Chapter-2

Review of Related Literature

A careful review and exploration of the related literature was indispensable to provide ideas, theories, explanation or hypothesis valuable in formulating the problem, to avoid the risk of duplicating the same study already undertaken, to suggest methods of research appropriate to the problem, to locate comparative data useful in the interpretation of results and to contribute to the general scholarship of the investigator. The current chapter was designed to bring light on a few related empirical studies which are relevant to the problem under study.
Kohlrush (1929) conducted a study of measurements on players of different games and sports at 1928 Olympic games held in Amsterdam. The measurements of height, weight, vital capacity and other body parts were taken. The data indicated that there were differences in body dimensions of players various games/sports events.

Cozens (1930) studied stature in relation to physical performance of college men. He found that:

- there was a negligible correlation between age and height;
- negligible correlation between age and weight;
- age had no bearing upon performance in general athletic ability;
- height and weights were apparently influencing factors to some extent in the matter of performance.

Cozens et al. (1937) state that there was no relationship between height and weight of girls with fundamental skill achievement in a variety of sports.

Espenschade (1963) evaluated relationship between physical performance and their age, height and weight of boys and girls of California. Physical performance test was administrator in order to evaluate these factors on the basis of grouping of students and for the establishment of norms for test performance. Where age is held constant, relationships of all performance with height and weight are low. The highest correlations were obtained for boys of junior high school age in the events of jumping and throwing. Significant changes with age do occur in relationship with the most events for both sexes. Age is recommended as a basis for test norms. It shows that age has direct bearing on physical performance.

Holland (1964) conducted a study to determine the value of speed, agility, upper arm strength, power, ball handing ability, reaction, shooting ability, passing ability, height, weight, age and previous experience in predicting ability to play high school basketball to determine which tests are most practical and useful to coaches in small high schools for predicting a successful high school basketball player. On tile basis of this study the following findings were under made
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• weight, height, experience, speed, power, ball handing ability, passing ability, shooting ability and reaction influence a player’s success in basketball.

• experience, ball handing, passing and shooting ability had the greatest influence on a player’s success in basketball.

• prediction of successful basketball players from the basketball ability scores was 78 per cent accurate. The accuracy of the prediction of starters was 68 per cent, of second team members 40 per cent, and of the all-star team, 38 percent.

Hirata (1966) conducted a study on the height, weight and age of the competitors of 1964 Olympic games. He found considerable differences in age, height and weight of participants in different events.

Clarena (1969) investigated the relationship of certain factors with success in volleyball. It was found that jumping ability and reaction time were significantly related to success in volleyball.

Smith (1969) studied the relationship of volleyball playing ability to scores achieved in the sargent vertical jump. It was concluded that vertical jump is not accurate predictor of volleyball playing ability.

Bullen (1971) has found that the body composition in certain sports indicated that the athletes who were very lean but heavy because of a well—developed musculature were superior in performance in certain competitive sports activities, such as football, weight lifting and shot put.

A comparative study was conducted by DAHL (1971) to determine physical fitness differences between Negro and white boys. Sit—ups, standing broad jump and softball throw tests were used to measure the level of physical fitness on two hundred subjects. It was found that the Negro boys were significantly superior to the white boys on over all physical fitness level.

Ellenburg (1971) carried out a study on basketball players. The purpose of the study was to determine the value of a battery of ten skill tests and the personal
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factors of age, height and weight in predicting game performance and develop a
method for predicting player’s performance in high school basketball competition. It
was found that 30 second shooting test and vertical jump were the most reliable tests
for the performance. The five-item battery consisting of height, handgrip, vertical
jump, wall volley and 30 second shooting test can be practical and useful instrument
in predicting game performance.

Sidhu and Anand (1971) investigated 42 athletes and 46 non-athletes in
whom the athletes were found to be taller and heavier than the non-athletes. The
non-athletes were also seen to possess higher amount of subcutaneous fat than the
athletes.

Eiban (1972) conducted a study on Female athletes from 13 countries. He
found that the runners were shorter and lighter than the jumpers and throwers.
Whereas discus throwers were the tallest and the heaviest among all the categories
of athletes.

Shondell (1972) investigated the relationship of selected motor performance
and anthropometric traits to successful volleyball performance. This study was
conducted to identify the physical and anthropometric traits possessed by successful
volleyball players and to develop a physical performance test battery that would
prove valid, reliable and practical when used to identify the successful collegiate
volleyball players. The conclusion was made that cross validation procedure
employed supported the validity of the six-item battery as a predictor of expected
volleyball performance.

Cureton (1973) found the relationship of body composition and physical
performance. The age of the subjects was 8 to 11 years. The subjects were tested on
three independent body composition measures and thirteen physical performance
items. The body composition measures include body density, total body potassium
and sum of ten skin fold thickness measurements. The physical performance items
included the seven items of the AAHPER youth fitness test vertical jump, mile run
and four dynamometric strength tests. The value of the body composition measures
was inter-correlated with the physical performance items using the Pearson’s
Product Moment correlation coefficient. Body density was positively related to all
types of physical performance except static strength. The higher relationship was obtained between body density and performance on pull-ups, 600-yards run and 50-yards dash. Negative correlation was obtained between skin fold thickness measurements and scores of all motor performance test items except the softball throw. The highest negative correlation was obtained between the skin fold sum and performance on 600-yards run, pull-ups and mile run.

Muthiah and Venkateswarlu (1973) did investigation on the Indian track and field athletes and found that throwers were heavier, taller and older than other athletes. Jumpers and hurdlers were lighter than throwers but were taller and heavier than sprinters. Among runners, the age increased and the height and weight decreased with increase in the distances they ran.

Venkateswarlu (1973) conducted a study on national level players of different games/events and non-athletes. He found that the basketball players were taller than players of other games.

Yoest (1973) conducted a comparative study of cardiovascular fitness and selected anthropometric measurements. He concluded that age, height, lean body mass and body surface did not significantly correlate with cardiovascular fitness. However, body composition representing body fat limited the performance of college men.

