CHAPTER-II
REVIEW OF RELATED LITERATURE

Literature means writings and a body of literature refers to all the published writings in a particular style on a particular subject. In research, a body of literature is a collection of published information and data relevant to a research question. 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. A literature review is an account of what has been published on a topic by accredited scholars and researchers. Typically, the literature review forms an important chapter in the thesis, where its purpose is to provide the background and justification for the research undertaken (Bruce, 1994). A literature review can be defined as the selection of available documents (both published and unpublished) on the topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfill certain aims or express certain views on the nature of the topic and how it is to be investigated and the effective evaluation of these documents in relation to the research being proposed (Hart, 1998). A literature review can be a precursor in the introduction of a research paper, or it can be an entire paper in itself, often the first stage of large research projects, allowing the supervisor to ascertain that the student is on the correct path. A literature review is a critical and in depth evaluation of previous research. It is a summary and synopsis of a particular area of research, allowing anybody reading the paper to establish why you are pursuing this particular research program. A good literature review expands upon the reasons behind selecting a particular research question.

"The literature in any field forms the foundation upon which all future work will be built and the flaws of old one to remove. If we fail to build the foundation of knowledge provided by the review of literature, our work is likely to be shallow and native and will often duplicate work that has already been done better by someone else." Borg, W.R. 1978.

Keeping in view the objectives of this study a review of related literature has been kept up in this chapter. Various studies, which have been completed, serve as a guideline not only to provide knowledge with regard to the quantum of work already
done in the field but also to serve as a pointer to the gaps and lacunae that still exist in
the concerned field of research.

STUDIES RELATED TO ANTHROPOMETRY AND BODY COMPOSITION

Parnell (1951) used a set of measurements taken by Tanner on members of
the Oxford University athletic club and acknowledged the inadequancy of his sample
but recorded the following interesting facts. The shortest mean sub-ischial leg length
was found in a control group of college men, slightly longer in sprinters, still longer in
long distance runners, hurdlers & high jumpers and greatest in discus, javelin & shot
put group.

Harold’s (1953) study investigated the following aspects:

a) Size and shape seem to have an influence on physical performance.
b) The obese have poorest performance.
c) Maximum size, body shape does not provide maximum physical fitness.
d) The large and fatty body varies in physical performance than the normal and
thin boys.

Sheldon and his associates (1954) had made many interesting observations
regarding the somatotype of college football players in America. They have brought
out the probable nature of the somatotypes which are successful in the case of players
playing at various field positions.

In a case of junior high school athletes, Shelley (1960) found that those
athletes who were outstanding in Football were largely mesomorphic or mid types and
they were taller and heavier than other athletes.

Wiley (1963) compared 12 years old non-athletes and Football players and
found no difference between the somatotype means, but the Football players were
taller and heavier than the non athletes.

Heath (1963) somatotyped 66 university football players, using his
modification of sheldon’s method, when compared with means for college students
rated by Sheldon and others (1940). These Football players were approximately one
and half units higher on the first component and one and one quarter units lower on
the third component.
Espenschade (1963) studied relationship between physical performances of school children with their age, height and weight. The relationship of age, height and weight to performance of boys and girls on California Physical Performance test was studied in order to evaluate these factors on the basis of grouping of students and for the establishments of norms. The highest correlations were obtained for boys of junior high school age in the events of jumping and throwing. Significant changes with age occur in relationship with most events for both sexes. The California Classification Plan is superior. It shows that age has direct bearing on physical performance.

Margaret (1964) studied body structure and design factors in the motor performance of college women. Speed, Sargent Jumps, and 600 yards run/walk, back strength, leg strength and strength index were studied in relation to 43 measures of body structure and design. The latter measurements were secured by means of photographic techniques, including measure of length, depth area, as well as non-linear expression of body built design and experimental combinations of variables. The correlation was significant beyond 0.01 level, obtained between performance criterion and one or more variables from each group, the height relationship being consistent with experimental combination of variables.

Novak (1965) conducted a study on high school Football and Basketball boys and concluded that their average total body fat amounted to be 7.2 percent and lean body mass 92.8 percent.

Carter (1968) summarized Sheldon's (1954) colorful description of college and professional Football players. When the Heath-Carter rating showed that the physiques were even more extreme than Sheldon suggested. In addition, the trend is towards greater size and higher mesomorphy among contemporary college and professional players. Sheldon (1940) observed that a coach who cannot distinguish between a 5.5 and 6 in mesomorphy might not win many Football games. Perhaps this is true today of small college level teams, but at higher levels it appears that well trained, rugged 6's, 7's and 8's are mandatory for even a glimmer of success.

Neilsen (1969) studied the relationship of body composition to selected measures of muscular strength. Twenty eight male student, 18 to 25 years of age, were tested for body density from percent body fat, percent body lean mass and lean body weight. The strength of nine major muscle groups of the body measured
isometrically. The inter correlations of the strength measures were all positive except for the elbow flexion and hip extension, although a little relationship was found to exist between strength and body composition variables. The multiple correlation coefficients indicated that strength was unusable as predictor of body composition.

Carter (1970) rated members of the 1964 San Diego State Football Team and 20 University of IOWA Football players according to the Heath criteria. It appears from his results that performance of endomorphs is a prerequisite for success in Football.

Shoundell, (1972) studied the relationship of selected motor performance and anthropometric traits of successful Volleyball performance. The purpose of this study was to identify the physical and anthropometric traits possessed by successful Volleyball players and to develop a physical performance battery that would prove valid, reliable and practical, when used to identify successful collegiate Volleyball players. The statistical techniques, step wise regression, coefficient and multiple correlation coefficients for the regression equation were used to provide inter-correlation coefficient of the independent variable and the dependent variables. The reliability coefficients of all items were computed by using interclass correlation techniques. Within the limitations of the study and based on findings, the conclusions were made that cross validation procedure employment supported the validity of six item batteries as a predictor of expected Volleyball performance.

