CHAPTER—II

REVIEW OF RELATED LITERATURE

Keeping in view the objectives of this study a review of related literature has been taken 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 serve as a pointer to the gaps and lacunae that still exist in the concerned field of research.

The literature, which is stored either in the form of books or in the form of monographic and journals etc. proves to be of the great help when they acquaint us of the methods to collect required information, statistical techniques employed and the evident outcomes of the researches done in the past. “Practically all human knowledge can be found in books and libraries; unlike other animals that must start a new with each generation, man builds upon the accumulated and recorded knowledge of the past.”

Mauley (1964) pointed out that “man is the only animal that does not have to begin a new in every generation, but can take advantage of knowledge which has accumulated through the centuries”. The importance and need of the study of old literature for healthy and proper guidance is clearly understood by many more investigators and research workers in various fields. We are fully agreed with this opinion because we must be well aware of the various facts and foundations of our field in the same manner as the competent physician must keep abreast of the latest medicine and newer technologies and the students of educational researches should become familiar with the location and use of sources of educational information.

2.1 Anthropometry and performance in sports

Cureton (1951) studied champion athletes and found that typical trackmen are light in skeletal framework with a relatively longer upper leg ratio and long
trunk relationship. He also noted that most good sprinters have narrow hips and that the more ponderous men with longer and larger trunk, but with relatively short limbs, are most likely to succeed in weight lifting, wrestling, gymnastics and diving.

*Bookwalter (1952)* conducted the study to show the relationship of physique and shape to physical performance. The Indian motor fitness test was carried on which comparing of four test items straddle chin-ups, push-ups, squat thrust and vertical jump. The data were studied from the standpoints of distribution of boys by physique and according to their development level. The physical fitness scores by physique group, the physical fitness scores by developmental level and physical fitness scores by combined grouping of physique and developmental levels. He concluded that – (i) the size and shape had an influence on physical performance, (ii) the thin and medium in physique that were large performed equally well physically. The same could be said about the smaller group.

The study of *Harold’s (1953)* investigated the following aspects: first the size and shape seem to have an influence on physical performance. Second the very obese are poorest performance and third the maximum size, body shape does not provide maximum physical fitness. It concluded that the large and fatty body varies in physical performance than the normal and thin boys.

*Mohr and Haverstics (1956)* conducted tests on 102 subjects over a period of 8 week volleyball course. The researchers gave them repeated volley tests at 3 feet and 7 feet restraining lines. Their heights were taken and were made to undergo tests of agility, combined running and rolling and vertical jump and reach test. Correlations were computed between volleyball tests and other factors. From the comparative study of these correlations, a significant relationship was found to exist between jumping and volleying, between agility and volleying and also between height and volleying.
Hindmarch (1960) administered the following tests to 100 Canadian born white boys, anthropometric height, weight, height-weight ratio, arm length, sitting height and leg length, performance in one minute sit-ups, standing broad jump and one minute squat thrusts, trunk flexibility criteria-Leighton trunk and hip extension-flexion test, Cureton trunk flexion test, modified Scott French Babing test and Kraus-Weber flexion test. The correlation between the anthropometric variables and performance tests and the flexibility criteria were low, the highest was .36 between the standing broad jump and the Scott French test. The Kraus-Weber test correlated .687 with the Scott-French test .830 with the Cureton test and .779 with Leighton’s test.

Pearson (1962) investigated the relationship between body size and speed. Twenty one untrained subjects were selected on the basis of body built, their measurement of height, weight, speed of sprint ‘start, RT as an adjunct of the ‘start’ and sample RT in the laboratory. The analysis of data permits the conclusion that the speed with which a person can get into action has little relation to his height, weight and calculated body fat as lean body mass for the population represented by the sample tested.

Wear and Miller (1962) studied the relationship of physique and development by the Wetzel grid. To performance in fitness tests, or junior high school boys, they found that subjects who were medium in physique and normal in developments to be the best performers and the subjects of heavy physique to be the poorest in performance.

Espenschada (1963) investigated the relationship of age, height and weight to the performance of boys and girls on performance test, low correlations were found between performance and height and weight when age was held constant.

Correnti and Zauli (1964) measured 166 Olympic track field competitors and eight swimmers at the 1960 Rome Olympic. The important findings are as
follow (a) Difference was observed in age, height and weight among the various events (b) within certain events body shape & form was similar but size varied.

*Parizkova, as referred by Johl (1964)* of the physical culture research institute in Prague studied the body composition of the Czechoslovakian national gymnastics team for men and women before and after their competitions at the Olympic Game in Rome in 1960. Measurements of body density and total skin fold thickness, yielding information on excess fat and body weight indicated an extremely favorable state of training of champion gymnasts several months before the contests. However, this highly selected group of athletes continued to improve during the maximally intensified exercise period immediately prior to the games. Their body density increased, skin fold thickness regressed and technical proficiency improved still further.