De Garry et al. (1974) conducted a study on Olympian athletes and found that:

- there is strong relationship between structure of the athletes and the specific event in which he excels.
- the throwers were taller and heavier.

Andrews (1976) undertook a comparative study of physical fitness of South African and Canadian boys. One-minute speed sit-ups, standing broad jump, shuttle run, flexed arm hang, 50 yards dash and 600 yards run test variables were administered. It was found that the South African boys are significantly superior in physical fitness level than the Canadian boys.
Gladden and Calacino (1978) investigated height, weight, skin folds, vertical jump and maximal anaerobic power of female participants of national tournament in United States. They found that the tournament was significantly correlated with age, height, vertical jump and maximal height on jump. The partial rank correlations showed that height and vertical jump were the major factors correlated with final standing.

Johnson (1978) conducted a study on college level wrestlers. The subjects were classified in two groups as successful and unsuccessful. Subjects were measured for height, weight, arm length and leg length. He found that the unsuccessful wrestlers had longer legs than average and successful wrestlers.

Amusa (1979) selected 46 subjects, who were well conditioned soccer player with at least two years playing experience at the college level. They were tested for running speed, power agility, VO2 max., strength, aerobic capacity and flexibility. In addition, anthropometric measurements consisting of skin fold and body diameters were taken, soccer playing ability served as the criterion and was measured by the rating of three experienced soccer coaches based on selected soccer skills and strategies. Analysis of data was done by zero order correlations and multiple R analysis resulting in the following findings:

- Age (experience) is the best single predictor of playing ability
- Weight, lean body mass and height are considered good predictors of playing ability.

Hirata (1979) conducted study on Olympic level Basketball, volleyball and handball players and athletes. He collected data on age, height and weight. He found that the average basketball player and high jumpers were the tallest of all the categories of the players.

Wharton (1980) investigated the AAHPER youth fitness test as predictor of skill development in field hockey. One hundred seven subjects were examined. A significant relationship was found between the scores of the youth fitness test and field hockey achievement as measures by the Schmithals-French field hockey achievement tests.
Bardanti (1982) took a comparative study of selected anthropometric and physical fitness measurements of Brazilian and American school children. The purposes of this investigation were to determine status of physical fitness of selected Brazilian boys and girls; to provide norms for Brazilian school children from scores achieved on selected physical fitness tests to investigated differences between performances of Brazilian boys and girls; and to determine if differences existed between norms for Brazilian and American boys and girls for selected physical fitness measurements. Height, weight, triceps skin fold, sub scapular skin fold, sit and reach test, modified sit—up test, nine minutes run and 12 minutes run and athletes ability, 50 meter dash and standing long jumping were taken. Results of study can be summarized as following:

- for selected Brazilian school populations aged six to 14 years. Height and weight of both sexes increased at approximately same rate. Girls were significantly taller and heavier than boys during adolescence.

- brazilian girls had higher values than boys for tricep and sub scapular skin fold measurements, and in sit and reach test.

- brazilian boys performed better than Brazilian girls in modified sit up test, nine minutes run test, 12 minutes run test, 50 metre dash test and standing long jump test.

The comparison between norms for Brazilian and American boys and girls showed that American boys and girls, in general, were taller and heavier, and had higher score in sit and reach test, modified sit up test, 50 metre dash test, and standing long jump test. Brazilian children exhibited greater amount of tricep and sub scapular skin folds and had higher scores on the nine minutes run test than American children.

Basunia (1982) found relationship between height agility, flexibility, reaction time vertical jump and sprinting speed of the soccer players. It can be contended that while selecting soccer players, greater consideration should be given to agility and flexibility instead of considering height only.
Chattopadhyay (1982) conducted a study of Physical fitness of the university level soccer and hockey players. Resting pulse rate, 12 minute run/walk and AAAHPER youth fitness test battery was used to measure the physical fitness of the players. It was found that fifty—yard dash has significant difference, favouring the soccer team and pull ups favouring hockey team.

Hebbelink (1982) investigated study on male Olympic athletes and took height, weight, segmental lengths, breadths, girths, and skin folds. The subjects were swimmers, cyclists, and canoeists, rowers, field hockey players, gymnasts and fencers. He found that the rowers were heavier and taller and had greater sitting height, leg length, and shoulder and hip breadth and forearm and thigh girths than most of the sportsmen. The gymnasts were lighter and shorter and had shorter arms and legs, smaller hip breadth, thigh and calf girths than other athletes.

Kansal (1982) tried to develop scientific criteria for the selection of budding athletes based on body measurements. Their height, weight, bi-acromical, humorous, biocondylar, chest and calf circumferences and performance on the 100 metre run, shot put and standing broad jump was examined and found that the above listed measurements show significant degree of relationship with individual performance with tests. They also attempted to prepare selection criteria for choosing budding athletes at young age.

Phipps (1982) investigated a study to determine which of general ability variables, specific skill variables and personality traits variables has the highest relationship with overall volleyball performance in high school girls. Three general ability tests, three specific volleyball skill tests and a personality test were administered and found that:

- there were little relationship between selected tests of general physical ability and personality traits and volleyball performance.
- there was a substantial relationship between selected specific skill tests and volleyball performance.

Puhl et al. (1982) conducted a study to examine the absolute and relative physical and physiological characteristics of elite male and female volleyball
players. The variable measures included percentage of body fat, VO₂ max post exercise blood lactic acid, and measures of vertical jumping ability and peak isokinetic torque for knee flexion and extension, shoulder extension and planter flexion. They found that the men were taller, heavier, had a higher body density and lean body weight and lower body fat. For gross measures of jumping ability, the mean achieved was greater and higher for the jump and reach and greater jump distance above the standing reach.