Malhotra and Associates (1973) reported that the forward players of the Indian Hockey team had minimum percentage of body fat which increased gradually the halves, backs and goal keepers.

Sodhi et al. (1974) conducted a study on the physique of Hockey players and reported the mean height, weight and age with respect to the field position of the players. The backs were found to be tallest followed in a descending order by the half backs and the forwards. However, in respect of weight, the forwards were lighter and the backs were heaviest, the body fat which increased gradually towards the halves, backs and goalkeepers.

Sidhu and Sodhi (1975) worked on the effect of physical activity on body composition of top ranking Indian Hockey players undergoing coaching for the Asian games of 1974. The players in this investigation were divided into three main groups.
in accordance with the load of exercise. Group-I consists of inside left, inside right and centre half, group-II consists of outside left, center forward & right half and group-III consist of right back, left back and left half. The group-I players registered the maximum decrease body fat after 52 days of intensive training. Similarly, the group-III players who underwent the minimum load of physical activity had shown an increase in the amount of body fat. The group-II players manifested a decreased but to smaller extend than group-III.

**Martin (1976)** conducted a study by comparing the selected anthropometric measurements and physical performance between Mexican American and Anglo American adolescent boys. He also compared the body size, body structure and physical performance between the subjects at adjacent age level within each individual racial group. The body size was assessed by standing height and body weight measurement. The body structure was interpreted as upper arm girth, chest girth, abdominal girth and thigh girth and calf girth measurement. The physical performance was determined by selected motor ability test. It was concluded that the Anglo American subjects were significantly taller than the Mexican American subjects. It was also concluded that excluding standing height, the Mexican and Anglo American subjects did not differ in body size and body structure and these two races did not differ in physical performance.

**Amuso (1979)** selected 46 subjects who were well-conditioned Soccer players with at least two years playing experience at college level. They were tested for anthropometric measurements consisting of skinfold and body diameters. Analysis of data was by zero order correlation's and multiple regression analysis resulting in the conclusion that age (experience) was found to be the best single predictor of playing ability. Weight, lean body mass and height were considered good predictors of playing ability.

**Bell (1979)** studied body composition components of 56 second class survey union Football players: 28 forwards and 28 backs. Forwards were found to have 19.5% TBF (Total body fat) and 80.5 % LBM (Lean body mass). Backs had 12.2% TBF and 87.8% LBM. It was felt that greater attention should be given to the ratio of TBF to LBM in determining body weight and that there should be an increased emphasis of the LBM at the expense of TBF.
Bhatnagar (1980) Conducted a study on 23 rural sportsmen (athletics = 8, volleyball = 8, kabaddi = 7), of Madhya Pradesh (India) pertaining to their weight, height, sitting height, subcutaneous tissue, folds of biceps, triceps, sub scapular and suprailiac region. They were found to be lighter, shorter and with less amount of fat as compared to sportive activities indicated that Volleyball players were lightest, shortest with maximum of fat as compared to Kabaddi players and Athletes, whereas Kabaddi players were heaviest and tallest among all the rural sportsmen of Madhya Pradesh.

Sodhi (1980) has mentioned that in body composition studies the most important aim is not only an overall characterization of body components but also its quantitative evaluation as exact as possible according to actual methodological possibilities. Absolute amount of lean body weight serves together with body weight as basic somatic characteristic of body type and as a reference of standard to which oxygen plate and muscle strength etc. are related. On the other hand, the quantitative changes in depot fat can provide an important information on lipid metabolism and shifts in every substrates used as a fuel for muscle work.

Spence et al. (1980) studied the anthropometric and performance characteristics of 15 highly skilled members of the United States Women’s National Volleyball training team. Out of these, six women players were selected for the Pan American team. The selected players were taller, heavier, faster, more agile and better jumpers than the non selected player. The strength measurements did not indicate consistent difference, where as the VO$^2$ max was greater in the nonselected than selected player. In establishing the profile of specific qualities and ability that Volleyball players require, this study suggested that body size and motor ability were particularly important.

Sharma and Shukla (1981), collected data on 300 subjects on five sports specialties [Athletics, Hockey, Football, Cricket and Volleyball] drawn from institutions of sports in the state of Uttar Pradesh. The result showed that Volleyball players and throwers somewhat similar in characteristics except that throwers found to be more mesomorphic and less ectomorphic than the Volleyball players. Significant differences among the long distance runners, sprinters, throwers and Volleyball players were revealed on the first component [endomorphy], while on second component [mesomorphy] and the third component [ectomorphy] there existed
dissimilarity showing variation among throwers, Volleyball players, sprinters with cricketers and Footballers, Hockey and long distance runners.

**Kansal (1982)** attempted to develop scientific criteria for the selection of budding athletes based on morphological status. He conducted a study on 246 male students ranging from 11 to 17 years. Their height, weight, bi-acromial length, humerus bicondylar diameter, chest and calf circumferences and performance on the 100 meters run, shot put and standing broad jump was examined. He concluded that the above listed measurements show significant degree of these differential roles. He attempted to prepare selection criteria for choosing budding athletes at young age.

Thirty Indian women Hockey players selected to participate in the World Cup Championship to be held at Spain were examined by **Sidhu and his colleagues (1984)**. The results showed that players differ in body composition according to the field of specialization. Amount of fat was minimum in forwards and maximum in goalkeepers. Distribution of fat at the sites of biceps, triceps and sub scapular region also showed the same.

The stoppers and the goal keepers in the national level Football in India had more lean tissue in limb segments, with broader distal epiphyseal diameters of humerus and femur (**Sodhi and Sidhu, 1984**). It was found that the lean tissue in the limb segments of forwards, halves and goalkeepers was better developed in the National level Football players than those of the University level Footballers. The body fat was found to be least in the forwards, and maximum in the goal keepers of the National level Football players. In the case of University level Football players, both the forwards and halves have less of body fat than the backs and the stoppers. However, in case of the National level Football players, the subcutaneous tissue in the limbs were found to be less in the forwards, halves and backs which gradually increased in the stoppers and goalkeepers of this group. All players in University level; and National Football possessed better developed lean tissue in the thigh in relation to that in the upper arm and possessed less of body fat than the controls. However, among the players of similar field positions in the two groups, the body fat was considerably greater in the case of the state level Football players.

