio. Results indicated significant difference between the two groups in height, weight, percentage body fat, fat mass, lean body mass and waist-to-hip ratio. Male group was superior in height, weight, lean body mass and waist-to-hip ratio, and female group was superior in percentage body fat and fat mass than the other group. No difference was observed in body mass index of the two groups.

Koley et. al.\textsuperscript{15} (2010) conducted a study, firstly, to evaluate the anthropometric profile of Indian inter-university volleyball players and, secondly, to search the correlation of body mass index, % body fat, hand grip strength (right dominant) and Vo2max. With other anthropometric characteristics studied. Eleven anthropometric characteristics, four body composition parameters, two physical and two physiological variables and nine arm anthropometric characteristics were measured on randomly selected 63 inter-university Indian volleyball players (38 males and 25 females) aged 18–25 years from Guru Nanak Dev University, Amritsar, Punjab, India with adequate controls (n = 102, 52 males and 50 females). The results indicated that male volleyball players were taller (6.63%) and heavier (7.31%) and female volleyball players were slightly taller (0.31%) and lighter (3.74%) than their control counterparts. One way analysis of variance showed significant (p≤0.004-0.000) between group differences in all the variables (except hip circumference) between volleyball players and controls. In volley players, significantly positive correlations were found with BMI and other 19 variables, with percent body fat and 6 variables, with right hand grip strength and 20 variables and with Vo2max and other 19 variables, and significantly negative correlations were found with percent body fat and other 16 variables, with right hand grip strength and other 7 variables and with Vo2max with other 8 variables. The findings of the present study might be useful in


future investigation on player selection, talent identification in volleyball and training program development.

**Kumar & Sharma** (2010) conducted a study on selected anthropometric variables of female volleyball players of senior secondary school level. 24 female senior secondary school level volleyball players were evaluated. Selected anthropometric variables such as foot length, foot breadth, foot height, heel breadth, in step circumference, ankle height, ankle circumference, bowl of foot width, bowl of foot circumference, bowl circumference, buttock-knee distance, buttock-leg length, calf circumference, calf height, circumference of knee, knee height, knee height sitting, knee to knee width, leg length sitting, leg length without foot, length of lower leg and length of thigh were assessed. Results showed that there were significant differences in the variables of heel breadth, ankle height and bowl height. The significant difference were recorded when comparison of speed of movement between left and right foot was made.

**Zhang** (2010) conducted a study to determine the anthropometric characteristics of elite Chinese women volleyball players, identify the differences in the anthropometric profile and physical performance between the players at different volleyball positions, and examine the correlations between the anthropometric profile and the physical performance of the players. Thirty-one anthropometric indices and four physical performances (medicine ball throwing, running vertical jump, T shuttle run agility test and timed 20 sit ups) were measured for 100 volleyball players recruited from the top eight teams of 2007-2008 national championship. The average age of the players was 22.3±3.6 (SD) years and the average training age was 9.7±4.0 years. For the elite Chinese women volleyball players, the average values of stature, body mass, sitting height, standing reach height, and BMI were respectively 183.6±5.8 cm, 70.5±7.6 kg, 95.7±3.5 cm, 236.7±7.8 cm, and 20.9±2.0. The overall anthropometric characteristics of these volleyball players can be described as high stature; relatively longer forearm, palm, calf and Achilles’ tendon lengths but a

