CHAPTER – II

REVIEW OF RELATED LITERATURE

2.1 INTRODUCTION

A literature review is a body of text that aims to review the critical points of current knowledge including substantive findings as well as theoretical and methodological contributions to a particular topic. Its ultimate goal is to bring the reader up to date with current literature on a topic and forms the basis for another goal, such as future research that may be needed in the area. It gives an overview of what has been said, who the key writers are, what are the prevailing theories and hypotheses, what questions are being asked, & what methods and methodologies are appropriate and useful. As such, it is not in itself primary research, but rather it reports on other findings.

The present reviews are based upon the available literature in respect to the study under investigation and therefore confined to the studies to which the investigator has accessed. All the relevant literature thus obtained by the researcher has been presented in this chapter to furnish necessary background material to evaluate the significance of the study. The research scholar has made every possible effort to go through the literatures related to the problem in the game of volleyball wherever available. The scholar has gleaned through almost every source like research quarterly, journals of various kinds, periodicals, encyclopedias, relevant books and e-resources to pick up related material.
The reviews of the literature have been classified under the following headings:

1. Studies on Anthropometric and Motor Fitness Variables.
2. Summary of the literature.

2.2 STUDIES ON ANTHROMETRIC AND MOTOR FITNESS VARIABLES

Arvind & Behera (2013) determined the relationship of anthropometric characteristics and kinematics variables with spiking of volleyball players. The subjects were twelve male junior national volleyball players (average height 177.19 cm, weight 64.35 kg, age below 19 years old). All subjects had participated in 39th Junior National Championship for boys and girls held at Shari Dungargarh, Bikaner Rajasthan (India) from 22-12-2012 to 28-12-2012. 12 volleyball players from Utttrakhand representing their states in under-19 national tournament were selected by purposive sampling method. In this study the spiking performance of the subject recorded by subjective judgment criterion. The performance of spike was recorded by the score in the spike which obtained by using three point scales by the three judges. Three spikes were recorded for each volleyball player and the recorded mean of the scores for trial was performance of spiker as there is no established standard test to test the spike. The anthropometrics characteristics measured by anthropometry equipments (Ross craft Innovations Company, Canada). Two High speed video camera with tripod (Sony Model- 3CCD and Casio Exilim EX-F1) used for videography of spike. Silicon coach Pro-7, motion analyzer software powered
by Silicon coach Ltd. was used for video analysis. The results show that the value of co-efficient of correlation of selected anthropometrics characteristics with off speed spike performance were standing height (0.612), sitting height (0.343) and body weight (0.022), whereas tabulated value at 10 degree of freedom at .05 level of significance is 0.553. The value of co-efficient of correlation of selected angular kinematics variables at moment of ball contact in hitting phase spike were right ankle joint (-0.321), right Knee joint (0.564), right hip joint(-0.117), shoulder joint (-0.070), elbow joint (-0.641) and body inclination (-0.335), whereas tabulated value for 10 degree of freedom at .05 level of significance is 0.553. It is suggested that results from this study can provide useful information for coaches to train volleyball players in off speed spike.

Diego, et.al., (2013) compared the anthropometric and physical fitness characteristics of Brazilian adolescents who practice team court sports and to compare specific parameters obtained for adolescents with data from the general population. This was a cross-sectional study of 1,348 male adolescents grouped as follows: basketball players (n = 287), indoor soccer players (n = 665), handball players (n = 108) and volleyball players (n = 288), all between 10 and 14 years of age. Anthropometric (body mass, body height, arm span and body mass index) and physical fitness data (flexibility, muscular strength, explosive power, speed, aerobic fitness and agility) were collected. The Brazilian population was used as a reference and compared to the adolescent subjects using Z scores for all variables. Anthropometric characteristics and
performances in physical fitness tests differed (p<0.05) among players of different sports. In addition, for each variable assessed, adolescents who practiced team court sports showed similar or improved results compared to their counterparts in the general population (p<0.05). Furthermore, the anthropometric and physical fitness characteristics differed depending on the team court sport practiced. These findings may elucidate which physical abilities are most impacted by the practise of a particular team sport as well as help teachers and physical education and sport professionals identify talented adolescents.

Fattahi, et al., (2013) determined 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.

Garcia, et al., (2013) compared volleyball game-related statistics by outcome (winners and losers of sets) and set number (total, initial and last) to identify characteristics that discriminated game performance. Game-related statistics from 314 sets (44 matches) played by teams of male 14 to 15 years old in a regional volleyball championship were analysed (2011). Differences between contexts (winning or losing teams) and "set number" (total, initial and last) were assessed. A discriminate analysis was then performed according to outcome (winners and losers of sets) and "set number" (total, initial and last). The results showed differences (winning or losing sets) in several variables of Complexes I (attack point and error reception) and II (serve and aces). Game-
related statistics which discriminate performance in the sets index the serve, positive reception and attack point. The predictors of performance at these ages when players are still learning could help coaches plan their training.

**Gil, et.al., (2013)** conducted a study on 520 volleyball players between the ages of 12 and 16 years. The independent variable was the amount of training, defined as the number of weekly hours that the volleyball player devoted to training. The dependent variable was cognitive expertise, measured by declarative knowledge and procedural knowledge. A univariate analysis of variance was done to examine the relationship between the number of weekly hours and the declarative and procedural knowledge reached by volleyball players in the athletic formation training stages. Statistical significance was set at $p < 0.05$. There were significant differences in knowledge according to the number of weekly training hours ($p < 0.001$). These results confirm that there is a relationship between the quantity of practice and the development of cognitive expertise. It is recommended that young players dedicate at least 4 hours weekly to training to achieve a significant improvement in cognitive expertise.

**Grgantov, et.al., (2013)** determining the factor structure of explosive power, as well as the influence of each factor on situational efficiency, 56 young female volleyball players were tested using 14 tests for assessing nonspecific and specific explosive power. By factor analysis, 4 significant factors were isolated which explained the total of over 80% of the common variability in young female volleyball players. The first factor was defined as
volleyball-specific jumping, the second factor as nonspecific jumping and sprinting, the third factor as throwing explosive power, while the fourth factor was interpreted as volleyball-specific throwing and spiking speed from the ground. Results obtained by regression analysis in the latent space of explosive power indicate that the identified factors are good predictors of player quality in young female volleyball players. The fourth factor defined as throwing and spiking speed from the ground had the largest influence on player quality, followed by volleyball-specific jumping and nonspecific jumping and sprinting, and to a much lesser extent, by throwing explosive power. The results obtained in this age group bring to the fore the ability of spiking and serving a ball of high speed, which hinders the opponents from playing those balls in serve reception and field defence. This ability, combined with a high standing vertical jump reach and spike approach vertical jump reach (which is the basis of the 1st varimax factor) enables successful performance of all volleyball elements by which points are won in complex 1 (spike) and complex 2 (serve and block). Even though the 2nd factor (nonspecific jumping and sprinting) has a slightly smaller impact on situational efficiency in young players, this ability provides preconditions i.e. preparation for successful realisation of all volleyball elements, so greater attention must be paid to perfecting it in young female volleyball players.