**Mathur and Salokun (1985)** conducted a study on 150 female subjects, found that the athletes were significantly taller, heavier and had larger bi-acromial and
bicristal diameters as compared to non-athletes. The percentage of fat was significantly higher in non-athletes. The significant difference between the anthropometric variables and body composition of university and national level athletes were observed. The measurements were significant between athletes and non-athletes and between athletes of different sports.

Chauhan (1986) studied the relationship between selected anthropometric variables and endurance running performance. He concluded that height, leg length, total arm length, shoulder, chest, abdomen, hip and knee girths, thigh and calf skin fold, lean body mass had significant and negative correlations with 1500 meter endurance running performance, whereas 10,000 meters running performance had statistically insignificant correlations with linear segments, girth and diameter measurements, except with skin fold measurements (triceps, suprailiac, midaxillary, thigh and calf skin folds) and body composition variables i.e., body density, fat percentage, fat weight and lean body mass.

Multiple correlations of 1500-meter running performance with combination of selected anthropometric variables were significant. Similarly, the multiple correlations were not of significant size to put them into the prediction equation.

In another study Mokha and Sidhu (1986) reported data on the female Hockey players. The forwards and halves possessed lesser amount of body fat as compared to backs and goalkeepers because in case of former players a lot of running-around is required as compared to the other ones.

Chauhan et al. (1987) conducted a study on the relationship between selected anthropometric variables and performance in standing broad jump of college level women and concluded that age and foot breadth had positive correlation with performance in standing broad jump, whereas hip girth and calf skinfolds, fat weight and lean body mass had significant but negative correlation with the performance in the standing broad jump. Further, the multiple correlation of the combination of selected anthropometric variables i.e., age, height, foot breadth, hip girth and thigh girth with performance in standing broad jump was found to be significant at 5% level. The multiple correlations found were not sufficient to be used in the prediction of performance.
Kansal et al. (1987) conducted a study in which the anthropometric measurements were taken of 23 Football and 15 Volleyball players who attended an inter-varsity coaching camp with a view to study there physique and body morphology. They also studied 100 control subjects. The differential anthropometric variables including linear, circumferential and skin fold measurements were taken. The body physique was calculated from skin fold using Health-Carter Method (1969) and body fat was computed from skinfolds using Durnin and Womersely (1974) equations. It is found that the Footballers were of average height, however, the Volleyballers were taller than their control counterparts. The Footballers had larger trunks and smaller lower extremities than the Volleyballers who did not differ much from the controls in this relationship. The Volleyballers had linear physique and large limb girths but less body fat than controls. It indicated their relatively more muscularity. The somatotype of Volleyballers and Footballers were 2.16, 23.30, 9.70, 1.87 and 3.59 respectively, indicating less endomorphic components than controls. When compared with Olympic level players, the players of present study were found shorter and lighter.

Martirosov et al. (1987) examined 254 leading Footballers of the world from 10 national young combined teams. The leading Footballers of the world are of more than middle height and tall, the body mass is proportional to its length, the fat mass values are not great. Their specific somatotype is well-balanced mesomorphically and ectomesomorphically. The average somatotype of the Footballers examined can be presented as 1.7-5.6-2.6.

Sodhi et al. (1987) studied anthropometric characteristics of Indian Volleyball players at different level of competition. The result revealed that the Volleyball group possessed less rating of mesomorphic components than the control group. In ectomorphic component, Volleyball players were found to be more lean and thin than the control group.

Kuriaokose (1988) conducted a study of anthropometric measurements and body composition variable on judo players. He took nine anthropometric measurements and three body composition variables for this study. The judo player’s ability was taken as the criterion measure and all the variables were taken as the independent variables. The Pearson’s Product Movement Correlation was used to find out the relationship between anthropometric measurement and criterion measure. A
multiple correlation was computed to find out the combined effect of the anthropometric measurement to judo performance. He concluded that:

1. The performance in judo is positively significant related to the chest girth.
2. The judo performance is negatively significant related to ponderal index, which means that for better judo performance a judoka should possess greater body weight in proportion to body height.
3. The lean body mass, upper arm / fore arm ratio of sitting height are the most important predicting variables under the limitation of the study.

Show (1990) compared 38 athletes of Delhi University on selected kinanthropometric variables by using Analysis of Variance. The result showed that the long and middle distance female runners of Delhi University having long upper and forearm length in comparison to sprinters, though middle and long distance runners did not differ in upper and forearm length. The short, middle and long distance runners did not differ significantly in height, weight, arm length, foot length, hip girth, calf girth, biceps skin fold, triceps skin fold, sub scapular skin fold, sum of skin all fold, height, leg length ratio, fore arm and upper arm length ratio and ponderal index.

Dey (1991) conducted a study of anthropometric measurements and body composition on high and low cardio-respiratory fitness of boys and observed that in secondary schools boys belonging to high cardio-respiratory fitness groups; possess significant small abdominal girth measurements, lower percentage of body fat, less fat weight, higher lean body mass as compared to low cardio-respiratory fitness groups. Multiple correlations of absolute variables from both high and low cardio-respiratory fitness group reveals that both the groups possess a peculiar physique and absolute anthropometric variables among themselves and maintain certain amount of proportions which is quite unique in itself.