*Hirata (1966)* collected anthropometric data for 31 variables on 457 athletes, 309 males in 20 sports and 148 females in 10 sports. The descriptive statistics was used for 12 male sports and 5 female sports. The physique of athletes was analyzed through examination of absolute and relative size, somatotype, body composition and factor analysis of Montreal (1976), Mexico (1968) Olympics athletes. The male athletes from Montreal are larger than those from Mexico City on most measures of body size. The mean somatotype of the athletes from both Olympic samples was almost identical. Male and female students are smaller than the athletes on most size variables, except that the male athletes are older, have narrow hips and smaller skin folds. The athletes of both sexes are less endomorphic and more mesomorphic than the students. In term of proportions, male athletes compared to students have similar mass and tend to have slightly longer limb segments, greater bone breadths (but narrow hips) and upper body girths lower skin folds and greater bone muscles and residual masses. The exceptions are greater proportional mass in judo competitors, weight lifters and wrestlers, as well as few differences between fencers and field hockey players when compared with the students. Among the female sports canoeists, rowers and
swimmers have similar proportions, masses to the students but track and field athletes and gymnasts are proportionally lighter. The female athletes have proportionally narrow hips, larger girths (except for jumpers) and smaller skin folds but larger muscles mass than the students.

(1966) Garry studied the relationship of college footballer’s strength, speed and agility to the ranking rate by the coaches and divided the players in two groups. Correlations were computed between them through subjective evaluation and strength, speed and agility. It was concluded from the findings of the study that the arm strength and agility were not the valid predictive of football ability. Total strength and ‘T’ scores were moderate predictive of football playing ability whereas the leg strength and speed were the significant predictive of football playing ability.

Read (1967) found that the better gymnasts (male) averaged significantly shorter in sitting height and arm span than other two lower ability group of gymnasts.

Smith (1969) carried out research work on three groups of volleyball players at different levels of play comprising 66 beginners, 11 varsity players respectively. His findings revealed that the vertical jump correlated 0.35 with the Brady Test, 0.55 with the judges evaluation for the beginners. The ‘r’ between the vertical jumping ability of the varsity players and a potential playing ability ranking by their coaches was -.36. It was concluded that the vertical jump was not an accurate predictor of volleyball playing ability.

Generally, it is considered that success in team game is more related to knowledge of the game strategies, technical efficiency, and performance capabilities. Therefore, it becomes difficult to predict potentially talented players. There are number of factor which affect the performance of sportspersons, such as age, sex, physical growth, physiological, biochemical, genetically, anthropological and psychological (Carter, 1970). Among these factors, the size, shape, physique,
proportions, somatotype, fitness skill efficiency level also play significant role in better performance.

Shoundell (1972) studied the relationship of selected motor performance and anthropometric traits to successful volleyball performance. The problem of this study was to identify the physical and anthropometric traits possessed by successful volleyball players and upon determination to develop a physical performance test battery that would prove valid, reliable and practical when used to identify potentially successful collegiate volleyball players. Statistical techniques utilized provided inter-correlation coefficient between the independent variables and the dependent variables; stepwise regression coefficient provided the square of the multiple coefficients of all items were computed by using inter-class correlation techniques. Within the limitation of this study and based on the findings, the following conclusion was made: Cross validation procedure employed supported the validity of the six item battery as a predictor of expected volleyball performance.

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 back 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.

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 measurements. The body structure was interpreted as upper arm girth, chest girth, abdominal girth, thigh girth and calf girth measurements. The physical
performance was determined by selected motor ability tests. 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.

Diez (1978) studied the relationship among selected anthropometric
variables and relative body fat on inter college level women. The subjects were
enrolled in physical education classes at university of Illinois. The percentage of
body fat was estimated by densitometer using underwater weight, skinfolds sites,
eight body circumferences and seven body diameters were evaluated as predictors
of body density. The results indicated that simple anthropometric measurements
could be used to predict body density and body fat in college level women but that
the use of regression equation developed on other samples of college level women
are somewhat less predictive of fat contents.

Singh, M. (1978) has reviewed the literature on human physique and
performance. He has emphasized that an individual differs significantly in his
basic traits and participation in physical activities will not appreciably change his
maturity, body size and physique type, these individual differences will drastically
influence physical performance. Thus, these traits should be considered in judging
individual potentials for participating in physical activities of different type.
Evidence of this is commonplace observe the well proportional physique of Boxers
and Gymnasts, the super structure of great Basketball players, the solidarity of top
flight football players, the wiriness of champion distance runners and massive built
of great shot putters and discus throwers. The hurdlers have been found to have
long legs and short trunk. The gymnasts are found to be short and high jumper tall.
Various other studies also suggest that different body size, shapes and proportions
are beneficial in different physical activities. The Japanese who are best for small
built such as Gymnastics, long distance running, light class in boxing, weight
lifting etc are the best. Similarly, for Americans, who are large and lean, such
sports as Basketball, Volley Ball, Swimming, Long jumping and short and middle distance running are the best.

**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 suprailliac 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 were heaviest and tallest among all the rural sportsmen of Madhya Pradesh.

**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 i.e. volleyball, basketball, throwers, sprinters and distance runners. The differences in various measurements within the group have been attributed to physical demand of each sport.

**Chauhan, M.S. (1986)** studied the relationship between selected anthropometric variables and endurance running performance. He concluded that height, leg length, thigh length, total arm length, shoulder, chest, abdomen, hip and knee girths, thigh and calf skin folds, and lean body mass had significant and negative correlations with 1500 meters running performances, whereas 10,000 meters running performance had statistically insignificant correlations with linear segments, girths and diameter measurements, except with skin fold measurements (triceps, supra iliac, mid-auxiliary, thigh and calf skin folds) and body composition variables (i.e. body density, fat percentage, fat weight and lean body mass).
Uppal and Ray (1986) have introduced in their study that body fat is considered to be a liability in the performance of motor performance. However very few objectives of the study have been which could establish a direct relationship between body fat and the performance of various motor activities. Direct evidence of this nature would be a very useful in demonstrating to both athletes and non-athletes that excess of body fat has adverse effect on motor performance.