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shorter sitting height; wider femur, biliocristal and biacromial breadths; larger difference between relaxed and tensed arm girth, smaller wrist and ankle girths, smaller ankle girth / Achilles' tendon length index; and smaller skin folds. The results also revealed that most of the anthropometric variables were poorly correlated with the selected physical performance measurements, except that the biepicondylar femur breadth, calf girth and calf length indices were significantly correlated with the running jump height. There were significant differences among the anthropometric profiles of the players at different volleyball positions, especially in the indices of body mass, stature, standing reach height, radiale-stylion length, acromiale-dactylium length, midstylion-dactylium length, iliospinale height, tibiale-laterale height length, biacromial breadth, biliocristal breadth, transverse chest breadth and gluteal girth (all P<0.001). However, the physical performance of the players at different positions showed no significant between-position difference except the running jump height. The average somatotype values of elite Chinese women volleyball players were "3.7-2.9-4.0", belonging to endomorph ectomorph. Their somatotypes were found mainly in four of the 13 categories, with 29% in endomorphic ectomorph, 14% in balanced ectomorph, 11% in balanced endomorph and 9% in ectomorph-endomorph. The somatotype of the spikers and liberos was of the central type, that of the second spikers and second setters was endomorphic ectomorph, and that of the setters was endomorph-ectomorph. Based on the findings of this study, it is recommended that the following anthropometric indices be considered in recruitment for women volleyball players: body mass, stature, sitting height, biacromial breadth, subscapular skinfold, ankle girth, forearm girth and achilles' tendon length.

Bokan\(^{18}\) (2009) conducted a study on motor abilities of volleyball players and tests for their assessment. Under the term general motor abilities we imply the motor abilities which can be found in other kinds of sport according to their general characteristics: coordination, strength, speed, endurance, flexibility, balance, and precision. Specific motor abilities are the motor abilities that are specifically developed in each sports branch, taking into account that they are not completely new motor abilities, but the abilities that are "built" out of the general motor abilities by specific training or they are combined into specific motor abilities for each individual

sport. On the basis of consulted works, the majority of volleyball experts under the term of specific motor abilities imply the following: explosive strength and agility, flexibility, body coordination, alternative movements speed, limbs coordination. In the concluding part of the work there are tests that are most often used for estimation of general and specific motor abilities of volleyball players.

**Marques et al.** (2009) conducted a study to investigate the anthropometric and strength characteristics of 35 professional male volleyball players. 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 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 player’s significantly stronger than the setters and liberos. The setter positional group had significantly poorer parallel squat performances than the outside hitter and opposite hitter groups. No other significant differences 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.

**Sheppard et. al.** (2009) conducted a study 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 (±SD) frequency of block jumps for Middles (11.00 ± 3.14)

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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.

Sotiropoulos et al.\(^2\)\(^1\) (2009) conducted a study to measure a number of anthropometric characteristics and vertical jump performance of elite youth women volleyball players, from the national teams of the Balkan countries, and make comparisons based on nationality and players positions. The sample consisted of eighty six athletes from Greece, Bulgaria, Serbia, Moldavia, Turkey and Romania. The volleyball players were also compared according to their playing position i.e. setters, outside hitters, universals, middle blockers and liberos. The subjects were measured for body height, body mass, body mass index and body fat percentage and performed four types of vertical jump; a squat jump initiated from a knee flexion of 90°, a counter-movement jump, a counter-movement jump with arm swing and a drop jump from a dropping height of 40 cm from which reactive strength was also calculated. According to the results, the volleyball players of Greece and Romania had higher body fat percentage than Moldavia and Bulgaria’s players. Middle blockers were taller than the setters, outside hitters and liberos. Universals were taller

than the setters and liberos, and the outside hitters than the liberos. No differences were observed in body mass index between the players and the teams, though middle blockers had higher body mass than the setters, outside hitters and liberos. In squat jump, counter movement jump and drop jump the volleyball players of Turkey had higher values than the volleyball players of Greece and Bulgaria. In countermovement jump with arm swing, the volleyball players of Turkey had also higher values than the volleyball players of Greece, Bulgaria and Moldavia. Furthermore, the volleyball players of Turkey and Serbia had higher reactive strength values than the volleyball players of Greece and Bulgaria and the volleyball players of Turkey had also higher values than the volleyball players of Romania.