Sodhi et al. (1991) conducted a study on 116 selected ball game players, who participated in National Games (45 Volleyball players, 26 Basketball players and 45 Hockey players). Each group was compared with Olympians as well. The somatotype of each player was estimated by using modified Heath-Carter method. In about a decade result of a study showed a trend of improvement in the body size of Indian players of each sports. In comparison to their Olympian counterparts, they were still
shorter in size, lighter in weight and poorer in development of mesomorphic component, greater predominance of ectomorphy component was still persistent in their Indian sportsmen.

**Musaiger et al. (1994)** selected 304 athletes from first class clubs related to four common sports Football, Handball, Volleyball and Basketball and compared with 53 non-athlete adults. The findings revealed that there were differences in body composition among athletes according to the type of sport. Basketballers and Volleyballers were the tallest athletes, while Handballers were the heaviest. Skinfold thickness measurements showed that Basketball and Handball players have more subcutaneous fat than other athletic groups.

**Kumar (1995)** studied the relationship between selected anthropometric variables and performance in athletics programme of high schools and senior secondary school students. He concluded that performance in all running events 100 meters, 400 meters, 800 meters, 1500 meters, and 10,000 meters events have significant relation with age, body weight, height, leg length, thigh circumference, calf circumference, femur biocondylar diameter, biacrominal breadth, fat weight and lean body mass.

**Sparling et al. (1998)** evaluated total bone mineral density (BMD) and body composition (% fat) in world class women field Hockey players. They reported that the mean whole body BMD value for members of the 1996 United States Olympic women's field Hockey team is one of the highest reported for any women's sports team. Moreover, the mean fat free mass per unit height was quite high and % fat was low. In this group of world class sportswomen, low % fat was not associated with low BMD.

**Dey and Debray (1999)** investigated the morphological and physiological parameters of Indian National female soccer players, according to their playing position. Results of the present study showed that goalkeepers were superior in height, weight and body fat percent as compared to the players of other field position though the difference was found to be statistically insignificant except back strength where goalkeeper showed significantly higher values. On the other hand mesomorphic component was found to be more in midfielder. Like mesomorphic rating, maximum
oxygen uptake capacity and related parameters were also found to be more in the midfielder as compared to other groups.

Reeves et al. (1999) conducted a comparative study to determine the anthropometric measurements and body composition of Football teams in the UK and Malaysia. A total of 32 Footballers from two teams were studied. The UK team was significantly heavier, taller and had a higher body fat content than their Malaysian counterpart. There was no significant difference in VO2 max between the two teams, with the Malaysians recorded a slightly higher VO2 max. With regard to playing position, the defenders were found to be the most physically robust and yet had the highest VO2 max, while the midfielders had the lightest in body weights.

Anthropometric and work rate profile of elite South American International Soccer players were examined by Rienzi et al. (2000). Segmental lengths, limbs and body compositions were involved in anthropometric variables. The player’s mean height and body weight were 1.77 ± 0.4m and 75.4 ± 4.41kg, respectively. The sum of skinfolds were found to be 23.6 ± 6mm and 62 ± 6mm. Estimated percentage adiposity of the players was 11.6% but no significant correlation has been observed for any of the other relationship between the anthropometric variables and work rate profile.

Kaur (2000) investigated 260 SAI trainers of team and individual game in relation to somatotype and psycho-social variables. The games were Athletics, Boxing, Cycling, Gymnastics, Judo, Swimming, Wrestling, Handball, Hockey, Basketball, Football and Volleyball. It was observed that the mean somatotype of athletes were 2.02-4.2-2.95, Wrestlers were 1.85-4.57-2.61. The Judokas were 1.67-3.77-3.99 and somatotype of Cyclists were 1.78-3.88-3.14 and average somatotypes of team games were 1.89-3.25-3.83. It was also concluded that the average somatotype of Basketball players were 2.14-3.28-3.33, Football players were 1.95-3.91-3.29, Volleyball players were 1.66-3.07-4.39 and the somatotype of Hockey players were 1.75-3.04-3.86.

Caktroglu, M. et al. (2002) investigated body composition, primarily concerned with somatotypes and measuring adiposity. The object of this study was to determine some body proportions of Handballers. The study included 57 male Handballers from six teams competing in the Regional First League between
Universities. Body proportions were determined by using Anthropometric Measuring techniques and Percent Adiposity with the use of a Holtain skinfold caliper according to the Yuhasz' technique. The Handballers were found to be normal according to Body Mass Index, medium built according to the Corniê Index, Mezotiskelie according to the Monocular Index, broad-shouldered according to Acromio-Iliac Index, and narrow-hipped according to the Hip Index. The mean body fat percentage was measured as 16.7±4.1 due to peculiar features of Handballers. The players are expected to have wider shoulders and narrower hips than normal individuals.

The aim of Chauhan et al. (2003) study was to describe the relationship between anthropometric variables and middle running performance and concluded the age, linear measurement i.e., height, leg length, thigh length, shoulder, chest, abdomen, hip, thigh, knee girths, ankle diameter and calf skin fold have positive and significant correlations. The multiple correlation of combination of anthropocentric variables i.e., height, thigh girth, bi-acromial diameter, thigh skin fold with middle distance running performance is significant at 0.01 level, but multiple correlation is not of sufficient size, so the regression equation cannot be put in to prediction of running performance.

Pearson et al. (2004) 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, skinfold 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.

**Bhola, G. (2004)** investigated on the prediction of playing abilities of North Indian Junior Basketball players in relation to their motor fitness and selected kinanthropometric measurements. Subjects were 200 junior Basketball players of North India. He concluded that age, height, sitting height, leg length, thigh length, total arm length, upper arm length, fore arm length and hand length have significant and positive correlations whereas lower leg length, weight and foot length have significant but negative correlations with the performance of field goal speed ability of the junior Basketball players. Arm, chest, thigh and knee girths have positive and significant correlations and calf girth has negative and significant correlation with performance in field goal speed ability of the subject. Elbow and femur bicondylar diameters have positive and significant correlations whereas as wrist has negative but significant correlation with performance in field goal speed ability.