Kansal et al. (1987) conducted a study in which the anthropometric measurements were taken of 23 football players and 15 volley ball players who attend an inter-university coaching camp with a view to study their physique and body morphology. They also studied 100 control subjects. The differential anthropometric variables including linear, circumferential and skinfold measurements were taken. The body physique was calculated from skinfold using Heath-Carter Method (1969), and 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 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 and footballers had linear physique and large limb girths but less body fat than controls indicated their relatively more musculosity. The anthropometric somatotype of volleyballers and footballers were 2.16, 23.3, 9.7 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.

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, hand length, foot length, hip girth, calf girth, biceps skin fold, triceps skin fold, subscapular skinfold, sum of skin folds, 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 of high and low cardio-respiratory fitness boys and observed that in secondary schools belonging to high cardio-respiratory fitness, fitness group possesses 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 groups reveal that both the groups possess a peculiar physique and absolute anthropometric variables among themselves maintain certain amount of proportions which is quite unique in itself.

Singal et al. (1993) conducted a study on the inter-sportive differences in anthropometric measurements and body composition of national level women. While comparing with controls, they found that sports women of all games generally taller, with bigger trunks, broader shoulder, wider elbows, wrists, knee and ankles except gymnasts. The circumferences were larger; the subcutaneous tissue was lesser in all categories of players as compared to controls. The body fat and percent body fat were lesser in players and the lean body mass (LBM) and percent lean body mass were found to be more in all sportswomen. Inter-sportive difference for sportswomen indicated that basketball women were found to be taller, heavier with bigger trunk and broad diameters than all the other sportswomen. Body fat, percent body fat and lean body mass were found to be more in basketball players and percentage of lean body mass in gymnasts.

Kumar (1995) studied the relationship between selected anthropometric variables and performance in athletics programme of high school and senior secondary school students. He concluded that performance in all running events
100 meters, 200 meters, 400 meters, 800 meters 1500 meters, 5000 meters and 10000 meters events have significant relation with age, body weight height, leg length, thigh length, shoulder, chest, abdomen, hip, upper arm, thigh, calf girth, femur bycondylar, biacromial, fat weight and lean body mass.

_Damsgaard, R. et al., (2000),_ studied the effect of genetic factors, birth weight, early childhood growth, sport, hours of training, and pubertal status on the stature and body mass index (BMI) of children aged 9-13 participating in sports at a competitive level, 184 children (96 girls, 88 boys), competing in swimming, tennis, team handball, and gymnastics, were investigated, assessing their height, weight, pubertal development, and BMI. Of these, 137 (76 girls, 61 boys) returned a questionnaire, which enabled us to determine height and BMI at age 2-4, birth weight, and parental heights. Significant differences in standard deviation scores (SDS) for actual height and for height at age 2-4 were found in both sexes between the four sports. In girls, BMI SDS was significantly different between the four sports, whereas no difference was found in boys. Each sport investigated separately showed no change in height SDS and BMI SDS between ages 2-4 and 9-13. A regression analysis showed that target height, height at age 2-4, and pubertal status had a significant impact on actual height. Interestingly, the type of sport and hours of training per week had no effect on height SDS. In boys, BMI at age 2-4 and pubertal status had a significant effect on actual BMI, whereas in girls, only BMI at age 2-4 was significant.

_Rasnus, D., et al., (2001),_ conducted a study in which he primarily to investigate anthropometric variables, body composition and pubertal development in children aged 9–13 participating in competitive sports. Secondly, the influence of age, sport, training hours and pubertal development/maternal menarcheal age on body composition and pubertal development was explored. A total of 183 (96 girls, 87 boys) children performing swimming (Sw), tennis (Te), European team handball (TH), and gymnastics (Gy) took part in the study. Anthropometric measurements and pubertal development were determined. The participants
completed a questionnaire regarding hours of training per week and maternal menarcheal age. Significant differences in stature (z-scores) were found in both boys (Sw=0.06; Te=0.04; TH=0.05; Gy=−0.66, $P<0.004$) and girls (Sw=0.12; Te=0.19; TH=0.25; Gy=−0.96, $P<0.004$). In girls, sum of skinfolds in millimetres (Sw=33.4; Te=33.3; TH=41.0; Gy=27.2, $P<0.02$) and body mass index z-scores (SW=0.00; Te=−0.27; TH=0.35; Gy=−0.25, $P<0.001$) were different between the sports. A regression analysis revealed that in girls, age and maternal menarcheal age were significantly associated with pubertal development ($P<0.005$ and $P<0.01$), respectively, and sport was associated with the sum of skin folds ($P<0.05$), in boys, only age was significantly associated ($P<0.005$). In conclusion, anthropometric and body composition differences exist in athletes of both sexes from different sports but are more evident in females. Most importantly, we did not find any effect of training on body composition or pubertal development, confirming previous data that children in competitive sports are selected due to constitutional factors.

**Singh, S., Singh, J. and Singh, H. (2002)** studied on the relationship of body height and body weight with selected physical fitness variables in untrained female children of 10 to 14 years age groups with body height and weight, standing board jumps, thirty meters sprint, medicine ball put, six into ten meters shuttle run. Standing vertical jump and eight hundred meters run test were used to assess to the fitness level. They concluded that:

There is positive and significant relationship between height and body weight of all age groups except 13 years group.