Martin, et al. (2013) described 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 analysed. 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 characterised 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.

Mazon, et al., (2013) compared the seasonal changes (preparation period [PP] and competition period [CP]) of vertical jumping performance and knee muscle strength in a team of under-19 women volleyball players (N = 12, 16.2 ± 1.5 years). The countermovement jump was used to evaluate jumping performance. The isometric knee extension moment at 150 ms from the onset of contraction (T150) and at a maximum of contraction (TMAX) were
determined at 9 knee angles (from 10° to 90°, full knee extension = 0°). The peak isokinetic knee extension (TISOK-EXT) and flexion (TISOK-FLEX) moment were determined at 60, 180, and 240°·s. Repeated-measures analysis of variance was applied to the differences between PP and CP (p ≤ 0.05). Significant increases in jumping performance were found for jump height, peak impulse, total impulse, peak power, and takeoff velocity (p ≤ 0.05). At the knee flexion angles from 40° to 90°, T150 was significantly increased (p ≤ 0.05), whereas the increase was not significant at the rather extended knee angles of 10°, 20°, and 30° (p > 0.05). Only at 90° of knee flexion (p ≤ 0.05), TMAX was significantly increased. With the exception of TISOK-FLEX at 60°·s (p ≤ 0.05), the increases of TISOK-EXT and TISOK-FLEX were not significant (p > 0.05). The TISOK-EXT/TISOK-FLEX ratios were not significantly changed (p > 0.05). The main application of the study is that it provides performance standards and potential criteria for variable selection for jumping performance and knee muscle strength seasonal evaluation.

**Milic, et al., (2013)** set of 18 test for assessing anthropometric characteristics and 12 tests for assessing motor abilities was used on a sample of 183 young female volleyball players (average age of 13.11 +/- 1.07 years) to determine the latent structure of biomotor status, as well as relations of that status to situational efficiency in female volleyball players. Situational efficiency of young volleyball players was assessed on a five-point Likert scale, in relation to each individual player's contribution to the performance of her team, and with regard to the result of that team achieved in the competition.
By factor analysis, 3 anthropometric ("endo-mesomorphy", "longitudinal
dimensionality of the skeleton" and "transverse dimensionality of the
skeleton") and 4 motor factors ("explosive power of legs and agility",
"precision", "explosive power of arms and flexibility" and "balance") were
obtained. Significant impact of morphological-motor factors on situational
efficiency of young female volleyball players was obtained by regression
analysis. Set of predictor variables accounts for 40% of the total variance of the
system. On a univariate level, all extracted factors, except precision and
balance, had a significant impact on situational efficiency. Factors named
"longitudinal dimensionality of the skeleton" and "explosive power of legs and
agility" had the greatest partial contribution in explaining the criteria. Obtained
results confirmed previous findings about the importance of individual
dimensions of biomotor status for efficiency in volleyball.

Nikolaidis, et al., (2013) examined (a) the prevalence of
overweight/obesity, and (b) the relationship between body mass index (BMI),
body fat percentage (BF) and physical fitness in adolescent and adult female
volleyball players. Adolescent (n = 102, aged 15.2 ± 2.0 year) and adult (n =
57, 25.9 ± 5.0 year) players were examined for anthropometric characteristics
and body composition, and performed the physical working capacity in heart
rate 170 min(-1) test, a force-velocity test, the Wingate anaerobic test (WAnT),
sit-and-reach test (SAR), handgrip strength test (HST) and countermovement
vertical jump (CVJ). Based on international BMI cut-off points, 27.5% (n = 28)
of adolescent and 12.3% (n = 7) of adult participants were classified as
overweight, with the prevalence of overweight being higher in girls than in women ($\chi(2) = 4.90, P = 0.027$). BMI was correlated with BF in both age groups ($r = 0.72$, $P < 0.001$ in girls; $r = 0.75$, $P < 0.001$ in women). Normal participants had superior certain physical and physiological characteristics than those who were overweight. For instance, normal girls and women had higher mean power during WAnT than their overweight counterparts ($P = 0.003$ and $P = 0.009$ respectively). Except for flexibility, BMI and BF were inversely related with physical fitness (e.g., BMI vs. HST $r = -0.39$, $P < 0.001$ in girls; BF vs. CVJ $r = -0.45$, $P < 0.001$ in women). The findings confirmed the negative effect of overweight and fatness on selected parameters of physical fitness. The prevalence of overweight in adolescent volleyball players was higher than in general population, which was a novel finding, suggesting that proper exercise interventions should be developed to target the excess of body mass in youth volleyball clubs.

Schaal, et.al., (2013) examined physiologic performance test differences by competition level (high school and Division-I collegiate athletes) and player position (hitter, setter, defensive specialist) in 4 volleyball-related tests. A secondary purpose was to establish whether a 150-ym shuttle could be used as a field test to assess anaerobic capacity. Female participants from 4 varsity high school volleyball teams ($n = 27$) and 2 Division-I collegiate volleyball teams ($n = 26$) were recruited for the study. Participants completed 4 performance-based field tests (vertical jump, agility T-test, and 150- and 300-ym shuttle runs) after completing a standardized dynamic warm-up. A 2 way multivariate analysis of
variance with Bonferroni post hoc adjustments (when appropriate) and effect sizes were used for the analyses. The most important findings of this study were that (a) college volleyball athletes were older, heavier, and taller than high school athletes; (b) high school athletes had performance deficiencies in vertical jump/lower-body power, agility, and anaerobic fitness; (c) lower-body power was the only statistically significant difference in the performance test measures by player position; and (d) the correlation between the 150- and 300-yd shuttle was moderate (r = 0.488). Female high school volleyball players may enhance their ability to play collegiate volleyball by improving their vertical jump, lower-body power, agility, and anaerobic fitness. Furthermore, all player positions should emphasize lower-body power conditioning. These physical test scores provide baseline performance scores that should help strength and conditioning coaches create programs that will address deficits in female volleyball player performance, especially as they transition from high school to college.