**Cavas, et al. (2004)** conducted a comparative study to investigate the anthropometric parameters and body composition in Handball, Basketball, Badminton, Volleyball and Underwater Rugby players who were students in Physical Education and Sports Department in Turkey. 49 female and 51 male athletes have taken part in this study. Skinfolds of triceps, abdomen, suprailliac, chest (for only male), rear thigh (for only female), subcapula and front thigh have been measured in both female and male athletes. Estimated percentage body fat, body fat weight and fat free body mass have also been measured in athletes. The skinfolds of rear thigh in female players are significant (p<0.05) higher than those of other female and male skinfold values. Minimum skinfold values have been observed in subcapula and chest of female and male athletes, respectively. Although estimated percentage body fat and body fat weight values in female athletes are significantly (p<0.05) higher than those of male athletes, fat free body mass in male athletes who have taken part in this study are appropriate for the sports they are exercising. The results have also shown
that ability selection has been applied successfully by Physical Education and Sports Department in Turkey.

**Moreno et al. (2004)** assess body composition in young male Football players (n=239) and compared the results with those of reference population (n=453). Body mass index do not show any significant difference between Football (soccer) and reference groups in any age category. The percentage of total body fat was significantly lower in the Football (soccer) group than in the reference group.

**Carter et al. (2005)** compared the somatotype and size of elite female Basketball players in terms of playing position and team performance. Anthropometry and somatotype data were collected on 168 players from 14 countries before the Women’s World Basketball Championship, Australia, 1994. There were 64 guards (mean+s: age 25.4 years, height 1.72 m, mass 66.1 kg, somatotype = 2.9 – 3.9 – 2.6), 57 forwards (age 25.2 years, height 1.81 m, mass 73.3 kg, somatotype = 2.8 – 3.5 – 3.2) and 47 centres (age 24.1 years, height 1.90 m, mass 82.6 kg, somatotype = 3.2 – 3.1 – 3.4). Guards had greater mesomorphy than centres and less ectomorphy than forwards and centres. In the four top versus four bottom teams, guards were taller and more ectomorphic, forwards were taller, with lower mesomorphy and higher ectomorphy and centres did not differ.

**Chauhan and Chauhan (2005)** investigated the relationship between anthropometric variables and explosive arm strength of Volleyball players. They found that linear measurements i.e., height, sitting height, trunk length, leg length, foot length, body girth; body diameters; skinfolds and body compositions variables, i.e., fat percentage, fat weight and lean body mass have positive and significant correlations with explosive arm strength of Volleyball players.

**Chauhan (2005)** conducted a study on 40 Volleyball players in relation to their explosive arm strength and anthropometric variables. Product Moment Method for correlations and Wherry Do Little Method for calculating multiple correlation and Developing Regression Equation were used. Linear measurements, i.e., height, sitting height, trunk length, leg length, lower leg length, total arm length, upper and forearm length, foot length; body girth, i.e., shoulder, chest, abdomen, hip, thigh; body diameter, i.e., bi-acromial, bitrochanteric, femur bicondylar and skin folds, i.e., biceps, triceps, sub scapular, suprailiac, mid auxiliary, sum of four skinfolds and body
composition variables, i.e., fat percentage, fat weight and lean body mass showed positive and significant correlations with explosive arm strength of Volleyball players. Multiple correlation of height, bi-acromial and elbow diameter, lean body mass taken together with explosive arm strength has been found significant at 1% level.

**Kang et al. (2005)** conducted a study based on the longitudinal somatometric measurements of national female Hockey players (senior n=19, junior n=40). They found that height, weight and mesomorphic component of international players showed significant dominance over Indian national players and also showed significant differences. They also found that senior players are heavier in weight, less in height, high % body fat, low % LMB and have lesser musculoskeletal development when compared to the international players.

**Bayios et al. (2006)** determine the anthropometric profile, body composition and somatotype of elite Greek female Basketball, Volleyball and Handball players. Volleyball players were the tallest among the three groups of athletes, had the lowest values of body fat and their somatotype was characterized as balanced endomorph (3.4-2.7-2.9). Basketball players were taller and leaner than Handball players, with a somatotype characterized as mesomorph-endomorph (3.7-3.2-2.4). Handball players were the shortest of all, had the highest percentage of body fat and their somatotype was mesomorph-endomorph (4.2-4.7-1.8).

**Devi and Singh (2006)** studied the somatotype of 18 Manipuri and 18 Punjabi women Football players. They found significant variations in age and stature between the two groups. The Manipur players are shorter and lighter in all lines of play, with the exception of goal keepers. Comparing the somatotype component rating of the players, it is observed that, except the goal keepers, all other players show dominance of endomorphic component (being highest) over mesomorphic and ectomorphic rating (being the least). At the same time, Manipur players have higher endomorphic and mesomorphic rating than the Punjab players.

**Christoph and Christina (2007)** examined 39 Soccer players of the third division as well as 22 Handball players of the second division and 17 Handball players of fourth division. The group differences for the endomorphy and mesomorphy are highly significant and for ectomorphy, significant.
fat portion was significantly lower for the Soccer players with (6.6%) than for the Handball players (8.4%). All heights and longitudinal dimensions as well as the circumferences with exception of the thigh girth were larger for Handball players, whereby no important proportional differences were registered.

**Vasques, Giordani Daniel et al. (2007)** assessed Handball players in which he compared the anthropometric and body composition variables from the best male Handball athletes competing in the Santa Catarina state youth competition. Seven of the twelve coaches participating in the Santa Catarina open youth games 2004 (up to 18 years) freely consented to select the seven best athletes in the competition to these seven best athletes in the competition (one goalkeeper, one pivot, two wingers and three backcourt players). In addition to these seven players, there were further 79 team members taking part, bringing the total sample size to 86 athletes. The following variables were analyzed: body weight (MC), height (ES), arm span (ENV), hand breadth (DPA), wrist breadth (DRU), forearm (PA), parentage fat (%G), fat mass (MG) and lean body mass (MCM). Descriptive statistics (means and standard deviations) were employed to classify the athletes according to court position. The chosen athletes were compared with the others using the single-sample t-test (p<0.05) and percentage rank. It was found that four of the chosen athletes (pivot, left winger, central and right backcourts) exhibited superior morphology in relation to other athletes playing in the same positions (p<0.05). Body morphology appears to be an important criterion for the performance of the chosen athletes. It is suggested that studies be undertaken to relate morphology with game performance in different age categories.