Height of 10 and 11 years groups is found to be significantly related to body weight, 30 meters run, medicine ball put, standing vertical jump and standing broad jump test performance.

There is no significant relationship between height and selected motor tests of the age group of thirteen years.
A significant relationship does not exist between height and 800 meters run and 6 x 10 meters shuttle run.

A negative relationship exists between body weight and performance in standing vertical jumps and standing broad jumps.

A significant relationship exists between body weight and shoulder strength of age group 11 and above.

A significant but negative relationship exists between body weight and 800 meters test of age group 10 to 13.

Agility shows a significant relationship with body weight of 10 to 13 years age group.

*Chauhan et al. (2003)* determined the prediction of sprinting ability in relation to anthropometric variables and concluded that age, body weight, height, leg length, lower leg length, total arm length, shoulder, chest, abdomen, hip, thigh and calf circumferences bicromial diameter, bicristal diameter, fat weight and lean body mass have negative and significant relationship of senior secondary school boys. Multiple correlation of a combination of three anthropometric variables i.e. leg length; bicromial diameter & lean body mass with sprinting ability performance is significant at .01 level. The multiple correlations of sufficient size and hence the regression equation drawn can be put into prediction of sprinting ability of schoolboys.

The aim of the *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, bicromial diameter thigh skin fold with middle distance running performance is significant at .01 level, but
multiple correlation is not of sufficient size, so the regression equation cannot be put in to prediction of running performance.

*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. Other variables have no significant correlations with performance in 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 where as wrist has negative but significant correlation with performance in field goal speed ability.

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 semi-final winner volleyball players.
2.2 **Sports skills, strength measures and performance**

*Clarke (1957)* conducted a study to find out the relationship of strength and anthropometrics measurements with physical performance of 53 unselected non-disabled male students at the University of Oregon, involving the trunk and leg length. He concluded that correlation among some of the anthropometrics variables were especially high i.e. between standing height and leg length (0.91), between foot length and leg length (0.88), between body weight and hip width(0.87), between height and strength test i.e. trunk flexion and extension (0.65). The multiple correlations were found significant for leg lift (0.74) with body weight, ankle dorsal flexion strength back lift (0.71) with knee extension strength hip width, trunk flexion strength and knee flexion strength and for standing broad jump (0.66) with adipose tissue over the abdomen (negative) and hips extension strength (positive).

*Logan (1961)* has expressed that strength is necessary for the stability of joints particularly of the extremities. Speed is the ability to react quickly and execute motor movements under given conditions.

*Margaret (1964)* studied body structure and design factors in the motor performance of college performance of college women, pure speed, sergeant jump, 600-yards run/walk, back strength, leg strength and strength index were studied in relation to 43 measures of body structure and design. The later measurements were secured by length, depth area of non linear expression of body built design and experimental combination of variables. The correlation was significant and one or more variables from each group, the height relationship being consistent with experimental combination of variables.

*(1965) The American Association for Health, Physical Education and Recreation (AAHPER)* constructed a test in volleyball for boys and girls. This test included the skill as serving, volleying, passing and set upping. This test established a high degree of reliability and validity.
(1966) Tergerson investigated the relationship of selected measure of wrist strength, vision and general motor ability to badminton playing ability. The French short serve and clear test and Miller Wall Volley Test were administered to 23 Sophomore College Women. Motor ability was measure through the Scott Test plantar and dorsiflexion strength with a tensinometer, temporal vision with a parameter and depth perception with Howard-Dolwan apparatus. Total badminton ability correlated significantly with general motor ability and depth perception. The highest and lowest six players differed significantly in motor ability, depth perception and peripheral vision but not in total wrist strength.

Cumming (1967) muscular strength and explosive strength are required for a gymnast to perform on various apparatus. Hence gymnasts at high level are found to be the leanest the strongest and the most flexible of all athletes. Of all the components of motor fitness i.e. the strength, speed, power, flexibility, endurance and balance, the most important single component is strength. To execute strength dominating elements in a combination, as per the requirements laid in the code of points for men and women (at least eleven elements combination) performance in addition to strength is faced with the problem to continue the activity over a prolonged duration without any interruption. Thus, making the entire work a strength and endurance dominating activity.

Greenlee (1969) investigated the relationship of selected measure of strength, balance and kinesthesis and bowing performance. Test of leg strength, grip strength, arm and shoulder girdle strength, static and dynamic balance and various measures of kinesthesis including wrist extension, rotatory position of the forearm and forward weight shift were administered to 122 beginning bowlers during the last two week of an eight week bowling course. These test results were correlated with an average of the last 6games bowled. A significant positive relationship was found between dynamic balance and bowling performance.
**Neilsen (1969)** studied the relationship of body composition to selected measures of muscular strength. Twenty eight male students, 18 to 25 years of age, were tested for body density from which percent body fat, body fat weight, percent body lean mass and lean body weight were calculated. The strength of nine major muscle groups of the body was 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 them or between strength and body composition variables. The multiple correlation coefficients indicated that strength was unusable as predictor of body composition.