Selmanovic, et al., (2013) conducted a research on a sample of 125 eleven-year-old boys divided into three groups (two experimental and one control) which were examined by 12 motor tests at the beginning and at the end of the 9-month period. The tests included evaluation of explosive power dynamic and static strength endurance, co-ordination, flexibility and hand frequency motion. Although all three treatments together, complemented by the natural growth and developmental factors, induced significant quantitative changes, the results showed the highest motor improvements in the basketball
experimental group, followed by the volleyball experimental group. While explosive power mainly contributed toward significant difference between the control and experimental groups in the final measurement, univariate test results also showed distinctive improvements in dynamic strength, hand frequency motion and various factors of co-ordination within experimental groups. The general conclusion points to the fact that even one additional PE session per week of the given program is sufficient to produce significant changes in motor abilities of elementary school fifth graders. Therefore the authors' support the legal provisions of mandatory implementation of extra-curricular forms of physical activity in elementary schools.

Manikandan & Suresh (2012) conducted a study to find out the effect of ladder training on selected performance factors among volleyball players. The purpose of the study was to find out the effect of ladder training on selected performance variables of men volleyball players. To achieve the purpose 30 volleyball players from Selvam Group of Institutions, Namakkal were selected as subjects and their age ranged from 18 to 24 years. The study was formulated as a true random group design, consisting of a pre-test and post-test. The subjects were randomly assigned to two equal groups of fifteen each and named as Group ‘A’ and Group ‘B’. Group ‘A’ underwent ladder training and Group ‘B’ undergone no training. The ladder training group was undergone training for six weeks on alternate days. The performance factors volley pass and serving were selected as variables. Analysis of covariance was used, where the final means were adjusted for differences in the initial means and the adjusted means
were tested for significance. From the analysis of data it was found that the ladder training group showed significant improvement on all selected variables.

Nemet, et al., (2012) experimented forty state level volleyball players with trunk instability were randomly divided into two groups, control ([C] m=10; f=10) and experimental ([E] m=10; f=10). Modified double straight leg lowering test was used to check the degree of trunk instability. Counter movement jump, squat jump, spike jump and block jumps were used to measure jumping abilities and a wobble board test was used to test balance. Pre- and post readings were noted before and after the nine-week training protocol and statistical data analysis was done using SPSS 16. After nine weeks of core stabilization training, trunk stability (P<0.001), block difference (BD) in block jump (P<0.01) were enhanced significantly comparing to (C) group using independent T test. Effect size Cohen's d score demonstrated better improvement of spike jump (d=0.25) and block jump (d=0.52) in (E) group. Other jumps and static balance were improved but non-significant when compared between groups. Nine-week strategic core strengthening exercise program increases trunk stability and in turn improves block difference (vertical jump parameter).

Pau, et al., (2012) assessed the effectiveness of a 6-week balance training (BT) protocol, integrated in regular training sessions, on postural sway of young female volleyball players (n = 26, age 13.0 +/- 0.2 years) divided into two groups (intervention and control; 13 per group). Trials were performed for bipedal and unipedal stance conditions before and after the BT protocol, using
a pressure platform to collect center-of-pressure (COP) time series that were processed to calculate sway area, COP path length, and maximum displacement range in anteroposterior and mediolateral directions. The intervention group exhibited smaller sway areas in eyes closed conditions (intervention = 42.76 mm², control = 67.60 mm²; p < 0.05) and Romberg quotients (intervention = 1.11 mm, control = 1.82 mm) in bipedal stance, while all the other parameters were unaffected. BT also reduced sway area (intervention = 122.70 mm², control = 187.18 mm²) and anteroposterior COP displacements (intervention = 20.18 mm, control = 22.38 mm) of the non-dominant limb for single-leg stance. No significant change was found for the dominant limb. Although it is possible to hypothesize a beneficial effect of BT on young athletes, further investigations are required to clarify its actual effect on balance performance with respect to normal volleyball training.

Sharma, et al., (2012) developed a profile for 15 members of the United States Women’s National Volleyball Training Team. Data were obtained from anthropometric, strength, physiologic and motor performance domains. Within-group comparisons were made between the six women who were selected for the Pan-American Team and the nine who were not. The Pan-American selectees were taller and heavier and demonstrated greater motor ability than the non-selectees. Strength measurements did not indicate consistent differences between the two sub-groups. The non-selected players had a greater VO2max than those selected. Between-group comparisons on selected variables were made between the subject and other American women
volleyball players. The training team subjects were taller and heavier than the comparative groups. The training team group demonstrated lower heart rate MAX (180 beats/min) than the other groups reported, and their VO2max (43.2 ml/kg/min) was within the range of the comparative groups.

Sheppard, et al., (2012) examined the anthropometric, vertical jump and strength quality changes over 2 years in a group of national team volleyball players. Fourteen national team volleyball players (age, 23.0 ± 4.1 years; height, 1.98 ± 0.07 m; weight, 91.7 ± 7.9 kg) began and completed this study. Participants had all played international matches (representing Australia) before the examination time period and continued to do so during the international season. Anthropometry (stature, mass and sum of 7 skinfolds), vertical jump measures (countermovement vertical jump; depth jump from 0.35 m, DJ; spike jump, SPJ, all including arm swing) and lower-body power (jump squat at body mass and jump squat + 50% body weight, JS50) measures were tested before and at the conclusion of the investigation period. Significant (p < 0.05) improvements were observed in sum of 7 skinfolds, DJ, SPJ and JS50 performance, with large magnitude changes (d > 0.70) in the sum of 7 skinfolds reduction, SPJ and leg extensor power. This study has demonstrated that elite male volleyball players can improve leanness and power, which contribute to improvements in vertical jump.

Vedat, et al., (2012) conducted a research to determine the anthropometric, somatotype and performance characteristics of the Turkish National U-14 Female Volleyball Team that participated in the national team
selection session. Fifty-eight (58) female volleyball players from various towns in Turkey camped to compete in the national team selection carried out at METU sports hall in 2007 participated in the study. Heath-Carter method was used to determine the somatotype characteristics. Correlate (bivariate) statistics was used to determine any relationships between the players’ somatotypes and their performance measures. The mean age, height and weight values of the participants (n=58) were 14.38±0.98 years, 177.17±5.42 cm, 60.97±8.10 kg, respectively. The mean values of the performance evaluation tests including vertical jump, standing long jump, and 20 – metre run were 41.14±4.76 cm, 191.24±16.33 cm and 3.78±1.18 sec, respectively. The mean somatotype values of the players were as follows: endomorphy 3.44±0.98, mesomorphy 2.13±1.00, ectomorphy 4.46±1.09. The research was helpful in providing a guide regarding the selection of female volleyball players as well as designing training programmes and plans related to specific player positions.