**Bandyopadhyay (2007)** selected 50 sedentary males and 128 sports persons (Volleyball=82, Soccer=46) of 20-24 years from West Bengal, India, to evaluate and compare their anthropometry and body composition. Skinfolds, girth measurements, body fat percentage (%fat), and endomorphy were significantly higher among sedentary individuals, but lean body mass (LBM) and mesomorphy were significantly higher among the sports persons. Soccer and Volleyball players were found to be ectomorphic mesomorph, whereas sedentary subjects were endomorphic mesomorph. The Soccer and Volleyball players had higher %fat with lower body height and body mass than their overseas counterparts.
Leonardo et al. (2007) having studied the profile of under-15 Brazilian Soccer players by field position have reported that there were no significant difference in the field position in anthropometric measures such as body mass, and sum of skin folds.

Jonathan Bloomfield et al. (2007) studied the anthropometric parameters of different positions in (FA) English Premier League. Professional Soccer players from three positional groups (Defenders, Mid-fielders and Strikers) representing various professional clubs in 2003-2004 season and reported that significant differences existed between players in different positions. Goalkeepers were found to be significantly taller and heavier than outfield players. Goalkeepers also displayed greater leg extensor power than midfielders and defenders. Midfielders were older than strikers; defenders were taller than midfielders and strikers more powerful than midfielders. Professional players do vary in weight and size especially when ethnic influences are taken into account. For example, data on International Asian teams demonstrated that their players were smaller in physical size, especially when compared to European teams. Midfielders are often the smallest while central defenders are often the tallest and heaviest outfield players on the pitch. A scientific study showed that a professional team had an average body weight of 77.7 kg compared to 73.4 kg for semi-professionals. Body shape or somatotype studies indicate that professional players tend to belong to the mesomorphy category meaning a more muscular make-up. Indeed, studies on top English League Players when compared to all Olympic athletes showed that they mostly resembled.

In accordance with Davis et al. goalkeepers in Football were taller and heavier than outfield players. Defenders were significantly taller than midfield players, which can be taken as an indication that size is an advantage in this position to be able to reach high balls in their defensive role and perhaps to increase their reach in tackling duels, as well.

Sheppard et al. (2008) examined 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 IRM 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.

Sinha and Kapri (2008) find out the relationship of selected motor traits and selected anthropometric measurements on the performance of Archery Shooting. It was found that height has got significant positive correlation with arm span and leg length. It was further found that arm span had significant positive correlation with leg and flexibility. Body fat showed significant negative correlation with endurance performance. Leg strength and abdominal strength had significant influence on the speed and agility performance.

A study was attempted by Mohan and Sharma (2009) to find out the relationship between Volleyball skill efficiency variables with age, height and weight of Volleyball players. For it 334 male Volleyball players were selected randomly from different colleges of Himachal Pradesh. They used the Helmen Volleyball Skill Test to measure the skill efficiency level. The analysis of data shows that height and weight of winner Volleyball players have higher correlation with skill variables i.e., face pass and wall spike, than the loser Volleyball players. A significant but negative relationship exists between age and skill variables i.e., face pass and wall spike of winner Volleyball players.
Gopinathan and Helina (2009) determined the relationship of anthropometric and physical fitness variables with Handball performance. Results revealed that the anthropometric variables of height, weight, arm length, leg length, palm span and sum of four skinfolds and physical fitness variables of speed, agility, explosive power, shoulder strength, strength endurance and endurance were having significant relationship with Handball performance and only flexibility was not having significant relationship with Handball performance.

The purpose of the Chauhan, M.S. and Ramchander, (2009) investigation was to scribe the correlation between the selected anthropometric variables and explosive leg strength and also to develop the regression equation for the prediction of explosive leg strength of Volleyball players between the ages of 18 to 24 years. The data was collected from inter collegiate Volleyball players taken as subjects of the study by using anthropometric rod, skinfold caliper, vernier caliper and steel tape. The product movement method for correlation and regression equation was used. Linear measurements i.e., height, lower leg length, total arm length, foot length and foot breadth, girth measurements i.e., shoulder, chest, abdomen, hip, thigh and calf girth, body diameters i.e., bi-acromial, femur bicondylar and ankle diameters and skinfold measurements i.e., biceps, triceps, sub scapular, suprailiac, mid-auxiliary and thigh skin fold measurements and fat percentage, fat weight and lean body mass have been found highly significant and hence the developed equation can be used in the prediction of explosive leg strength of Volleyball players.

Kaur et al. (2009) showed that Hockey players of both levels i.e., national and state, were found to be significantly taller and lighter than control group. State level female Hockey players possess significantly greater bone mass as compared to national level and control group. The national level female Hockey players have significantly greater muscle mass than state level: but both groups, national and state level have more muscle mass than the control group and national level female Hockey players have lesser percent fat then state level. The female players of both groups, national and state levels were found to possess significantly lesser percent fat than the control group.

Kumar et al. (2009) analysed the selected anthropometric variables and iso-inertial strength with hitting speed, among different playing positions. From the results, it was observed that except the standing height, all other variables namely
hitting speed, body weight, and iso-inertial strength of dominant and non dominant arm show significant relationship. Hitting speed of fullbacks was better than halfbacks, and in body weight fullbacks were better than forwards and halfbacks. Hitting speed of forwards was better than halfbacks. In iso-inertial strength of dominant arm the fullbacks were better than the forwards. Iso-inertial strength of both dominant and non dominant arm, the halfbacks was better than the forwards.