Grigoris et al.\textsuperscript{22} (2008) conducted a study to know the morphological characteristics of 163 elite female volleyball players. Body weight, height, breadth, girths and skinfold thickness were measured. The results revealed that body height ranged from 161cm to 194cm, the mean value of 177.1 \pm 6.5cm was not inferior to that of international players. Adiposity of these players was higher than that of reported in other studies. Elite volleyball players had balanced endomorphs (3.4-2.7-2.9). According to different playing positions significant differences were found among the players which were due to their varying roles and physical demands during the volleyball game.

Sheppard et. al.\textsuperscript{23} (2008) conducted a study on 163 elite female volleyball players to examine the potential strength, power, and anthropometric contributors to vertical jump performances that are considered specific to volleyball success: the spike jump (SPJ) and counter-movement vertical jump (CMVJ). To assess the relationship among strength, power, and anthropometric variables with CMVJ and SPJ, a correlation and regression analysis was performed. In addition, a comparison of strength, power, and anthropometric differences between the seven best subjects and the seven worst athletes on the CMVJ test and SPJ test was performed. When


expressed as body mass relative measures, moderate correlations (0.53–0.65; p ≤ 0.01) were observed between the 1RM measures and both relative CMVJ and relative SPJ. Very strong correlations were observed between relative (absolute height standing reach height) depth jump performance and relative SPJ (0.85; p ≤ 0.01) and relative CMVJ (0.93; p ≤ 0.01). The single best regression model component for relative CMVJ was the relative depth jump performance, explaining 84% of performance. The single best predictor for relative SPJ was also the relative depth jump performance (72% of performance), with the three-component models of relative depth jump, relative CMVJ, spike jump contribution (percent difference between SPJ and CMVJ), and relative CMVJ, spike jump contribution, and peak force, accounting for 96% and 97%, respectively. The results of this study clearly demonstrate that in an elite population of volleyball players, stretch-shortening cycle performance and the ability to tolerate high stretch loads, as in the depth jump, is critical to performance in the jumps associated with volleyball performance.

Gabbett and Georgieff24 (2007) conducted a study to evaluate the physiological and anthropometric characteristics of junior volleyball players. One hundred and fifty-three junior national, state and novice volleyball players were tested. Subjects underwent measurements of standard anthropometry (body mass, height, standing reach height, and sum of 7 skinfolds), lower-body muscular power (vertical jump and spike jump), upper-body muscular power (overhead medicine ball throw), speed (5m and 10m sprint), agility (T-test), and estimated maximal aerobic power (multistage fitness test) during the competitive phase of the season. Results showed that the significant differences were detected among junior national, state, and novice volleyball players for height, standing reach height, skinfold thickness, lower-body muscular power, and agility, and estimated maximal aerobic power, physiological and anthropometric characteristics of players showed improvement with increases in playing level. Male players were taller, heavier, leaner, and had greater standing reach height, speed, agility, muscular power, and estimated maximal aerobic power than female players.

Gabbett et al.\textsuperscript{25} (2007) conducted a study to determine whether physiological, anthropometric, and skill test results could discriminate between junior volleyball players of varying ability. Twenty-eight junior volleyball players competed for selection in a talent-identification volleyball programme. Participants underwent measurements of stature, standing reach stature, body mass, skinfold thickness, overhead medicine ball throw, vertical jump, spike jump, 5-m and 10-m speed, "T" test agility, maximal aerobic power, and passing, setting, serving, and spiking technique and accuracy. A discriminant analysis was conducted on the selected and non-selected groups to obtain a regression equation that could be used to predict selection in junior volleyball squads based on the dependent variables. Passing and serving technique were the only significant variables included in the discriminant analysis. Cross-validation results showed that 17 of 19 selected players (89.5\%) and 5 of 9 non-selected players (55.6\%) were correctly classified into selected and non-selected groups, respectively, providing an overall predictive accuracy of 78.6\%. The results of this study demonstrate that selected skill test results (i.e. subjective coach evaluations of passing technique and serving technique), but not physiological and anthropometric data, discriminate between successful and unsuccessful talent-identified junior volleyball players. These results demonstrate the importance of developing passing and serving technique in talent-identified junior volleyball players.