Adhikari (1983) opined in his research study, the relationship of power, agility and selected speed characteristics to block jump and three stride jump in volleyball. The results showed that:

- power of an individual contributed much to performance of block jump and three stride jump and showed positive relationship with each other.
- agility, which was a required factor in performance in vertical jump, correlated significantly with block jump and three-stride jump.
- speed, reaction time and speed of movement did not contribute much in performance of block jump and three-stride jump.
- power and agility played an equal role in the performance of block jump as well as three-stride jump because there was no significant difference at the block jump and three-stride jump.

Alam (1983) investigated the relationship of reaction time, agility and flexibility with the performance in running broad jump. The product moment correlation method was used to compute correlation between dependent variables and independent variables. Thus the significant correlation was found between reaction time, flexibility, agility and performance of running broad jump. The obtained value of correlation was found statistically significant at .05 level of confidence.

Bale and Davis (1983) studied body build, explosive strength, grip strength and cardio-respiratory fitness of female field hockey players and results were compared with similar investigations of female hockey players. The subjects were divided into four groups according to their respective playing positions and the
above morphological strength and fitness variables were examined in relation to these field positions. The somato and body composition of the forward and half backs were similar but both these groups were lighter, had lower percentage of fats and lean body weight than the back and goalkeepers. The halfbacks were fittest both on the tests of explosive strength and on the test of cardiovascular fitness.

Chakravarty (1983) studied the relationship of leg strength, agility, grip strength, balance and flexibility to performance in gymnastics. It was concluded that:

- arm length, leg strength and left grip strength of gymnasts was not found to be significantly related to gymnastic performance.
- agility of a gymnast was not confirmed as a factor in developing performance in gymnastic.
- spine and shoulder flexibility did not contribute towards gymnastic performance.
- dynamic balance and gymnastic performance showed insignificant relationship.
- right grip strength was the most important variable that contributed to performance in gymnastic.

Gill (1983) found the relationship between grip strength, arm strength, hand, foot and stepping reaction time to playing ability in badminton. It is 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 of 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.

Kanungsukkasem (1983) conducted a study to measure and compare height, weight residual, skin fold thickness, percent of body fat, body circumference, strength, flexibility, reaction time and the resting electrocardiograph of 80 Oklahoma State University male students between 20 to 30 years of age from
middle east, east and south east Asian countries who were selected by stratified random sampling. The results of the study showed that:

- the United States should had a significantly higher mean value of height than the Middle East and also had significantly higher mean values of height and weight than the East and South East Asia.

- the Middle East should has a significantly higher mean value of the sum of six sites of skin fold thickness than the East and South East Asia.

- the Middle East should had a significantly higher mean value of the body circumferences of shoulder, chest, buttock, thigh, forearm and ankle than the East and South East Asia.

- the Middle East had significantly higher means values of the circumferences of shoulder, biceps, wrist and ankle than the United States.

- the East and South East Asia had significantly higher mean value of shoulder circumference than the United States.

- the United States had significantly higher mean values of left and right grip strength than the Middle East and East and South East Asia.

- no significant differences were found in the means of the above fitness variables between the new and old foreign students.

Data derived from a pre-post basic skills arithmetic test, pre-post cardio-respiratory fitness test attendance gathered from 280 students were treated using the Pearson’s Product moment correlation coefficient, independent ‘t’ test, related t’ test and chi-square. It was concluded that:

- there is a correlation between cardio-respiratory fitness and performance in basic arithmetic performance for fifth grade students.
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- there is a significant difference ($P < 0.01$) in improvement of cardio-respiratory fitness and performance in basic arithmetic for students who were in the experimental group versus students who were in the control group.

- there is higher correlation between improvement in cardio-respiratory fitness and improvement in basic arithmetic performance for students in the low and medium range of performance in basic arithmetic than for students in higher ranges of performance.

- there is a negative correlation between days absent and improvement in cardio-respiratory fitness and improvement in basic arithmetic performance for the experimental and control group.

Siridhar (1984) investigated the relationship of selected motor fitness components to playing ability in volleyball. Product moment correlation was computed.

In the conclusion, it was found that:

- power was the most significant motor fitness component underlying performance in the game of volleyball.

- muscular endurance, circulatory respiratory endurance and flexibility also contributed to the volleyball playing ability in a real manner.

- agility showed an insignificant relationship to playing ability in volleyball.

Sodhi and Sidhu (1984) have mentioned in their book that it is evident that physical and body composition has an important role to play in the performance of various physical activities such as: athletics, cycling, weight lifting, wrestling, football, hockey, basketball and volleyball.

Devi (1985) conducted a study to find out the relationship of selected motor fitness to playing ability in volleyball. It was found that:

- arm strength abdominal strength, leg strength and shoulder flexibility were significantly related to playing ability in volleyball.
grip strength did not correlate significantly to playing ability in volleyball.

- Wrist flexibility and ankle flexibility had insignificant relationship to playing ability in volleyball.

- Trunk flexibility showed negative correlation to playing ability in volleyball.

Saadzol (1985) studied whether students at the high school level involved in various athletic activities differ in their physical abilities, in strength, speed agility, endurance and coordination. The subjects were weight lifting, tennis and track athletes.

The data were measured by the following methods: athletic scores were analyzed according to the contribution of athletic activity in five categories: strength (bench press and squat) speed (100 yard dash) agility (Zigzag run) endurance (1000 yard run) and coordination (jump rope). Means and standard deviations were established for all comparisons. The significance of the difference of their means for each group was computed using an uncorrelated form of the five categories of physical components. Based on the finding, it was concluded that weight lifting athletes are basically stronger and faster than tennis players; furthermore, that track athletes has greater endurance than tennis team athletes. Finally, it was concluded that no differences exist among the three groups of athletes with respect to all other physical components of performance.