**Knight (1970)** studied the relationship of repeated wall-volleys, the volleyball pass and volleyball playing ability taking Eleventh Grade Girls as the subjects. The subjects performed volleyball wall-volleys, the volleyball pass in the game situation. Data for determining the relationship of these skills were the scores from the administration of Mohr and Haverstics repeated wall-volley test. Liba and Suttinger’s rating scale test were administered at the end of 6 week volleyball unit. Correlations were computed between scores on each of the tests. It was concluded that Liba and Standffeur’s volleyball test and Mohr and Haverstics repeated wall-volley test at the seven-feet restraining line may be used to predict playing ability as measure by Suttinger’s Rating Scale.

**Toyoda (1971)** found out through an investigation that the volleyball players have different types of requirements according to the nature of activity. He concluded that a volleyball player requires muscular strength and power, muscular as well as cardio-respiratory (Cardio-respiratory) endurance, agility and speed of movement, flexibility of muscles and joints, ability to control body movements like timing, rhythm, or coordination and relaxation and coordination of the whole body. These elements were found to possess significant relationship with the skills in volleyball.
Shondell (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 used provide inter-correlation coefficient of the independent variable and the dependent variables, step wise regression coefficient, constants and square of the multiple correlation coefficient for the regression equation at each step. The reliability coefficient of all items were computed by using interclass correlation techniques with in the limitations of the study and based on findings, the following conclusions were made: the cross validation procedure employment supported the validity of six item battery as a predictor of expected volleyball performance.

Toyoda (1973) et.al. conducted tests of physical fitness on Japanese male volleyball team to physical abilities of the players. The tests administered comprised muscular strength, grip strength, back strength, basketball distance throwing, vertical jump, block jump, three consecutive broad jumps, sit-ups (20 sec and bending of upper body (20 sec).

The tests of agility included 20 m dash, 3 shuttle run of 9m distance, rolls, side-stepping (1.2m main line for 20 sec) rolling test (time required for 5 forward rolls, 5 backward rolls and standing up and total body reaction time.

The test for cardio-respiratory endurance was Harvard Step Test (5 minute stepping on 50cm block) maximum O2 uptake and amount of O2 dept.

The flexibility test included forward and backward bending of the body and the duration of hand stand. The tests of dexterity included those of the horizontal bar, horse mat-work and trampoline.
The findings of this investigation indicated that the volleyball players possess these qualities.

**Gunney (1973)** reported that if two athletes are equally trained with identical body built the taller gymnasts is at a disadvantage because he or she has a smaller strength body weight ratio than the shorter gymnast.

**Cox (1974)** studied the relationship between team performance in volleyball and the skill components for serving, service-reception, setting, spiking, spike-defense and free ball passing as measured through adapted charting procedures. Multivariate analysis of variance, discriminate analysis and multivariate correlation techniques were employed to analysis the resultant data of the investigation.

The findings of the study indicated that on being considered together the volleyball skills of serving, service reception, setting, spiking, spike reception and free ball passing as measured by adapted statistical charting procedures, showed significant relationship with team performance when analysed from winning or losing point of view and also in terms of the total percentage of the points scored by the team charting procedures. When the criterion variable of team performance was taken into consideration in terms of winning or losing, the findings revealed the following conclusions:

Serving and free ball passing were of little significance towards success prediction in volleyball.

Spiking and spike-defense made excellent contribution for making prediction about success.

The order of skills in volleyball which proved most influential in predicting team success was spiking followed by spike-defense, service-reception, setting, serving and free ball passing.
And now, when the criterion variable of team performance in terms of percentage of marks/points scored by each team being chartered was taken into consideration, the findings revealed the following conclusion:

Setting did not make any significant contribution in terms of accounting for the variance of team performance scores.

Spiking and spike-defense made a major contribution in terms of accounting for the team performance scores.

The order of volleyball skills that proved most effective in predictive team success was spike-defiance followed by spiking, service reception, setting, serving and free ball passing.

*Rivet (1978)* analyzed his study that jumping is very significant factor in volleyball performance. He has to use his maximum power during spiking to meet the ball at highest point in order to score. Even during block jumps, the player had to jump at his maximum for a number of times to block a spiked ball. The power of arms is not less significant for spiking and serving and the power of fingers also contributes to an overhead pass.

*Spence (1980) et. al.,* developed a descriptive profile of 15 member of United States Women National Volleyball team, who were highly skilled. The data were obtained from anthropometric measures, strength, physiological and motor performance domains comprising jump and reach, triple hop, agility run, and 20 m dash. Comparison was made between six women volleyball players who were selected for the Pan American Team and the nine other players who were not selected. The Pan American selected were taller and heavier and demonstrated better motor ability than the non-selected ones. Strength measurement did not indicate consistent differences between the two sub-groups. The non-selected players had a greater Vo2 max than those of selected ones.
Murugesan (1981) carried out his research work on a group of 30 male Volleyball players of Lakshmibai National College of Physical Education, Gwalior to determine “the relationship between height, agility and vertical jump to spiking in volleyball. The investigator established the relationship of these three variables to spiking in volleyball. The finding of his study indicated that the vertical jump is the most reliable and dependable single variable in judging the spiking ability of male volleyball players. It was also found that the combination of height and vertical jump proved to be the most reliable factor in assessing the spiking ability of volleyball players. The combination of all the three variables viz., height, agility and vertical jump was found quite valid and reliable for predicting the spiking ability of a volleyball player.

Walia (1981) from his study on gymnasts found that explosive strength is required to perform scoring movements and jumps on different events. Maximum strength comes into play while performing strength/static’s elements. Strength and endurance play dominant role while performing complete exercises which consists of at least 12 elements, on each apparatus with the exception of vaulting horse.