**Visnesh & Bahr (2012)** conducted a study to examine the relationship between training and competition load, body composition and risk for developing jumper's knee. Participants are elite volleyball players, aged 16-18 years. Training and competition load was recorded continuously and body composition semiannually. Jumper's knee was diagnosed on a standardized clinical examination. We recruited 141 healthy students (69 males and 72 females) and 28 developed jumper's knee (22 boys and six girls). In a multivariate analyses, boys had three to four times higher risk compared with girls. Volleyball training had an odds ratio (OR) 1.72 (1.18-2.53) for every
extra hour trained, and match exposure was the strongest sports-related predictor for developing jumper's knee with an OR of 3.88 (1.80-8.40) for every extra set played per week. Conclusion, male gender, a high volume of volleyball training and match exposure were risk factors for developing jumper's knee.

Alar & Lennart (2011) determined whether anthropometric, physical, psychological and skill test results could be used to discriminate between male junior volleyball players of varying ability. A total of 66 elite and non-elite male Estonian volleyball players aged 16–17 years were measured for anthropometric and physical variables and sport-specific skills. In addition, the players provided self-report of dispositional achievement goals, perceived sport competence and enjoyment and their game intelligence were measured. Selected youth players scored better than non-selected youth players on physical (explosive strength), technical (passing and spiking), and cognitive (game intelligence) characteristics and reported higher mastery-approach goals, perceived sport competence and enjoyment of sport. The most discriminating variables were game intelligence, mastery approach goals, perceived sport competence and passing technique. These results suggest the important role of multidimensional performance measures in selecting and developing young male volleyball players.

Cortell, et al., (2011) analysed the movement patterns and direction of locomotion in professional men's beach volleyball. A quantitative analysis of beach volleyball play was carried out for 10 players in the European Beach
Volleyball Championship 2005. Video recordings were made of the 1,997 movements in 4 matches. Analysis showed that male players used more offensive than defensive movement patterns. Defensive movement patterns were more blocks and defense than receptions. Offensive movement patterns were more attack and placements than attack preparation moves. Advance was the direction of locomotion most used. Identifying and understanding such movement patterns are vital to defining specific, effective training strategies for men's beach volleyball player.

Koley & Pal (2011) estimated the dominant handgrip strength and its correlations with some hand and arm anthropometric variables in 101 randomly selected Indian inter-university female volleyball players aged 18-25 years (mean age 20.52±1.40) from six Indian universities. Three anthropometric variables, i.e. height, weight, BMI, two hand anthropometric variables, viz. right and left hand width and length, four arm anthropometric variables, i.e. upper arm length, lower arm length, upper extremity length, upper arm circumference and dominant right and non-dominant handgrip strength were measured among Indian inter-university female volleyball players by standard anthropometric techniques. The findings of the present study indicated that Indian female volleyball players had higher mean values in eleven variables and lesser mean values in two variables than their control counterparts, showing significant differences (P<0.032-0.001) in height (t=2.63), weight (t=8.66), left hand width (t=2.10), left and right hand length (t=9.99 and 10.40 respectively), right upper arm length (t=8.48), right forearm length (t=5.41),
dominant (right) and non-dominant (left) handgrip strength (t=9.37 and 6.76 respectively). In female volleyball players, dominant handgrip strength had significantly positive correlations (P=0.01) with all the variables studied. It may be concluded that dominant handgrip strength had strong positive correlations with all the variables studied in Indian inter-university female volleyball players.

Lamontagne, et al., (2011) examined the effect of 4 week of CrMS on 1 RM spike jump (SJ) and repeated block jump (BJ) performance among 12 elite males of the Sherbrooke University volleyball team. Using a parallel, randomized, double-blind protocol, participants were supplemented with a placebo or creatine solution for 28 d, at a dose of 20 g/d in days 1-4, 10 g/d on days 5-6, and 5 g/d on days 7-28. Pre- and postsupplementation, subjects performed the 1 RM SJ test, followed by the repeated BJ test (10 series of 10 BJs; 3 s interval between jumps; 2 min recovery between series). Due to injuries (N = 2) and outlier data (N = 2), results are reported for eight subjects. Following supplementation, both groups improved SJ and repeated BJ performance. The change in performance during the 1 RM SJ test and over the first two repeated BJ series was unclear between groups. For series 3-6 and 7-10, respectively, CrMS further improved repeated BJ performance by 2.8% (likely beneficial change) and 1.9% (possibly beneficial change), compared with the placebo. Percent repeated BJ decline in performance across the 10 series did not differ between groups pre- and postsupplementation. In conclusion, CrMS likely improved repeated BJ height capability without
influencing the magnitude of muscular fatigue in these elite, university-level volleyball players.

Fonseca, et al. (2010) investigated the anthropometrics characteristics of male Brazilian junior volleyball players, organised into 3 sports requirement groups: high qualification (HQ) formed by the national team, middle qualification (MQ) formed by athletes playing in the Brazilian national championships and low qualification (LQ) formed by players at school level. 101 athletes were observed, HQ (n=16), MQ (n=68) and LQ (n=17), aged 16.7 ± 0.5; 16.6 ± 0.5 and 16.2 ± 0.7 years, respectively. The following were evaluated: body mass, height, standing reach height, % body fat and Heath & Carter somatotype. The statistical analysis was descriptive and inferential, the Kruskal Wallis test being used for detecting differences between groups (p<0.05 significance) and Spearman correlation coefficient for establishing association between anthropometric characteristics and requirement levels, considering p<0.05 e p<0.01 to be significant and highly significant, respectively. Significant differences (p<0.05) were detected between athlete groups for body mass, height, standing reach height and ectomorphy. A "strong" correlation for height and "regular" correlation for standing reach height; body mass and ectomorphy were observed, according to players' height or classification. The results gave normative data for athletes which will allow coaches and physical instructors to use such information during training as a sports' selection instrument for young talented volleyball players.
Laffaye & Choukou (2010) investigated in skilled volleyball players (a) the effect of dropping height on women's and men's performance and (b) the drop jump technique with regard to gender. Nine male and 9 female skilled volleyball players were instructed to jump as high as they could, using a drop jump, from a box of 30 cm or from 2 boxes (60 cm). Kinematic and kinetic data were collected using 6 cameras and a force plate. The human body was summarized by using a 4-segment model (foot, shank, thigh, head-arms-trunk). Males performed higher jumps than females (46.6 +/- 7.5 cm vs. 36 +/- 5.4 cm; p < 0.05). This could be explained by higher mean power (56.9 +/- 26 W/kg vs. 42.4 +/- 19 W/kg; p < 0.05) and shorter eccentric time (-46.3%), both of which allowed a better stretch-shortening cycle. This study shows that women and men have different jump techniques when they drop from a higher position but without increasing the vertical performance. Women increase the values of force and stiffness (respectively +21.4% and +17.9%) without changing the temporal structure of the jump. Men reduce the eccentric time of the jump (41% vs. 31.8%) and keep the force parameters constant. The study findings indicate that it is necessary to find an optimal height for plyometric training for each athlete, allowing enhancement.