Scriber (1985) conducted a study to evaluate a college football-conditioning program by investigating selecting components of physical fitness. The assessment was made by measuring changes in body composition, cardiovascular endurance, and muscular strength in college football players during various periods of training and detraining. It was found that there was significant difference between groups for body composition and cardiovascular endurance. Significant changes occurred over time in the entire group for body composition cardiovascular endurance and upper and lower muscular strength.
Virgets (1985) conducted a study to determine the relationship of a 4—week period of weight loss to a number of physiological strength and motor performance variables. Subjects were 19 male college boxers and were studied for 4 weeks. During this time the boxers reduced their weight through a combination of dieting, exercise and dehydration techniques. Eleven physiological, strength and motor performance variables were measured and recorded on each subject at three conditions. (zero weight loss, weight loss at 2 weeks and weight loss at 4 weeks)

The results from this investigation showed that weight losses averaging 4.7% between trials 1 and 2, and 8.2% between trails 1 and 3 had no significant effect on the variable scores. The results indicated that an 8.2% loss of total body weight did not have a significant effect on any of the physiological, strength and motor performance measures that related to boxing performance.

Sharma, Chauhan and Parkash (1987) investigated the body measurement of endurance runners of National games and non-sportsman. Out of 40 subjects 20 were national school endurance runners and other twenty were non-sportsmen. The subjects were measured for twenty-four body measurements. The following conclusions were drawn:

- endurance runners for the national school games were found to be shorter and lighter in body weight with low fat contents than average young’ man, but equal in lean body mass and more in body density;

- the skeletal measurements i.e. height, sitting height, total leg length, trunk length and total arm length were found shorter in endurance runners as compared to the average young man, and the differences were found to be statistically significant;

- the circumferences of the endurance runners i.e. neck, shoulder, abdomen, hip and knee were also found to be smaller than those of control group.

- the bone diameters of hip, femur and ankle of the endurance runners were also shorter than those of the average younger man but the shoulder diameter differences were not significant.
Rawat (1989) studied to determine the physical, physiological and motor skill variables of men volleyball players, which could best contribute in the playing ability of volleyball players. He found that explosive power, agility and ankle flexibility were main contributors to the volleyball playing ability and cardiovascular endurance, lean bodyweight and pulse pressure (physiological variables) were the best contributors to volleyball playing ability.

Uppal and Gill (1989) conducted a study on the relationship of strength to performance in gymnastics. Four strength tests- arm strength, abdominal strength, grip strength and explosive legs strength were administered on 80 male gymnasts. Relationship was established by computing Pearson’s Product Moment correlation. The analysis of data revealed that performance in gymnastics is significantly related to arm strength, abdominal strength right grip strength, left hand grip strength and explosive leg strength. Hence it is possible to predict gymnastic performance on the basis of strength variables. Further the multiple correlation indicated that in order to predict performance in gymnastics instead of depending only upon a single variable, all the variables may be given due consideration.

Ghuman (1990) conducted a study to examine the relationship of selected motor fitness and anthropometric measurements to gymnastic performance at different levels of achievement. The study was conducted on 140 male gymnasts who participated in Senior National, All India inter—university and National School games. Motor fitness components selected were speed, agility, arm power, arm strength endurance, abdominal strength endurance, legs power, flexibility and dynamic balance. Selected anthropometric measurements of height, sitting height, leg length, arm length, weight, shoulder width, chest width, hip width, arm circumference, chest circumference, hip circumference, thigh circumference and calf circumference were taken. On the basis of the study the following conclusions were drawn:

- the motor fitness components of strength, endurance, dynamic balance, power, speed, agility, flexibility of hip region and shoulder flexibility were significantly related to gymnastic performance at all the three levels.
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- at the senior national level, anthropometric measurements of height, weight, hip width, hip circumference, arm length and leg length correlated significantly but negatively except chest circumference, which resulted in significant positive correlation with gymnastic performance.

- at the National School level, weight, arm circumference and shoulders width resulted in significant positive correlation with gymnastic but at Inter-University level none of the anthropometric measurement showed significant correlation with gymnastic performance.

- there were no significant differences between Senior National and Inter-University level gymnasts in all the selected anthropometric measurements.

- the senior National gymnasts differed from the National School gymnasts in all the anthropometric measurements except arm length and leg length.

- the Inter—University level gymnasts also differ from the National School gymnasts in all the anthropometric measurements except arm length.

Diwarka (1991) conducted a study to investigate the relationship of physical, physiological and motor skill variables to volleyball playing ability and to assess the combined contribution of physical, physiological and motor skill variables to volleyball playing ability. Physical variables included speed, arm length, explosive power, dynamic balance, agility, flexibility, age, height and weight are taken. Physiological variables including pulse rate, systolic blood pressure, diastolic blood pressure and cardiovascular endurance were measured. Motor skill variables were volleying, serving, passing and set up. One hundred Female volleyball players who participated in the inter-college level tournaments were taken as subjects.

Chandel (1993) conducted a comparative study on physical fitness, physiological and anthropometric variables between the tribal and the non-tribal.
Two hundred sixty tribal and two hundred twenty non-tribal students are taken as subjects of the study. AAHPER youth fitness test battery consisting of six test items—sit up, pull up, standing broad jump, 50—yard dash, shuttle run, 600-yard run/walk was used to measure physical fitness of the subjects. Selected physiological parameters such as pulse rate, blood pressure, and hemoglobin were measured and some anthropometric measurements were taken. The following conclusions were drawn:

- a significant difference in mean score of anthropometric variables was found in favour of the tribal. They were found heavier in weight, better in height, possessing broader shoulder, wider chest cavity, bigger hip, thigh and calf circumferences.

- the tribal were found superior in all except on physical fitness variable, as significant mean difference was found in their favour in sit up, standing broad jump, shuttle run, 50-yard dash, 600-yard run/walk. Hence it could be safely concluded that the tribal were superior in speed, agility, endurance and counterparts.

- the tribal are superior to non-tribal in physical fitness, cardiovascular endurance and anthropometric measurements.

Pearson’s ProductMoment Correlation (r) was used to analysethe data to assess the relationship of volleyball playing ability to each of the physical, physiological and motor skill variables; multiple stepwise regression was applied for assessing the combined contribution of physical variables to volleyball playing ability; physiological variables to volleyball playing ability and motor skill variables to volleyball playing ability. In order to assess limiting factors for volleyball playing ability, multiple regression equation was worked out. On the basis of analysis the following conclusions have been drawn:

- the physical variables namely speed, arm length, leg explosive power, dynamic power, dynamic balance, agility, wrist flexibility, trunk flexibility and height were found significantly related to the playing ability of the total sample of volleyball players.
• the physical variables such as dynamic balance, flexed arm hang and trunk hyperextension were found best predictors for the playing ability of total sample of volleyball players.