**Swapan K. Dey et al. (2010)** having conducted study on one hundred fifty (150) male Indian Footballers of six different national clubs of India including three from Kolkata (East Bengal, Mohan Bagan & Mohammedan Sporting) and other three from Goanese clubs (Salgaokar, Vasco & Dempo). Comparing anthropometric, motor ability and physiological profiles of Indian national club footballers have reported that the players were also sub-divided according to their specific field positions. Physical and physiological profiles including height, weight, percentage body fat (%BF), flexibility, agility, explosive power, and VO2 max were measured by standard procedures. It was reported that the mean values of age, height, weight and %BF were significantly different among Footballers of different national clubs. Among the motor ability and physiological qualities only flexibility, agility and VO2 max were significantly different among the Footballers of different national clubs (p<0.01). It was also reported that the mean values of height, weight, vertical jump and VO2 max of Indian national club players were found to be inferior to those of European, American and Australian Footballers. However, the %body fat of Indian Footballers according to their specific field positions was found to be comparable with their international counterparts. The defender, midfielder and striker of the reported study were inferior in endurance (VO2 max) as compared to their international counterparts. It was observed by the researchers that genetic factors may be the cause of smaller body size of the subject of their study as compared to their international counterparts. So, it was concluded by the researchers that the differences among the Footballers of their study with their international counterparts and specific playing positions was probably the cause of hereditary factors and differences in activity in the game.

**Carbuhn AF, Fernandez TE, Bragg AF, Green JS, Crouse SF, (2010)** studied the characteristics of off-season, preseason, and postseason bone and body composition measures in women collegiate athletes. From 2006 through 2008, 67 women collegiate athletes from 5 sports, Softball (n = 17), Basketball (n = 10),
Volleyball (n = 7), Swimming (n = 16), and Athletics (jumpers and sprinters) (n = 17) were scanned using dual energy X-ray absorptiometry (DXA) at 3 seasonal periods: (a) off-season = before preseason training, (b) preseason = after preseason training, and (c) postseason = after competitive season. Dual energy X-ray absorptiometry scans were analyzed for total body mass, lean mass (LM), fat mass (FM), percent body fat (%BF), bone mineral content, bone mineral density (BMD), arm BMD, leg BMD, pelvis BMD, and spine BMD. Data were analyzed between sports using analysis of variance (ANOVA) with Turkey post hoc follow-ups and within each sport using repeated-measures ANOVA and LSD; alpha < 0.05. Significant off-season to preseason or postseason changes in %BF, LM and BMD within each sport were as follows, respectively: Softball, -7, +4, +1%; Basketball, -11, +4, +1%; Volleyball, unchanged, unchanged, +2%; Swimming, unchanged, +2.5%, unchanged; jumpers and sprinters (Athletics), -7, +3.5, +1%. Comparisons among athletes in each sport showed bone measurements of Swimmers averaged 4-19% lower than that of athletes in any other sport, whereas for track jumpers and sprinters, %BF and FM averaged 36 and 43% lower compared with other sports at all seasonal periods. Values for athletes playing Basketball and Volleyball were most similar, whereas Softball players, values fell between all other players. These data serve as sport-specific reference values for comparisons at in-season and off-season training periods among women collegiate athletes in various sports.

Vishaw Gaurav, Mandeep Singh and Sukhdev Singh, (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 and suprailiac skin fold thicknesses (p<0.01), 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. 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.

Singh et al. (2011) find out the difference in selected anthropometric variables in Volleyball players at different level of performance. The results revealed that loser players were inferior in block jump and spike jump along with height and weight. This showed that the teams with better height and weight along with good jumping ability had better performance in the competition.

Vishaw et al. (2011) compared the somatic traits and body composition between Volleyball players and controls. Forty eight young male subjects (Volleyball players: N=24 and controls: N=24) of age group 18-25 years were randomly selected from the different colleges affiliated to Guru Nanak Dev University, Amritsar, Punjab, India. All the participants were assessed for height, weight, breadths, girths and skinfold thickness. The independent samples t-test revealed that Volleyball players had significantly higher height (p<0.05), as compared to controls. The Volleyball players were also found to have significantly greater lean body mass (p<0.01) and ectomorphic component (p<0.05) as compared to controls. Controls had significantly greater percent body fat and total body fat (p<0.05) as compared to Volleyball players. The Volleyball players of this study were found to have higher percentage body fat with lower body height and body weight. Further investigations are needed on above studied variables along with fitness and physiological variables to assess relationship among them with performance in Volleyball.

Koley Shyamal (2011) studied the arm anthropometric profile in Indian inter-varsity Basketball players. The purpose of this study was threefold: firstly, to evaluate the arm anthropometric profile of Indian inter-varsity Basketball players; secondly, to search for the correlations among these arm anthropometric characteristics; and thirdly, to search for the association of handgrip with arm anthropometric characteristics in Indian inter-varsity Basketball players. Three anthropometric characteristics, nine arm anthropometric characteristics and grip strength of both right and left hand were measured on randomly selected 60 Indian inter-varsity Basketball players (35 males and 25 females, aged 18-25 years) of six universities, who
participated in the inter-varsity championship organized at Guru Nanak Dev University, Punjab, India. An adequate number of control subjects were also taken from the same place for comparisons. The results indicated statistically significant \((p < 0.05 - 0.01)\) differences between the male Basketball players and the controls in height, right handgrip strength, upper arm, forearm and total arm length whereas no significant differences were found between the female Basketball players and the controls. Highly significant \((p < 0.01)\) sex differences were found in the Basketball players in almost all the variables studied (except BMI an arm fat area). Significantly positive correlations were noted among the arm anthropometric characteristics studied (except arm fat area and arm fat index) and with right and left handgrip strength.