Shyamal, et al. (2010) conducted a study of two-folds, 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 V\textsubscript{O}2\text{max.} 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 Vo_{2\,\text{max}} 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 Vo_{2\,\text{max}} 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.

Lidor, et al., (2010) reviewed a series of studies (n = 31) on physical attributes, physiological attributes, and on-court performances of female volleyball players. Empirical and practical knowledge emerging from studies on training-related issues in volleyball, such as body mass, fat-free mass, aerobic profile, strength, and agility and speed, should be integrated and
applied when planning annual training programs for volleyball players. Based on our review, it was found that (a) players of a higher skill level are taller, somewhat heavier, and have higher vertical jump values than players of a lower level; (b) the aerobic profile of female volleyball players is similar to that of female basketball players; (c) ballistic resistance training can increase vertical jump values in female volleyball players; and (d) preseason conditioning should be conducted to prevent fatigue and reduced performance at the beginning of the season. Among the research concerns discussed in the article are that there is a lack data for on-court performance and time-motion analysis in female volleyball players and that more experimental/manipulative studies are needed to examine the effectiveness of different training programs on physiological attributes of female volleyball players. Two practical implications are suggested for volleyball, strength and conditioning coaches: (a) functional and nonfunctional overreaching should be carefully monitored when planning strength and conditioning programs, and (b) volleyball programs should include ballistic-type training.

Masci, et al., (2010) conducted a study on seven male volleyball players and seven male non-jumper athletes. The following tests were performed in a random order: single countermovement jump (CMJ), single squat jump. At the end of the series, subjects performed a repetitive CMJ test. Electromyographic signals were recorded from vastus lateralis and biceps femoris muscles on both sides. Ground reaction forces and moments were measured with a force plate. Volleyball athletes performed better in all tests and were more resistant to
fatigue than non-jumper athletes. Furthermore, volleyball athletes showed a reduced co-activation of knee flexor/extensor muscles. The present results seem to stand for a neural adaptation of the motor control scheme to training.

Quiroga, et al., (2010) conducted a study to determine whether the in-game role of players (setter, outside, middle, or opposite player) in elite women's volleyball is significantly related to the characteristics of their service. The sample consisted of 1,300 service deliveries (total serves for all matches) made by players in the 8 teams participating in 2 Final 4 stages of the Indesit European Champions League. The variables recorded were in-game role of the server, service type, speed of delivery, service area, target zone, and effectiveness of delivery. Results showed a significant relation between the server's in-game role and service type (p < 0.01), service speed (p < 0.01), service area (p < 0.01), and effectiveness of delivery (p < 0.001). The most significant relation observed was with the service area, primarily because of the server having to make a quick transition to the defense zone. Setters and opposite players most commonly served from behind zone 1 (100 and 80% of serves, respectively), which they defended after serving. Similarly, middle players served most frequently from behind zone 5 (47% of serves), the zone they subsequently defended.

Yuyi (2010) determined 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 shorter sitting height; wider femur, biiliocristal 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 skinfolds. 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-styliion length, acromiale-dactylion length, midstyliion-dactylion length, iliospinale height, tibiale-laterale height length, biacromial breadth, biiliocristal 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 endomorphic-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.

Vishaw, et al., (2010) compared the anthropometric characteristics and somatotype of the Guru Nanak Dev University, Amritsar’s male basketball players and volleyball players. Sixty three sportspersons (volleyball=36 and basketball=27) of age group 18-25 years were selected from different colleges affiliated to Guru Nanak Dev University, Amritsar, Punjab, India. All the participants were assessed for height, weight, breadths, girths and skin fold thickness. An independent samples t-test revealed that basketball players had significantly higher height ($p<0.01$), weight ($p<0.01$) and body surface area ($p<0.01$) as compared to volleyball players. The basketball players were also
found to have significantly greater biceps (p<0.01) and suprailliac (p<0.01) skin fold thicknesses, calf circumference (p<0.05), percent body fat (p<0.01), total body fat (p<0.01), fat free mass (p<0.05) and endomorphic component (p<0.05) as compared to volleyball players. Volleyball players had significantly greater body density (p<0.01) 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. Further investigations are needed on the above studied variables along with fitness and physiological variables to assess relationships among them and with performances in volleyball and basketball. 

Sheppard, et.al., (2009) examined the strength, power and anthropometric contributors to vertical jump performances that are considered specific to volleyball success, including countermovement vertical jump (CMVJ) and spike jump (SPJ), by examining changes across 12 months in elite volleyball players. Anthropometry (height, mass, summation Sigma 7 skinfolds), vertical jump ability (CMVJ, SPJ, and depth jumps from 35 cm), kinetic and kinematic data from an unloaded and loaded (body mass + 50%) jump squat were assessed before and after 12 months of training in 20 elite male volleyball players. To examine the association between the change in each of the strength, power and anthropometric variables with the changes in CMVJ and SPJ, a correlation analysis of the percent change of each variable with the percent change in CMVJ and SPJ was performed. A significant correlation (r = 0.47; p = 0.04) was observed between changes in CMVJ and
Significant (p = 0.006-0.02) improvements in CMVJ were associated with increased peak force in the unloaded (r = 0.61) and loaded jump squat (r = 0.59) and greater relative power and peak velocity in the loaded jump squat (r = 0.49 and 0.51, respectively). The significant increase in CMVJ was strongly associated (r = 0.865; p < 0.001) with an improved depth-jump ability. Significant (p = 0.003-0.03) increases in SPJ were related to increases in relative power (r = 0.64), peak force (r = 0.46), and peak velocity (r = 0.49) in the loaded jump and improved depth-jumping ability (r = 0.591). This study demonstrates 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, are critical to improving jumping performance.

Sheppard, et al., (2009) investigated 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) 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.

Marques, et.al., (2009) investigated 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.

Bisseling (2008) assessed 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 ($0.53$-$0.65$; $p \leq 0.01$) 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 ($0.85$; $p$
< or = 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.