• the motor skill variables namely setup, serving and volleying were found best contributors to the playing ability of total sample of volleyball players.

Toor (1996) conducted a study to investigate physical, physiological and anthropometric determinants of performance in male inter-college level sprinters, jumpers and throwers. The data was collected on 105 sprinters, 100 jumpers and 100 throwers. Ten physical, ten physiological and twenty anthropometric measurements were taken. The Pearson’s Product Moment correlation was used to analyse the data to assess the relationship of performance of sprinters, jumpers and throwers with physical, physiological and anthropometric variables. The multiple step-wise regression was applied to assess the combined contribution of physical, physiological and anthropometric variables with performance. In order to assess the limited factors for top performance, the regression equation was worked out. On the basis of study he found that:

• the sprinters performance was significantly related to physical variables namely sit ups, Sargent jump, standing broad jump, back lift and 50- yard dash, physiological variables namely recycling pulse and sitting pulse rate and anthropometric variables namely age and calf circumference.

• the performance of jumpers was found significantly related to physical variables namely sit ups, sargent jump and standing broad jump and anthropometric variables namely age and bicep skin fold.

• the performance of throwers was found significantly related to chest normal chest expended variable, elbow width, shoulder width, chest width, knee width and hip width, weight variables.

Kishore (2001) constructed a standardize specific physical fitness test for boxers. Two hundred twenty boxers were selected to develop the norms. Twenty one
physical fitness test items were selected to evaluate the strength, speed, endurance, flexibility and agility components of physical fitness. Factor analysis technique was applied. The following conclusions were drawn:

I. The application of factor analysis technique yielding eight specific physical fitness variables of boxers are listed on the basis of factor loading:

- pushups related to arm strength
- medicine Ball Throw (Left Hand) related to explosive arm strength
- medicine Ball Throw (Right Hand) related to explosive arm strength
- 30 metres run related to leg speed
- 6 minutes run/walk related to endurance
- 1500 metres run related to specific endurance
- forward Bend and Reach related to trunk flexibility
- side step related to agility

II. All the eight test items of specific physical fitness tests are highly significant and are related to the specific physical fitness level of university and state level boxers.

III. A significant difference in the means was found between the three boxing weight categories and the boxers of the higher weight categories posses more strength as compared to the boxers of the lower weight categories who posses more speed and endurance.

Mehteny (1939) indicated the differences between Negro and white athletes in respect to their body measurements. The Negroes were found better than whites in weight, arm length, elbow width, leg length, lower leg length, knee width, shoulder breadth, chest depth and width, neck girth while the whites were better than Negroes in sitting height, total fat, hip width and ilium width.

Cureton (1941) has revealed that in general, people with long legs and long arms, and with relatively short and small trunks, were physically weak types in long-sustained heavy work, but they might show more endurance and speed in athletic
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activities. Long third class levers were noted favourable for speed and range of action as well as for their efficiency for force.

Digiovanna (1943) investigated the relation of selected structural and functional measures to success in each of several sports. It was found that factor of body explosive power was associated with athletic success. It also indicated that these factors were of varying importance to performance ability in difference sports.

Kireilis and Cureton (1947) studied the relationship between fat as measured with the calipers at six points if the exterior of the body to

- certain structural physical tests;
- functional organic efficiency tests and;
- motor fitness tests

There was significant negative correlation between performance of strenuous physical exercise and external fat on the body. Fat is a real handicap in most strenuous exercise, cardiovascular and respiratory measurements. They do not seem significantly related to external fat. In strenuous endurance running, the fat on the abdomen and buttocks seems to be more of handicap than fat on the thighs and cheeks.

Book Walter (1952) found the relationship of physique and shape to physical performance. The Indian motor fitness test was administered. The subjects were elementary school boys. He found that:

- the obese body has the poorest physical performance.
- size and shape seems to have an influence on physical performance.
- the large and fat boys were poor in physical performance than the normal and thin boys.

Pere et al. (1954) conducted the study on various body measurements and their relation with performance. The throwers were beneficial with taller height. There were significant correlations between the upper limbs length and performance and shoulder breadth and performance in throwers and long distance runners. While
negative correlation between chest circumference and performance in sprinters and positive in throwers were found.

Albrecht (1959) investigated the relationship between certain physical measurements and swimming success. No relationship was found between physical measurements and swimming success.

Huntinger (1959) conducted a comparative study to find out the difference in speed between American Negro and white children. 35-yard dash test was conducted to measure the speed. It was found from the statistical analysis that the Negro children were superior significantly to the white children.

Tanner and others (1960) studied the anthropometric measurements of the Olympic athletes who participated in 1960 Rome Olympics. They measured height, weight and other body measurements of the athletes of the same events but from different races. They were compared with each race and the white were compared with the Negroes. It was found that Negroes were larger than the whites in some measurements: their arms were longer than those of the white.

Tanner (1964) conducted a study on athletes at the Rome Olympics 1960. In his study he measured and analyzed the body size, length, girth proportion and amount of tissues in limbs and found significant differences among the means of different events.

Conger (1965) studied the physical performance and body shape as related to physical activity of college female. The subjects were divided into more or less active groups. The study concluded that more active group was heavier and had greater lean body mass.

Golding (1969) studied the relationship of cardiovascular step (Harvard Steptest) test with selected anthropometric measurements. The measured body shape, body composition and the Harvard step test scores were found to have a significant negative correlation.

Malhotra et al. (1972) investigated the functional capacity and body composition of throwers, jumpers, sprinters and middle and long distance runners. The trackmen jumpers were found to have a higher lean body mass with less fat
contents than the throwers who were tall and heavier build. Jumpers were stronger in muscle power. However, the throwers had also stronger muscle power and were strong in arm and shoulder muscle strength too.