Phipps (1982) studied selected general ability tests, specific skill tests and personality traits as the reductive elements of volleyball performance in the High School Girls. The objective of this research project was to determine as to which of these variables had highest relationship with overall performance in the game of volleyball. Three general ability tests, three specific volleyball skill tests and a personality trait test were administered to 120 High School Girls.

The outcome of the findings revealed that the specific test model had the high correlation with the overall performance. The variables of general ability and the personality trait were not the volleyball performance. The specific test model was the most valid predictive of the criterion scores followed by the combined and the specific model.
Gill (1983) investigated the relationship between grip strength, arm strength, hand, foot and stepping reaction time to playing ability in badminton. Sixty male badminton players who participated in the Gwalior district badminton championship for the year 1982-1983, served as subjects for this study and the variables were grip strength, arm strength, hand, foot stepping reaction times. A statistical analysis of the data revealed that arm strength, hand, foot and stepping reaction times were significantly related to playing ability in badminton whereas grip strength and playing ability in badminton were not significantly related to each other. Thus the variables arm strength, hand, foot and stepping reaction times contribute significantly to better performance in the game of badminton whereas grip strength does not do so.

Joseph (1983) conducted a study on 30 male volleyball players of Lakshmibai National College of Physical Education, Gwalior to determine the relationship of power, agility, shoulder flexibility, arm length and leg length to volleyball playing ability, Product Moment Correlation Method was employed to compute correlation between volleyball playing ability and each of the selected independent variables.

The findings of this research work made the following revelations:

The power was the most reliable variable in predicting the volleyball playing ability.

The arm length and leg length also found to be reliable variables in making prediction about volleyball playing ability.

The variables of agility and flexibility did not correlate significantly to volleyball playing ability.

Siridhar, (1984) studied the thirty male and female volleyball players to see the relationship of selected motor fitness components of playing ability in volleyball. Product moment correlation was computed in order to determine the
relationship of selected motor fitness components to playing ability in volleyball and to test the hypothesis with the level of significance set at 0.05. In the conclusion, she found that power was most significant fitness component underlying performance in game of volleyball. Muscular endurance, circulatory, respiratory endurance and flexibility also contribute to the volleyball playing ability in a real manner. Agility showed an insignificant relationship to playing ability in volleyball.

Bhola (1984) conducted her study on 20 male volleyball players of Lakshmibai National College of Physical Education, Gwalior, in order to determine the relationship of absolute leg length, relative leg length, foot length, dynamic power, ankle flexibility and agility to jumping ability in volleyball using three-stride rhythm. The investigation undertaken by her revealed:

Foot length and dynamic power showed significant relationship with jumping ability in volleyball using three-stride rhythm.

Right and left ankle also showed significant positive relationship to jumping ability in volleyball.

Agility was significantly related to male volleyball players.

Gill (1985) designed a study to investigate the relationship of selected physical and physiological variables with performance in Gymnastic and to determine their contribution towards prediction of performance in Gymnastic. The subjects of the study were eighty male gymnasts who participated in nationals 1984, held at Jabalpur. He found that:

Physical variables namely, arm strength, abdominal strength, right grip strength, left grip strength, explosive leg strength, agility (squat thrust), spine flexibility, shoulders flexibility, back and hamstring muscles flexibility and dynamic balance are significantly related to performance in Gymnastic and that they have equal importance in its prediction.
Among the physiological variables, cardio-respiratory endurance, speed of movement and reaction time are significantly related to performance in Gymnastic and they too are equally important in its prediction.

The relationship of anthropometric measurements namely, crusal index and ponderel index, are not significantly related to performance in Gymnastic.

Speed (30 meter run), agility (shuttle run) two hand co-ordination, kinesthetic perception, body density and human index are not significantly related to performance in Gymnastic.

It is possible to predict Gymnastic performance ability on the basis of physical (motor ability) and physiological variables; and

Instead of predicting Gymnastics performance ability on the basis of each physical and physiological variable separately the combined effect of physical and physiological variables can be more profitably utilized.

Kumar (1985) unpublished derived on interrelationship among leg power tests, spiking and blocking skills on 32 volleyball players at NIS Patiala. The tests conducted included vertical jump without approach and with approach, block jump, three consecutive long jumps with both the legs an with right and left leg, standing broad jump, half-squat, shuttle run (9-3-6-3-9) forward and backward bending of the body, 20m sprint and 40m sprint and 60m run, spiking and blocking.

The finding of Kumar’s (1986) investigations revealed that spiking and blocking skills did not bear inter-relationship. Spiking had significant correlation with 40m sprint, reach jump and jump without approach. The approach and without approach jumps were highly correlated with each other. Sprint tests showed a significant correlation with jump tests. The test of flexibility had correlation with agility only.
Chauhan, M.S., Sharma, V.P. and Sharma J.C. (1987) conducted a study on the relationship between selected anthropometric variables and performance in standing broad jump of collegiate women and concluded that age and foot breadth had positive correlation with performance in standing broad jump, whereas hip girth, thigh and calf skin folds, fat weight and lean body mass had significant but negative correlation with the performance in standing broad jump. Further, the multiple correlation of the combination of selected anthropometric variables i.e. age, weight, foot breadth, hip girth and thigh girth with performance in standing broad jump was found to be significant at .05 level. The multiple correlations found were not sufficient enough to be used in the prediction of performance.