Barnes, et al., (2007) conducted a study to (a) quantify vertical and horizontal force during a COD task, (b) identify possible predictors of court-sport-specific agility performance, and (c) examine performance difference between National Collegiate Athletic Association Division I, II, and III athletes. Twenty-nine collegiate female volleyball players completed a novel agility test, countermovement (CM) and drop jump tests, and an isometric leg extensor test. The number of athletes by division was as follows: I (n = 9), II (n = 11), and III (n = 9). The agility test consisted of 4 5-meter sprints with 3 180 degrees turns, including 1 on a multiaxial force platform so that the kinetic properties of the COD could be identified. One-way analysis of variance revealed that Division I athletes had significantly greater countermovement jump heights than Division III, and the effect size comparisons (Cohen's d)
showed large-magnitude differences between Division I and both Divisions II and III for jump height. No other differences in performance variables were noted between divisions, although effect sizes reached moderate values for some comparisons. Regression analysis revealed that CM displacement was a significant predictor of agility performance, explaining approximately 34% of the variance. Vertical force was found to account for much of the total force exerted during the contact phase of the COD task, suggesting that performance in the vertical domain may limit the COD task used herein. This study indicates that individuals with greater CM performance also have quicker agility times and suggests that training predominantly in the vertical domain may also yield improvements in certain types of agility performance. This may hold true even if such agility performance requires a horizontal component.

Gabbett (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 discriminate 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 discriminate 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.

Gabbett, et al., (2007) investigated the physiological and anthropometric characteristics of junior volleyball players competing at the elite, semi-elite, and novice levels and to establish performance standards for these athletes. One hundred and fifty-three junior national (N = 14 males; N = 20 females), state (N = 16 males; N = 42 females), and novice (N = 27 males; N = 34 females) volleyball players participated in this study. 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 (5-m and 10-m sprint), agility (T-test), and estimated maximal aerobic power (multistage fitness test) during the competitive phase of the season, after obtaining a degree of match fitness. Significant differences (p < 0.05) were detected among junior national, state and novice volleyball players for height, standing reach height,
skin fold thickness, lower-body muscular power, agility and estimated maximal aerobic power, with the physiological and anthropometric characteristics of players typically improving 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. These findings provide normative data and performance standards for junior volleyball players competing at the elite, semi-elite, and novice levels. Given the improvements in lower-body muscular power, agility, and estimated maximal aerobic power with increased playing level, and given the importance of these qualities to competitive performances, conditioning coaches should train these qualities to improve the playing performances of junior volleyball players.

Lidor, et al., (2007) assessed a volleyball service test performed not only under a rested condition but also immediately following physical exertion. Twenty-six male adolescent volleyball players (15 elite players of a coherent team [team A; mean age = 16.4 years] and 11 near-elite players of a high school team [team B; mean age = 16.3 years]) performed a service test in a rested condition and following physical exertion. The physical exertion consisted of a block at the net followed by a dig at the 3-m line, both performed twice and again a block at the net. The players performed 10 consecutive serves under the rested condition and 5 sets of 2 consecutive serves under the physical exertion condition. The points for each serve were allotted according to predestinated target areas. The data analyses indicated no differences between
the teams in service performances. No differences between the players' service scores in rested and physical exertion conditions were found. A high correlation (r = 0.97) was obtained between the total score of the test and the number of successful 7-point serves. A moderate correlation (r = 0.69) was found for the 7-point serves score following exercise. It was concluded that the number of serves hit successfully at the 7-point areas can be used by coaches as the total score of the test. In addition, the number of successful 7-point serves performed after physical exertion can provide coaches with relevant information on their players' serving skill level.

**Bayios, et al., (2006)** Investigated anthropometric profile, body composition and somatotype of elite Greek female basketball (B), volleyball (V) and handball (H) players, b) to compare the mean scores among sports and c) to detect possible differences in relation to competition level. A total of 518 female athletes, all members of the Greek first National League (A1 and A2 division) in B, V and H sport teams participated in the present study. Twelve anthropometric measures required for the calculation of body composition indexes and somatotype components were obtained according to the established literature. V athletes were the tallest (P<0.001) among the three groups of athletes, had the lowest values of body fat (P<0.001) and their somatotype was characterized as balanced endomorph (3.4-2.7-2.9). B athletes were taller (P<0.01) and leaner (P<0.001) than H players, with a somatotype characterized as mesomorph-endomorph (3.7-3.2-2.4). H athletes were the shortest of all (P<0.01), had the highest percentage of body fat (P<0.001) and
their somatotype was mesomorph-endomorph (4.2-4.7-1.8). In comparison with their A2 counterparts the A1 division players were taller (P<0.001) and heavier (P<0.01), but at the same time leaner (P<0.001), and exhibited higher homogeneity in somatotype characteristics (P<0.05). Anthropometric, body composition and somatotype variables of Greek female elite team ball players varied among sports; selection criteria, hours of training and sport-specific physiological demands during the game could explain the observed differences. More data are certainly needed to define the anthropometric profile of B, V and H female athletes internationally.

Duncan, et al., (2006) investigated 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.

Gabbett, et al., (2006) conducted a study to find out the effect of a skill-based training program on measurements of skill and physical fitness in talent-identified volleyball players. Twenty-six talented junior volleyball players (mean +/- SE age, 15.5 +/- 0.2 years) participated in an 8-week skill-based training program that included 3 skill-based court sessions per week. Skills sessions were designed to develop passing, setting, serving, spiking, and blocking technique and accuracy as well as game tactics and positioning skills. Coaches used a combination of technical and instructional coaching, coupled with skill-based games to facilitate learning. Subjects performed measurements of skill (passing, setting, serving, and spiking technique and accuracy), standard anthropometry (height, standing-reach height, body mass and sum of 7 skinfolds), lower-body muscular power (vertical jump, spike jump), upper-body muscular power (overhead medicine-ball throw), speed (5- and 10-m sprint), agility (T-test), and maximal aerobic power (multistage fitness test) before and after training. Training induced significant (p < 0.05) improvements
in spiking, setting, and passing accuracy and spiking and passing technique. Compared with pretraining, there were significant (p < 0.05) improvements in 5- and 10-m speed and agility. There were no significant differences between pretraining and posttraining for body mass, skinfold thickness, lower-body muscular power, upper-body muscular power, and maximal aerobic power. These findings demonstrate that skill-based volleyball training improves spiking, setting, and passing accuracy and spiking and passing technique, but has little effect on the physiological and anthropometric characteristics of players.