Lidor et al.\textsuperscript{26} (2007) conducted a study to examine the contribution of a battery of physical and motor tests to early phases of talent detection and early development in volleyball, and second, to differentiate between and compare the motor ability of 16-year-old starter (S) and non-starter (NS) volleyball players. Fifteen male adolescent volleyball players underwent assessment of physical and motor ability 6 times during a 15-month training program; however, not all of them took part in each testing phase. The battery was composed of 8 physical and motor tests and 2 skill tests. The physical and motor tests included 2 speed tests, an agility run, 4 explosive power tests, and an endurance test. The skill tests evaluated service

accuracy at rest and following effort. All participants improved their results in all but 2 tests (endurance and skill tests) across testing phases. Comparisons between the S (n=8) and NS (n=7) revealed that only one physical explosive power test (vertical jump with approach), was found to be a good indicator for distinguishing between the 2 groups of players. It was concluded that the volleyball battery of tests was not sensitive enough to distinguish between the "good" and "very good" players suggesting that physical and motor tests do not reflect open skill ability in volleyball.

Mohan and Sharma27 (2007) conducted a study on 334 volleyball players of Himachal Pradesh. The AAHPER youth fitness test battery, consisting of six test items: pull-ups, sit-ups, standing broad jump, shuttle run, 50 yard dash, and 600 yard run or walk was used to measure the motor fitness level of volleyball players. The findings of the study showed that winner volleyball players are better in almost all motor fitness components, except runners up and winner volleyball players as compared to looser volleyball players.

Duncan et. al.28 (2006) conducted a study to investigate the anthropometric and physiological characteristics of junior elite volleyball players. Twenty five national level volleyball players (mean (SD) age 17.5 (0.5) years) were assessed on a number of physiological and anthropometric variables. Somatotype was assessed using the Heath-Carter method, body composition (% body fat, % muscle mass) was assessed using surface anthropometry, leg strength was assessed using a leg and back dynamometer, low back and hamstring flexibility was assessed using the sit and reach test, and the vertical jump was used as a measure of lower body power. Maximal oxygen uptake was predicted using the 20 m multistage fitness test. Setters were more ectomorphic (p<0.05) and less mesomorphic (p<0.01) than centres. Mean (SD) of somatotype (endomorphy, mesomorphy, ectomorphy) for setters and centres was 2.6 (0.9), 1.9 (1.1), 5.3 (1.2) and 2.2 (0.8), 3.9 (1.1), 3.6 (0.7) respectively. Hitters had significantly greater low back and hamstring flexibility than opposites. Mean (SD) for sit and reach was 19.3 (8.3) cm for opposites and 37 (10.7) cm for hitters. There were no other significant differences in physiological and anthropometric variables across


playing positions (all p>0.05). Setters tend to be endomorphic ectomorphs, hitters and opposites tend to be balanced ectomorphs, whereas centres tend to be ectomorphic mesomorphs. These results indicate the need for sports scientists and conditioning professionals to take the body type of volleyball players into account when designing individualised position specific training programmes.

Chauhan and Chauhan\textsuperscript{29} (2005) conducted a study on 40 college level volleyball players of Kurukshetra University. They tested various body measurements i.e. height, sitting height, trunk length, upper and forearm length, foot length and circumference of chest, abdomen, hip, thigh and diameter of biacromial, bitrochantric, femur bicondylar and skinfolds of biceps, triceps, subscapular, suprailliac and mid axillary. It is necessary to have strong arm for volleyball players to perform skills such as blocking, smashing, and serving and receiving, so the objective of this study was to know the relationship between anthropometric variables and explosive arm strength. The results showed that anthropometric variables have positive and significant correlations with arm strength of volleyball players. It was concluded that multiple correlation of height, biacromial, elbow diameter, lean body mass taken together with explosive arm strength have been found significantly at 1% level. The size of the multiple correlations was sufficiently large and hence regression equation developed is useful for the prediction of the explosive arm strength.