Brangden (1973) conducted a comparative study of physical fitness and anthropometric measures of Mexican and Anglo-American males. Thirteen anthropometric measurements - were taken and AAPHER youth fitness test battery was used. The results indicated that the Anglo—American males are larger in gross body size and they are more physically fit than Mexican males.

Shondell (1975) conducted a study on the relationship of selected motor performance and anthropometric traits to successful volleyball players. He found that power appeared to be the most significant factor in successful volleyball performance.

Martin (1976) conducted a comparative study of selected anthropometric measurements and physical performance between Mexican-Americans and Anglo-American adolescent boys. Comparisons were made between body size, body structure and physical performance. Standing height and body weight measurements assessed the body size. Body structure was measured 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 found that the Anglo-American subjects were significantly taller than the Mexican-American subjects. It was also found that excluding standing height, the Mexican and Anglo-American subjects did not differ in body size and body structure and also these two races did not differ in physical performance.

Voll (1977) conducted a study on the predicting ability in basic modern dance skill through selected anthropometric and physical fitness measurements. On the basis of the findings, the researchers concluded that the ability in basic modern dance skills could be predicted from selected anthropometric and physical fitness measurements.

Bevans (1978) conducted a comparative study on the somatotype of 35 female gymnasts and 35 middle distance runners. Twelve measurements were taken. The analysis by the ‘t’ test showed that gymnasts were significantly heavier than
distance runners in body weight and the skin fold measurements of sub scapular, supra iliac and calf values as well as percentage of body fat. The gymnasts also had larger humerus and femur diameters.

Boris (1978) studied the relationship of anthropometric measurements with sprinting ability. He found that height, weight, length of limbs have little or no correlation with performance.

Woodword et al. (1978) studied the maximal oxygen consumption, body composition and anthropometrics, on Olympic level male players. He found that tallest rowers and water polo players have significantly large skeletal width and length measurements. The skin fold measurements showed larger fat folds on the trunk and extremities in water polo players and had significantly large skeletal width and length measurements. The total body fat in absolute value was found significantly higher in water polo players.

Kansal and others (1980) conducted a study on the physique of the soccer players. The subjects were Indian university soccer players. He concluded that the defensive players were significantly taller and heavier and the forward line players have slightly less body fat and more of lean body mass.

Sodhi (1980) studied the top ranking Indian National Basketball Players and revealed that with the increasing standard of the participants, the average height was greater. The top class teams in the world had a greater average height than teams of lower standard. A significant correlation was seen between height and performance in competitions. The value of correlation was very high with the field basketball scores. Thus, the greater the height of basketball players, the better their performance.

Sodhi (1980) investigated that athletes and players of different games have specific physique and body composition. He showed that there is some specific mechanical advantage of typical characteristics, in most of the athletes and sportsmen.

Spencer et al. (1980) conducted a study on the anthropometric and performance characteristics. Subjects were 13 and they were members of the
national volleyball team of the United States. Out of 15 players, 6 players were selected for the Pan-American team. Comparisons were made between selected and not selected players. The selected players were taller and heavier and demonstrated better motor ability than the none selected players. Strength measurements did not indicate consistent differences between the two sub groups, whereas the vo2 max was greater in the non selected players.

Yehoshua (1980) investigated the physiological and anthropometric factors underlying endurance performance in boys and girls. This study found the extent to which Vo2 max and three additional independent variables anaerobic threshold (AT) anaerobic capacity (ANC) and percentage of body fat can account for variance in endurance performance.

Results indicated that in 10-14 years old children there is a substantial relationship between measures of anaerobic and aerobic functions, although to some extent each provides independent information about endurance performance. While vo2 max is an important determinant of endurance performance, ANC was found to be as important, rejecting the contention that individual differences in distance running abilities of elementary school children predominantly reject variations in aerobic power. The sub maximal measure of AT (vo2 at AT) is just as effective as vo2 max in accounting form variance in endurance performance.

When girls and boys were compared, no reliable differences were found for run time and ANC. Boys exhibited reliably higher values for vo2 max and AT (vo2 at AT). No reliable difference in the percentage of fat was found for younger boys and girls, but older girls were significantly fatter than older boys.

Chandrashekar (1981) conducted a comparative study of physical fitness components of football and basketball players. He measured speed, flexibility, leg explosive strength, gross body coordination and cardio-respiratory endurance of the player. On the basis of analysis of data the following conclusions were drawn:

- the basketball players were comparatively superior to football players in extent flexibility and dynamic flexibility:
- the football players were superior in leg explosive strength, abdominal strength and gross body coordination.

Gangadharan (1981) conducted a comparative study on the selected anthropometric measurements of players of different games. He measured height, chest girth, upper arm girth, calf girth and weight and concluded that volleyball players significantly differed from the basketball and hockey players.

Murgeson (1981) conducted a study on relationship of some anthropometric and fitness variables with spiking in volleyball. He measured height, agility and vertical jump. He found that vertical jump is the most reliable single factor, which underlies the performance in spiking ability. Height and vertical jump combined variable proved to be the most reliable. For three variables height, agility and vertical jump were found to be valid and reliable for predicting spiking ability of male volleyball players.

Bandopadhyay (1982) investigated the relationship of selected anthropometric measurements, physical fitness and motor ability to soccer skill performance. Height weight, calf girth, thigh girth upper arm girth and chest girth were measured. Subjects were also tested in AAHPER youth fitness test for estimating physical fitness and Barrow’s motor ability test for assessing motor ability and Mc Donald soccer skill test for measuring soccer skill performance. He concluded that:

- there was a high correlation in physical fitness level as obtained from AAHPER youth fitness test with soccer skill performance;

- soccer skill performance was highly correlated with motor ability as obtained from Barrow’s Motor Ability Test of the soccer players;

- among the selected anthropometric measurements only thigh girth had significant relationship with soccer skill performance of the soccer player;

- the upper arm girth, chest girth, calf girth, weight and height had no relationship with McDonald soccer skill performance;
Carter (1982) investigated the body composition of the Olympic athletes. He found that the females had larger skin fold than males at all sites, but more difference was at trunk and limb sites. The lowest skinfold means were in male and female gymnasts and distance running and the highest mean in fencers and hockey players for males and canoeist rowers and swimming females.