Uppal and Roy (1987) made a study to assess the motor fitness components as a predictor of soccer playing ability. Twenty male soccer players were selected for the study and were administered five tests for measuring motor fitness components viz. 50 meter dash for speed, 4x10 meter shuttle run for agility, dynamometer for maximum leg strength, standing broad jump for explosive leg strength and Coopers’ 12 minutes run/walk for cardio-respiratory endurance. A panel of three judges assessed the soccer playing ability. The results of the study indicated that all the independent variables (speed, agility, maximum leg strength, explosive leg strength and cardio-respiratory endurance) were related significantly to the dependent variables (soccer playing abilities).

Chauhan (1988) indicates the better development of various regions of throwers. He conducted a study on the correlation of anthropometric variables with success in putting the shot by college women. He concluded that age, height, and biacromial diameter had positive and significant correlation with success in putting the shot, whereas sub scapular, thigh and calf skin folds, body density, and fat weight has negative and significant correlations with success in putting the shot of college women. Further the multiple correlation (R=. 575, P>.05) of the combination of selected anthropometric variables, i.e. age, height, total arm length, foot length, hip girth, thigh girth and biacromial diameter with success in putting
the shot of college age women was found significant at 0.05 level, but the multiple correlation was not of sufficient size to put in the prediction of success in putting the shot.

_Eliasz, J. (1993)_ found the relationship between the ball velocity during different types of throws in handball and basic motor ability parameters (muscle strength, arm speed) of twelve high-performance handball players took part in the experiment (six of them were at that moment members of the National Team) in order to improve the efficiency of training. The average values of basic parameters of physical characteristics of the subjects were: 89.0±7.8 kg (body mass), 1.88±0.05 m (body height) and 23.3±2.5 years of age. The Shapiro-Wilk test, Pearson's correlation matrix and multiple regression analysis were used (a=0.05). Statistically significant differences were found between maximal ball velocity during throws with a cross-over step, and ball velocities during other analyzed throws. The highest ball velocity was achieved during the throw with a cross-over step performed by play-makers. Among the motor ability factors, total muscle strength of the body (ISI), strength of trunk flexors (abdominal muscles) and maximal arm (shoulder joint) angular velocity (MSD) have a decisive effect on the ball velocity in analyzed throwing techniques. The maximal arm speed was found to be the most important factor determining ball velocity during - technically the simplest - throw on the spot. Muscle strength has greater influence on ball velocity during - technically more complicated - throw with an upward jump.

_Roland, T. et al., (2004),_ studied the relationship between maximum isometric strength, anthropometry and maximum velocity in over arm-throwing for male and female handball players. Twenty male and 20 female handball players were tested. The mean ball velocity was 23.2 ms$^{-1}$ and 19.1 ms$^{-1}$ for male and female handball players respectively. For males and females, similar correlations were found between maximal isometric strength and throwing velocity (men, $r=0.43$, $P=0.056$; women, $r=0.49$, $P=0.027$). Univariate analysis of variance between isometric strength and throwing velocity for men and women showed no
significant effect of gender ($F_{2.36}=0.116, P=0.89$). Body size had a strong positive effect on the throwing performance and isometric strength. Throwing velocity appeared to be affected by gender when size was expressed by mass or height ($P<0.001$). However, this dependence was completely explained by size differences when expressed as fat-free body mass (FFM). For strength, no gender effect was found at all, i.e. all gender differences were explained by size differences irrespective on how this was expressed. The finding that strength and velocity show a gender independent relationship strengthens the notion that gender difference is based on difference in muscle bulk. Conclusively FFM, as an approximation for skeletal muscle mass is the best measure to express body size when related to physical performance.

*Leyk, D. et al.,* study (2007), assessed the hand-grip strength has been identified as one limiting factor for manual lifting and carrying loads. To obtain epidemiologically relevant hand-grip strength data for pre-employment screening, determined maximal isometric hand-grip strength in 1,654 healthy men and 533 healthy women aged 20-25 years. Moreover, to assess the potential margins for improvement in hand-grip strength of women by training, we studied 60 highly trained elite female athletes from sports known to require high hand-grip forces (judo, handball). Maximal isometric hand-grip force was recorded over 15 s using a handheld hand-grip ergometer. Biometric parameters included lean body mass (LBM) and hand dimensions. Mean maximal hand-grip strength showed the expected clear difference between men (541 N) and women (329 N). Less expected was the gender related distribution of hand-grip strength: 90% of females produced less force than 95% of males. Though female athletes were significantly stronger (444 N) than their untrained female counterparts, this value corresponded to only the 25th percentile of the male subjects. Hand-grip strength was linearly correlated with LBM. Furthermore, both relative hand-grip strength parameters ($F_{\text{max}}$/body weight and $F_{\text{max}}$/LBM) did not show any correlation to hand dimensions. The present findings show that the differences in hand-grip strength of men and
women are larger than previously reported. An appreciable difference still remains when using lean body mass as reference. The results of female national elite athletes even indicate that the strength level attainable by extremely high training will rarely surpass the 50th percentile of untrained or not specifically trained men.

The purpose of the Chauhan, M.S. and Ramchander, (2009) investigation was to describe 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, skin fold caliper, vernier caliper and steel tape. The Product movement method for correlation and regression equation were used. Linear measurements i.e., height, trunk length, lower leg length, total arm length, foot length and foot breadth, girth measurements i.e., shoulder, chest, abdomen, hip thigh and calf girths, body diameters i.e., biacromial, bitrochanteric, femur bicondylar and ankle diameters and skin fold measurements i.e., biceps, triceps, sub scapular, supra iliac, 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.