Katic, et al., (2006) identified motor structures in elite female volleyball players aged 14-17, to assess the effect of those motor structures on their technical and situation efficiency. For this purpose, a battery of 12 motor tests as predictor variables, and a set of six technical elements and evaluation of performance quality as criterion variables were applied in a sample of 147 female volleyballers aged 14-15 and a sample of 50 female volleyballers aged 16-17. Analysis of variance between subgroups within the groups of volleyballers aged 14-15 and those aged 16-17 showed the results on all motor tests to improve with the increase in situation performance, which was especially pronounced in the tests assessing explosive strength and agility. The same held true for the results on all tests assessing volleyball techniques, spike and block in particular. In both samples, factor analysis of motor tests isolated two factors underlain by the generation and regulation of strength and the mechanism of speed regulation. Canonical correlation analysis between the
motor regulatory mechanisms and technical elements revealed determination of the mechanisms of strength and technical efficiency in both samples. Regression correlation analysis showed the mechanisms of strength regulation and speed to be good predictors of game performance in female volleyballers aged 14-15 and 16-17, whereby the mechanism of strength regulation had greater effect on the game performance than the mechanism of speed regulation. Regression correlation analysis also revealed the set of 6 techniques evaluated to be a good predictor of situation efficiency in both groups of female volleyballers aged 14-15 and 16-17. The block and spike techniques were found to be the best predictors of game performance quality in the former and the techniques of spike and block in the latter. Based on the results obtained, a possible model of selection for supreme score achievement in female volleyball is described.

Forthomme, et al., (2005) a spike effectiveness represents a determining element in volleyball. To compete at a high level, the player must, in particular, produce a spike characterized by a high ball velocity. Some muscular and physical features could influence ball velocity during the volleyball spike. A total of 19 male volleyball players from the 2 highest Belgian national divisions underwent an is kinetic assessment of the dominant shoulder and elbow. Ball velocity performance (radar gun) during a spike test, morphological feature, and jump capacity (ergo jump) of the player were measured. The tested relationship between the is kinetic parameters or physical features and field performances represented by spike velocity. They also compared first-division
and second-division player data. Spike velocity correlated significantly with strength performance of the dominant shoulder (internal rotators) and of the dominant elbow (flexors and extensors) in the concentric mode. Negative correlations were established with the concentric external rotator on internal rotator ratio at 400 deg/s and with the mixed ratio (external rotator at 60 deg/s in the eccentric mode on internal rotator at 240 deg/s in the concentric mode). Positive correlations appeared with both the volleyball players' jump capacity and body mass index. First-division players differed from second-division players by higher ball velocity and increased jump capacity. Some specific strength and physical characteristics correlated significantly with spike performance in high-level volleyball practice.

Kasabalis, et.al., (2005) conducted a study to evaluate the anaerobic power of elite male volleyball players, using the Wingate Anaerobic Test to examine the relationship between anaerobic powers and jumping performance. Athletes (n=56) and Nonathletic (n=53) were divided into three age groups: Adults (18-25 yr.), juniors (15-16 yr.) and Youth (10-11 yr.). Measurements of height, body mass, vertical jump and Wingate scores indicated higher values for athletes. The specific training effects of anaerobic power were more pronounced at the age of 10-11 years than for Nonathletic. A significant correlation coefficient between peak power and vertical jump was found for Athletes (r=.86) and for the total group (r=.82). These results indicated that vertical jump may predict the maximal anaerobic power and could be used by coaches as a
practical and easy-to-apply field screening test for evaluation in volleyball training.

**Bamac, et.al. (2003)** assessed the volleyball group consisted of 17 female, aged 20.47 +/- 2.47 years (mean +/- SD), 16 male aged 21.68 +/- 3.47 years (mean +/- SD); training for about 8 hours/week. The control group consisted of 15 non active females aged 21.73 +/- 2.68 years (mean +/- SD) and 14 non active males aged 23.35 +/- 4.16 years (mean +/- SD). Anthropometric determinations (height, weight, limb length, girth of arm and forearm) were made on each subject. Range of motion was evaluated by standard goniometric technique. Comparative plain films of both elbows were obtained in an anteroposterior projection. The volumes of the medial epicondyle and lateral epicondyle were determined by the principle of Cavalieri which is an effective stereologic volume calculation method. In the volleyball players, increased medial epicondyle volume was recorded in the dominant and non dominant arms as compared with the control subjects (P < 0.05). Wrist flexors are highly involved in spiking, blocking and serving in volleyball. In this study volume of medial epicondyle is founded which is the connection point of flexor muscle was increased because of loading.

**Gualdi & Zaccagni (2001)** examined the importance of the somatometric components of elite male and female volleyball players in relation to their different game roles and levels of performance. Two hundred and thirty-four male athletes (aged 24.7 +/- 4.4 years) and 244 female athletes (aged 23.1 +/- 4.4 years) from the Italian A1 and A2 volleyball leagues
underwent 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 average somatotype for men was 2.2-4.2-3.2 (SD 0.7-0.9-0.9) and for women it was 3.0-3.3-2.9 (SD 0.8-1.0-0.9). The somatotype was significantly different in players at different levels of performance (A1 vs A2 leagues), as it follows: 2.1-4.1-3.3 (SD 0.6-0.8-0.7) vs 2.3-4.3-3.0 (SD 0.7-1.0-0.8) in males; 2.9-3.1-3.0 (SD 0.8-1.0-0.9) vs 3.1-3.5-2.7 (SD 0.8-0.9-0.8) in females. The somatotype was also significantly different in players in different roles. In male sex the mean somatotypes for setters were 2.4-4.5-2.8 (SD 0.7-0.9-0.8), for centres they were 2.0-4.0-3.5 (SD 0.6-1.0-0.8), for spikers they were 2.2-4.3-3.0 (SD 0.6-0.9-0.7), for opposites they were 2.2-4.3-3.1 (SD 0.6-0.9-0.8). In female sex the mean somatotypes for setters were 3.1-3.6-2.5 (SD 0.8-1.0-1.0), for centres they were 2.8-3.1-3.1 (SD 0.8-0.9-0.7), for spikers they were 3.0-3.5-2.8 (SD 0.9-1.0-0.9) and for opposites they were 3.0-3.2-3.0 (SD 0.7-0.9-0.8). The physique of athletes in the A1 league is characterized by higher ectomorphy and lower endomorphy and mesomorphy. There is 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 is maximal in setters, while the ectomorphic component is maximal in centres.
Wang, et al., (2000) anthropology is a simple reliable method for quantifying body size and proportions by measuring body length, width, circumference (C), and skin fold thickness (SF). More than 19 sites for SF, 17 for C, 11 for width, and 9 for length have been included in equations to predict body fat percent with a standard error of estimate (SEE) range of +/- 3% to +/- 11% of the mean of the criterion measurement. Recent studies indicate that not only total body fat, but also regional fat and skeletal muscle, can be predicted from anthropometrics. Database supports the thesis that sex, age, ethnicity, and site influence anthropometric predictions; the prediction reliabilities are consistently higher for Whites than for other ethnic groups, and also by axial than by peripheral sites (biceps and calf). The reliability of anthropometrics depends on standardizing the caliper and site of measurement, and upon the measuring skill of the anthropometrist. A reproducibility of +/- 2% for C and +/- 10% for SF measurements usually is required to certify the anthropometrist.