Singh et al. (2011) find out the difference in selected anthropometric variables in Volleyball players at different level of performance. The results revealed that loser players were inferior in block jump and spike jump along with height and weight. This showed that the teams with better height and weight along with good jumping ability had better performance in the competition.

C. Jayakumar et al. (2013) analysed the selected hand anthropometric measurements among south zone inter university male Handball players. The selected players, right and left hand length and width were measured on 144 male handball players who had right hand as dominant hand. These players took part in south west zone inter university Handball tournament for the year 2010-2011 organized by S.R.T.M University, Nanded, Maharashtra. The hand length and width was selected as criterion variable and measured by vernier caliper, gulick tape and measuring scale. The collected data was analysed using ANOVA, when \(F\) is found to be significant, Tukey HSD post hoc test was applied. The result of the study showed that right hand length \((F = 1.61, p = 0.126)\) and left hand length \((F = 1.19, p = 0.308)\) show no significant difference between the groups. However, right hand width \((F = 5.450, p = 0.000)\) and left hand width \((F = 6.302, p = 0.000)\) shows that Rajasthan university Handball players showed greater hand width on both hands than other team players. It can be concluded that hand width shows significant variations among the south west zone inter university Handball tournament.

Lal and Sharma (2013) find out differences in somatotype between the Weight Lifters \((n=50)\) and Wrestlers \((n=50)\). The data for the present study were collected in the inter colleges of Himachal Pradesh University during the session
2008-2009. Each athlete was tested for various anthropometric measurements necessary for somatotype. Somatotype ratings were calculated by the equations developed by Heath and Carter (1990). To compare the somatotype between Weight Lifters and Wrestlers the 't' test was applied. The results indicated that Weight Lifters were older, shorter, and heavier than Wrestlers. It has been also found that Weight Lifters were dominant on endomorph and mesomorph component than Wrestlers and difference was found significant only in endomorph component, however Wrestlers were dominant on ectomorph component than Weight Lifters and difference was also found significant.

Stevo et al. (2013) described anthropometric characteristics and body composition of elite Soccer and Basketball players as well as to make comparisons between them. Seventy-one males were enrolled in the study, divided into three groups: twenty-six Soccer players, fourteen Basketball players and thirty-one healthy sedentary subjects. The results showed that there was no significant difference in body mass index among the groups, while a significant difference was found for body height and body weight as well as for all three of the body contents measured (muscle, bone and fat) among the groups. Basketball players were significantly taller and heavier than Soccer players and the subjects of the control group, while there was also a significant difference between the weight of Soccer players and the subjects of the control group, who were significantly heavier. The muscle and bone contents in the bodies of the subjects in the control group were significantly lower than that of all other subjects while there was no difference between Soccer and Basketball players. Lastly, the fat content in the body of the subjects in the control group was significantly higher than that of all of the other subjects, while there was no difference between Soccer and Basketball players. Therefore, these findings may give coaches from the region better working knowledge and suggest them to follow recent selection process methods and to be more careful during the recruitment.

Singh and Deol (2014) have done an anthropometric analysis to know about the comparative study of the Football players at different playing position of Punjabi University, Patiala. The study was conducted among 34 male Football players (Inter College level) from Punjabi University Patiala. The anthropometric variables selected for the study were height, weight, humerus bicondylar diameter, femur bicondylar diameter, biceps muscle girth, calf muscle girth, triceps skin fold, calf skinfold,
subcapular skinfold and supraspinal skinfold. Further the data was analyzed to find out the significant differences among the groups. The 't'-test statistical technique was used to analyze the significant difference and the level of significance was set at 0.05 level for testing the hypothesis. Further the data were analyzed to find out the significant difference among the group. The results revealed that there was no significant difference among the group in weight, humerus bicondylar, femur bicondylar, biceps muscle girth, calf muscle girth, triceps skinfold, subcapular skinfold, supraspinal skinfold, and calf skinfold. However there was significant difference between defender and midfielder in height.

Nageswaran, et al. (2014) analyse the selected anthropometric characteristics with the playing ability of the junior elite Basketball players in relation to their field positions namely guard, forward and center. The dependent variables as standing height, body weight, arm length, arm span, palm width, forearm girth and calf girth and as independent variable, playing ability (Coaches Rating) were selected as criterion variables for this study. The playing ability of the selected Basketball players was assessed by three qualified Basketball coaches. To examine the relationship between the selected anthropometric variables and the coaches rating on playing ability, the coefficient of correlation was used. To test the significance of the mean difference among the players of various positions namely guard, forward and center on criterion measures of selected anthropometric variables, One Way Analysis of Variance was used. In case of significance of mean difference observed on the criterion measure, to find out which pair of group is high among the others, as post-hoc test, the Schefee’s test was applied. The mean values of guard, forward and center were compared; the center players have maximum values in all the parameters followed by forward players and then the guard players.

Koley and Vashisth (2014) studied the correlations of back endurance with Anthropometric Variables and Performance Tests in Indian elite male Hockey players. The purpose of this study was of two-fold: first, to estimate the back endurance of Indian elite male field Hockey players and second, to search the correlation of it with selected anthropometric variables and performance tests. To serve this purpose, a total of ten anthropometric variables, viz. height, weight, BMI, biceps, triceps, subcapular and suprailiac skinfolds, percent body fat, back strength, two performance tests, viz. flexibility measures and tall kneeling and back endurance
were measured on purposely selected 80 Indian national level male Hockey players aged 16–21 years collected from PAP, Jalandhar, Punjab, India, during 2010-2012. The subjects were further divided as per their playing positions, viz. goalkeepers (n=15), center forwards (n=25), center halves (n=20) and full backs (n=20). In results, one way analysis of variance showed statistically significant (p ≤ 0.05) between-group differences only in body weight among these four sets of players. Significantly positive correlations (p ≤ 0.05 - 0.01) of back endurance were found with body weight, back strength, flexibility measures and tall kneeling in the Indian male Hockey players.