Mohan, L. & Sharma, Y.P. (2009) tested a total of 334 volleyball players from different colleges of Himachal Pradesh to judge their skill efficiency in relation to their performance. The purpose of the study was to find out significance differences of skill efficiency variables of volleyball players of Himachal Pradesh. To achieve the objectives of the study, Helmen volleyball Skill test consisting of three test items face pass, fore arm pass and wall spike was used to measure the skill efficiency level of volleyball players. Test of significance of the differences was applied in the present investigation to tackle the data. Significance of data was judged at .01 and .05 level of significance. The analysis of data shows that winner volleyball players are better in ball control with the finger pads (set) control the
ball with forearm pass, and spike the ball with controlled power and accuracy as compared to their loser counterparts.

The study by Singh Simarjeet and Singh Dharampal et al., (2009) showed a relationship of scoring skills i.e., spike, block and serve, with maximum spike jump and maximum block jump test performance and selected anthropometric variables, in an international level competition. The subjects for the study were players from 16 countries who participated in the men’s senior Volleyball World Championship, at Tokyo, in Japan, from 17 Nov. to 3 Dec. 2006. The data of these subjects was collected from http://www.fivb.org/web site and processed by the investigators. The data of 36 volleyball players, from 44 matches, was analyzed, ensuring that every player must have made minimum 10% total attempts made by the team. It was concluded that a non-significant relationship exists between age, height, weight and scoring skills. A non-significant relationship between scoring skills and jump reach in spike and block exists. An overview of success rate in scoring skills at 5 centimeters interval of height indicate that the players having the height between 201 to 205 centimeters have the height success rate in spike; whereas players with height between 190 to 195 centimeters have better success rate in serve and block.

Singh and Chauhan (2011) examined the correlation between the selected kinanthropometric variables and explosive leg strength and also to develop the regression equation for the prediction of explosive leg strength Basketball players between the age range of 18 to 25 years. They found that height, sitting height, trunk length, leg length, thigh length, shoulder, chest, abdomen, hip girth, elbow, hip, knee diameters, biceps, subscapular skin folds, fat weight and lean body mass have positive and significant correlation with explosive leg strength at .01 level of significance. The size of the multiple correlation was also sufficiently large and hence regression equation developed for the prediction of the explosive leg strength of Basketball players.
A study conducted by *Singh and Chauhan (2011)* shows that body weight, standing height, sitting height, trunk length, total arm length, upper arm length, leg length, thigh length, lower leg length, hand length and hand breadth; elbow, shoulder and hip diameters; shoulder, chest, abdomen and hip girths; biceps, triceps, sub scapular and calf skin folds; lean body mass, fat weight and motor fitness components i.e., speed, arm strength, flexibility and leg strength had significant correlations with shooting accuracy skill efficiency of Handball players. And the multiple correlation \((R=.833)\) of arm strength, leg strength, sitting height, total arm length, leg length, elbow diameter, chest girth, sub scapular skin fold and lean body mass with shooting accuracy skill efficiency of Handball players was significant and the value of multiple correlation of determination \((R^2=.694)\) indicates that 69.40 percent of variance of performance scores can be predicted on the basis of prediction equation.

They found the significant correlation of ball controlling and passing skill efficiency of Handball players with body weight, standing height, sitting height, trunk length, total arm length, upper arm length, leg length, thigh length, lower leg length, hand length and hand breadth; elbow, shoulder and hip diameters; shoulder, chest and hip girth; triceps, sub scapular, thigh and sum of four skin folds; lean body mass, fat weight and motor fitness components i.e., speed; arm strength, agility and leg strength at .01 level of confidence and the multiple correlation \((R=.854)\) of speed, arm strength, sitting height, total arm length, elbow diameter, sub scapular skin fold and lean body mass with ball controlling and passing skill efficiency of Handball players. Moreover, the value of multiple coefficient of determinant \((R^2=.7300)\) suggests that 73.00 percent of variance of ball controlling and passing skill efficiency of Handball players can be predicted on the basis of regression equation developed by these seven variables.

From the synthesis of the related literature, it is clear that the anthropometric and strength measures variables are very essential ingredients for improving the performance of volleyball players. Through the study of these
variables, the correlations of anthropometric variables and strength measures with the playing ability of players can be established and further the prediction equation for the evaluation of performance could be developed which will be beneficial for strengthening the training programme and also getting better performance in competitions.

After making an incisive study of the related literature with a critical insight we may all agree to the fact that the components of strength measures are highly related to the performance of any game and it takes great significance in the highly skill and technical sports of volleyball. Almost all the scholars have made an attempt to find the relationship of the strength measures with the anthropometric measurements so as to view analysis or interpret the performance shown by various players. One more point of similarity where almost all the leading personalities of sports have given their consent that it is the fact that India legs behind than the western countries in these dimension and work is still to be done with utter care as no work or a little work has been done to examine the correlation of total fitness in volleyball players performance and that the ideal body structure for volleyball players is medium to average stature, light skeleton, relatively more strength along with developed thoracic cage and lesser body fat. If we want to prepare winning teams the performance levels is to be increased which can only be facilitated by developing the fitness. The present investigation has been designed to find the correlation of strength measures, anthropometric variables and skill efficiency of volleyball players of university level competitions.