Stamm, et al., (2003) established which anthropometric characteristics, physical abilities and psycho-physiological properties determine the success of adolescent female volleyballers at competitions. For this purpose they studied 32 female volleyballers aged 13-16 years. The anthropometric examination included 43 measurements, 7 tests of physical fitness, and 4 series of computerized psycho-physiological tests (n=21). The performance of game elements was measured empirically during championship games using the original computer program Game. The proficiency of performing volleyball elements - serve, reception, feint, block and spike - was calculated by
regression models from the 14 anthropometric measurements, 4 physical fitness and 7 psycho physiological test results, which showed significant correlation with proficiency in the game. The predictive power of the models was at least 32% and in average 56%. The anthropometric factor was significant in the performance of all the elements of the game, being most essential (71-83%) for attack, block and feint. Good results in physical ability tests granted success in serve, attack and reception. It was possible to predict the efficiency of reception (44%) by endurance, flexibility and speed measuring tests. Medicine ball throwing test was essential for attack (22%). Psycho-physiological tests were significant for the performance of block (98%), attack (80%), feint (60%) and reception (39%).

Benefice, et.al., (1996) conducted a study on Protein Energy Malnutrition (PEM) on the motor performance of 4.5-6.5-year-old Senegalese children were studied. Body dimensions included weight, lengths, circumferences and four skin folds. Motor performance tests included a 3-min endurance run, 4 x 10 m shuttle-run, distance throw, standing long jump and grip strength. The sample consisted of 147 children: 52 children who were hospitalized for severe under nutrition (severe UN group) during infancy but who had been nutritionally rehabilitated; 63 children who were never severely malnourished but who were chronically exposed to mild-to-moderate under nutrition up to the time of study (chronic UN group); and 32 well nourished children (well nourished group) from well-off households. After adjusting for sex and age, the well nourished group performed better than the severe UN and
chronic UN groups. Principal components analysis resulted in two factors which explained 65% of the variance in anthropometry and motor performance. One was related to body size and the second to body composition. The three nutritional groups differed significantly in principal component scores for the two factors; chronic UN and severe UN children also differed for the second factor. Body composition, especially low fat mass appeared to be an important feature for motor performance in chronically undernourished children.

Hakkinen, et al., (1993) conducted a study on nine members of a female volleyball team in order to examine the changes in a physical fitness profile during the competitive season consisting of a first season (I) for 10 weeks followed by season II for 11 weeks. The entire season was characterized by 4-5 weekly sessions for playing drills and competitive games and by 2-3 weekly sessions for physical conditioning mostly for strength and explosive strength training. The control group consisted of eight other female volleyball players who trained for physical conditioning during the competitive season 1-2 times per week. The findings showed that the entire competitive season in experimental subjects led to no changes (from 47.3 +/- 1.7 to 48.1 +/- 3.4 ml x kg^-1 x min^-1) (n.s.) in VO₂max, but a significant (p < 0.05) decrease took place in average power in a 30 s anaerobic jumping test. Significant increases took place in the maximal vertical jumping heights in the squat (from 30.3 +/- 1.7 to 31.6 +/- 1.3 cm) (p < 0.05) and in the counter movement jump (from 32.8 +/- 1.6 to 34.3 +/- 1.3 cm) (p < 0.05) as well as in the spike and block jumps (p < 0.05) during competitive season.
Marey, et al., (1991) conducted a study to determine if the factors which coaches feel indicated superior player potential were the same as those factors which contribute to successful competition outcome. Players from two colleges were evaluated for general and specific performance variables prior to a regular season match between the teams. A player's ability rating was the total of four coaches' ranking on a 1-to-10 scale. Multiple regression analysis to predict player ability rating selected age, vertical jump, total body movement time, and agility (R = 0.87). However, step-wise discriminant analysis to differentiate winning and losing team members selected shoulder flexibility, agility, forearm bump and sit-and-reach flexibility. The canonical correlation between the winning-losing dichotomy and these skills was 0.74 and resulted in proper classification of 84.6% of the correct team members. It was concluded that the skills coaches consider indicative of superior ability are not necessarily the factors which dictate winning performance.

Thissen, et al., (1991) anthropometric and biomotor variables that discriminated among groups of elite adolescent female athletes aged 14.3 +/- 1.3 years (mean +/- s) from four different sports (tennis, n = 15; swimming, n = 23; figure skating, n = 46; volleyball, n = 16). The anthropometric variables included body mass, height, bi-epicondylar breadth of the distal extremity of the humerus and femur, maximal girth of the calf and biceps and the sum of five adipose skin folds. The biomotor variables were maximal aerobic power, muscular endurance and flexibility of the trunk. Discriminant analysis revealed three significant functions (P < 0.05). The first discriminant function primarily
represented differences between figure skaters and all other groups of athletes.

The other two underlined anthropometric and biomotor differences between swimmers and volleyball players and between tennis players and swimmers, respectively. After validation, the analysis showed that 88% of the athletes were correctly classified in their respective sports. The model confirms that elite adolescent female athletes show physical and biomotor differences that clearly distinguish them according to their particular sport.

Spence, et al., (1980) determined the accuracy of general and specific tests for identifying the players on freshmen (FR), junior varsity (JV) and varsity (VR) teams and the precision of tests to differentiate between starters and nonstarters at each level of play. Fifty high school volleyball players were tested during the first week of practice for six general and four specific motor performance tests. The specific tests included the overhead volley, forearm pass, wall spike and self bump/set test. The general tests included height, weight, percent body fat, agility run, vertical jump, and two flexibility maneuvers. VR players were significantly better in vertical jump, agility and all specific ball-handling tests than FR and JV players. The combination of forearm pass, overhead volley, vertical jump and weight correctly classified 68% of the players to their team level. The combination of bump-set, height, weight, and shoulder flexibility allowed correct classification of 78% of the starters and nonstarters. General and specific tests can successfully select and classify high school volleyball players.
2.3 CHAPTER SUMMARY

The review of literature helped the investigator to spot out relevant topics and variables. Further the literature helped the investigator to frame the suitable hypothesis leading to the problems. The latest literature also helped the investigator to support his finding with regard to the problem. Further the literature collected in the study also helped the research scholar to summarize his study. The researcher has presented the reviews in the related subjects by depending upon the highly authentic sources. Each review has been written in details in related to thesis. Finally the researcher puts an end to this chapter after giving all relevant details to each reviews of this chapter.

The reviews were presented under the section of anthropometric and motor variables. All the research studies presented in the section proved that the anthropometric and motor variables were the best predictors of playing ability among volleyball players. The research studies reviews were collected from journals available in the websites and some university libraries.

Based on the experience gained through review of the studies, the investigator formulated suitable methodology to be followed in this research, which is presented in Chapter III.