Guladi-Russo and Zaccagni\textsuperscript{30} (2001) conducted a study on two hundred and thirty-four male athletes and two hundred and forty-four female athletes from the Italian A1 and A2 volleyball leagues for anthropometric measurements during the 1992-1993 and 1993-1994 seasons. Somatotypes were estimated with the Heath-Carter method. Marked sexual dimorphism in somatotype was observed in the total sample. The somatotype was significantly different in players at different levels of performance. The somatotype was also significantly different in players in different roles. It was concluded that the physique of athletes in the A1 league was characterized by higher ectomorphy and lower endomorphy and mesomorphy. There


was also a slight tendency of male players to a greater homogeneity in somatotype within the group at the maximum level of performance. Moreover somatotype differs in relation to game role in volleyball players of both sexes: the mesomorphic component was maximal in setters, while the ectomorphic component was maximal in centres.

**Singh**\(^{31}\) (2000) conducted a study to know the relationship between physical characteristics, motor ability and motor skill variables of male volleyball players. He concluded that the height, flexibility, wrist flexion, wrist extension, trunk hyperextension, speed, arm strength, leg explosive power, dynamic balance and agility were the main contributor for the volleyball playing ability.

**Sodhi et. al.**\(^{32}\) (1990) conducted a study on 287 volleyball players and 196 non-volleyball players of 14 to 16 years of age group. The height, sitting height and hand span of subjects were measured. It was observed that these variables gradually increased with the age. In volleyball players hand size also increases with age. They also investigated that taller height with longer legs and arms and greater hand span were helpful in the game of volleyball.

**Rawat**\(^{33}\) (1989) conducted a study to determine the physical, physiological and motor skill variables of male volleyball players, which could best contribute in the playing ability of volleyball players. He found that explosive power, agility and ankle flexibility were main contribution for the volleyball playing ability and out of 7 physiological variables, cardiovascular endurance, lean body weight and pulse pressure were contributors and of the 4 motor skill variables, volleying and serving were the best contribution for volleyball playing ability.

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Devi\textsuperscript{34} (1985) conducted a study on twenty-four volleyball players to find out the relationship of selected strength and flexibility measures to playing ability in volleyball. The findings of her study concluded that arm strength, abdominal strength was significantly related to playing ability in volleyball. Grip strength did not correlate significantly to playing ability in volleyball. Wrist flexibility and ankle flexibility had insignificant relationship to playing ability in volleyball. Trunk flexibility showed negative but insignificant correlation to playing ability in volleyball.

Puhl et al.\textsuperscript{35} (1982) conducted a study on physical and physiological characteristics of elite men and women volleyball players. The total 22 volleyball players (8 male and 14 female) were investigated and findings of the investigation showed that the male volleyball players were taller, heavier and had a higher body density, lean body weight and low fat. The differences in the muscle mass between male and female volleyball players were apparently due to sex differences.

Viitasalo\textsuperscript{36} (1982) conducted a study on ten Russian elite male volleyball players were studied for their anthropometric dimensions, maximal isometric trunk extension and flexion, leg extension strength and vertical jumping height. In addition, the height of rise of the body centre of gravity h (C.G.), and the height of the hand and ball were analyzed from a video tape in spike and block jumps taken during actual competition. The two teams were found to differ significantly in the h (C.G.) during a vertical jumping test where a preliminary counter movement was allowed and in the lengths of lower limbs and legs; the Russian volleyball players jumped higher and had longer lower extremities. In actual competition, the hands of the Russian players while performing a spike were on the average ten centimeters higher (p less than .01) than the hand of the Finnish players. No significant differences were found, however, between the teams in the h (C.G.) during spiking. This finding seems to suggest that the Russians have better spike technique.

\textsuperscript{34} Devi, K. S. (1985) Relationship of selected strength and flexibility measure to playing ability in volleyball. Unpublished Master's Thesis Jiwaji University, Gwalior.