Joseph (1983) conducted a study to determine the relationship of power, agility, shoulder flexibility, arm length and leg length to volleyball playing ability. Subjects were 30 male volleyball players. Product moment correlation was used to compute correlation between playing ability and each of the selected independent variables. It was found that:

- power was the most reliable variable in prediction of playing ability of men volleyball players.
- arm length and leg length were also reliable variables in prediction of playing ability of male volleyball players.
- the variables of agility and shoulder flexibility showed insignificant relationship to the prediction of playing ability of male volleyball players.

Spencer (1983) undertook a study on relationship between cardio-respiratory fitness and performance in basic arithmetic skill. The following correlations were worked out:

- correlation between arithmetic performance and fitness performance for boys versus girls.
- correlation between arithmetic performance and fitness performance for students who received additional cardio-respiratory fitness training as part of their regular physical education program.
- correlation between the main scores of students in the high, medium and low range performance in basic arithmetic performance and their gain scores in cardio-respiratory fitness.
• correlation between cardio-respiratory fitness performance in basic arithmetic and attendance.

Eiben (1984) studied the anthropometric character of woman athletes during the European Athlete Championship. The results showed that:

• the sprinters had small stature was mainly due to their short trunk. Their lower extremities, especially their thighs were long as compared to trunk, the lower limb, especially the lower legs were strong with well-developed muscles.
• the hurdlers were also strong and muscular, their stature was nearly identical with the sprinters, however their trunk was somewhat lower and their lower extremities relatively shorter.

Joseph (1984) studied the relationship of selected anthropometric and the strength variables to speed performance. It was found that there was a significant relationship of leg power, abdominal strength, thigh girth and calf girth to speed performance.

Kela (1984) investigated the relationship between speed of movement, agility, shoulder and spine flexibility and performance in gymnastics. The findings of the study showed that while there was no significant correlation between speed of movement, spine and shoulder flexibility to performance in gymnastics, agility had a highly significant relationship with performance in gymnastics.

Mathew (1984) undertook a study to determine relationship of selected anthropometric measurements to performance on Brady volleyball test. Pearson’s product Moment correlation was employed to study the relationship of volleyball playing ability to each of the selected anthropometric measurements. The following conclusions were drawn:

• the height and weight of the players contributed to a much greater extent to the performance of Brady volleyball playing ability.
• arm length was also found to be an advantageous factor in the performance of Brady volleyball test.
• leg length and upper body length contributed to the performance on the said test to a very limited extent.

Murlidharan (1984) conducted a study on the relationship between anthropometric and physical performance variables to performance in long jump. It was concluded that:

• leg length, height, standing broad jump, 50 yard dash, shuttle run, sit and reach and vertical jump were the most significant variables and best predictors in running long jump.

• body weight did not prove to be reliable when single independent variable was correlated with the performance of running long jump.

Ramadan (1984) investigated the anthropometric characteristics of the Kuwaiti world cup soccer team to determine the body composition and somato type. Body composition was estimated by skinfold and somato type by the Health-Carter method.

Analysis by playing position revealed:

• the goalkeepers to have higher percentage of fat and mesomorphy.

• midfielders were the leanest.

• the starters were significantly older and less fat.

Sinha (1984) investigated the relationship of selected motor traits and anthropometric variables to performance in AAHPER basketball skill test. On the basis of the findings of the study, the following conclusions were drawn:

• explosive power, agility and cardiovascular endurance are the key motor traits that underlie performance of skill in basketball.

• height as well as relative leg length measurements are the main anthropometric characteristics which contribute to skill in basketball

• the motor traits of speed, grip strength and flexibility are not the prime factors for performance of skills in basketball.
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- excess body weight has restricting effect on basketball performance.

Smith and Mansfield (1984) conducted a study to determine if previously developed body composition prediction equations were valid for use with university football team. The subjects were football players and their mean age was 19.7 years. They were assessed for body density under water weighting, residual volume by holium dilution and 26 selected anthropometric measures. A predicted body density was obtained by use of two sets of equation developed from the college football players. The differences between predicted and observed body densities were analyzed. It was observed that the seven out of nine models examined failed to accurately predict the body density for the university football players.

Hebbelinck (1985) investigated the comparison among the Olympic athletes in seven sports and found that the swimmers were the youngest; rowers were the heaviest and taller and had greater sitting height, leg length, shoulder and hip breadth, forearm and thigh girth than most other sportsmen. The gymnasts were lighter and shorter and had shorter arms and legs, smaller hip breadth, thigh and calf girths than other athletes. The swimmers, canoeists, hockey players, fencers and cyclists were intermediate in most variables but with few differences among themselves. In field hockey the main differences were in weight, where the Argentineans as well as the whites were heavier than Indians and Pakistanis.

Kishore (1986) studied the relationship of anthropometric measurements to weight lifting performance, 30 weightlifters were selected as subjects. Arm length, leg length, upper arm girth, forearm girth and skin folds were measured. He found that:

- there is significant relationship between thigh girth, trunk girth, upper arm and forearm girth, lean body mass to weight lifting performance.
- there was negative relationship between leg length, thigh length to weight lifting performance.
- there was no significant relationship between arm lengths, fore leg length, calf girth and weight lifting performance.
Kansal et al. (1987) studied the physique and body morphology of volleyball and football players. Anthropometric measurements of 100-control subjects were also studied. The body physique was calculated from skin folds using Health Carter Method. It is found that:

- the footballers were of average height, however the volleyballers were taller than their controlled counterparts.
- the footballers had larger trunks and smaller lower extremities than the volleyballers who did not differ much from the controlled counterparts in this relationship.
- the volleyballers and footballers have linear physique and larger limb girths but less body fat than controls.

Shaw, Naruka and Luthra (1988) studied body measurements of judo players. Subjects were from north, south and west, three geographical regions. It was found that the judokas of different geographical regions were significantly different in height, fore arm length, trunk length, calf girth, chest girth, lean body mass, body fat, leg length, thigh length and fore leg length.

Sharma and Shukia (1990) investigated the anthropometrics and motor fitness variables of 40 players of hockey and football, they took 37 anthropometric measurements and five standardized motor fitness test. It was concluded that:

- the football players had significantly broader shoulders, chest circumference, humerus and femur bicondylar breadth and possess bigger thigh and calf muscles as compare to hockey players.
- in case of physical fitness tests the football players had higher values in sit ups and leg strength.
- hockey players indicated higher mean values in push-ups, back strength and grip strength.

Singh (1990) focused his study on motor fitness of physical education majors as related to psycho-physiological variables and body composition. One hundred
fifty seven male were taken from professional colleges of physical education as subjects. Revised AAHPER youth fitness test was used to measure their motor fitness, which was considered as criterion measures of the study. Their body composition measures comprised body weight, lean body weight and percentage of body fat taken from skin folds. From the results, it has been observed that:

- individual items, such as body weight, lean body weight and percentage of fat did not show any significance correlation with power.
- when body weight and percentage of fat were held constant, power showed a negative and positive significant correlation with body weight and percentage of fat respectively.
- physical education majors possessing lower pulse rate would be more agile.
- the increasing percentage of fat reduces the agility performance.

Greene JJ et al. (1998) conducted a study to determine possible anthropometric and performance sex differences in a population of high school basketball players. Measurements were collected during the first week of basketball practice before the 1995-1996 season. Varsity basketball players from 4 high schools were tested on a battery of measures chosen to detect possible anthropometric and performance sex differences. Fifty-four female and sixty-one male subjects, from varsity basketball teams at high schools enrolled in the athletic training outreach program at the University of Wisconsin Hospital Sports Medicine Center in Madison, WI, volunteered to take part in this study. We took anthropometric measurements on each of the 115 subjects. These included height, weight, body composition, ankle range of motion, and medial longitudinal arch type in weight bearing. Performance measures included the vertical jump, 22.86-m (25-yd) shuttle run, 18.29-m (20-yd) sprint, and single-limb balance time. We compared anthropometric and performance characteristics using a 2-sample t test. The only exception to this was for medial longitudinal arch type, where the 2 groups were compared using a 2-tailed Fisher's exact test. The male subjects were significantly
taller and heavier, while the females had a significantly higher percentage of body fat. There were no significant differences found for ankle plantar flexion and dorsiflexion, but the females had significantly more inversion and eversion range of motion. Analysis of medial longitudinal arch type found females to have a higher percentage of pronated arches and males to have a higher percentage of supinated arches. Performance testing revealed that the males were able to jump significantly higher and run the 22.86-m (25-yard) shuttle run and 18.29-m (20-yard) sprint significantly faster than the female subjects. There was no significant difference between the groups for single-limb balance time. We found significant anthropometric and performance sex differences in a cohort of high school basketball players. Further study of these measures is necessary to determine if these differences can predict the risk for ankle injuries in this particular population.

Justin Keogh et al. (1999) conducted a study to determine if anthropometric and fitness testing scores can be used to discriminate between players that were selected or not selected in an elite Under 18 Australian Rules Football side. A training squad of 40 Australian Rules football players was assessed on a battery of standard anthropometric and fitness tests just prior to the selection of the 30 man player roster for the upcoming season. Results showed that the selected players were significantly (P < 0.05) taller and had greater upper body strength than non-selected players. A discriminant analysis was performed which predicted with an accuracy of 80% whether each player was successful or unsuccessful in gaining selection. This suggested that physical conditioning and anthropometric measurements do play an important part in determining selection in elite junior Australian Rules football teams. However the discriminant function predicted non-selected players (90.9%) better than it predicted selected players (75.9%). Selected under 18 players were found to be similar to the values reported for elite to sub-elite senior players on height, sit and reach, CMJ and perhaps aerobic fitness, but considerably less than the senior players on 3RM bench press and body mass.

WB Young et al. (2005) conducted a study to determine if pre-season anthropometric and physiological measures were significantly different for the players from one Australian Football League (AFL) club selected to play in the first game of the season compared to the players not selected. Another purpose was to
compare fitness test results for defenders, forwards and mid-fielders in the same AFL club. Thirty-four players were tested for isolated quadriceps and hamstrings strength, leg extensor muscle strength and power, upper body strength. Springting speed, vertical jump (VJ), endurance, skinfolds and hamstring flexibility. The starters who were selected to play the first game were a significantly older and more experienced playing group, and were significantly better (p<0.05) in measures of leg power, springting speed and the distance covered in the YoYo intermittent recovery test compared to the non-starters. Although there were trends for the superiority of the starters, the differences in lower and upper body strength, VJ and predicted VO$_2$max were nonsignificant. The forwards generally produced the worst fitness scores of the playing positions with the midfielders having significantly lower skinfolds and the defenders possessing better hamstring strength and VJ compared to the forwards. It was concluded that some fitness qualities can differentiate between starters and non-starters, at least in one AFL club. Comparisons of playing positions and the development of fitness norms for AFL players require further research.

M. Wang et al. (2005) conducted a study to develop a regression equation to predict back extensor maximal voluntary contraction (back strength) for females based on several anthropometric and strength measurements using a multiple regression technique. Back strength is an important parameter in low back pain studies. However, the measurement of back strength is problematic in certain populations such as low back pain patients and pregnant women. Back strength was measured as both moment at L4/L5 and force. Ten anthropometric or strength measurements were chosen to develop the prediction equation. The data used for developing the models were from eighty non-pregnant female subjects, age 18–42 and with no history of back pain in the past year. Backwards stepwise analysis was performed in order to choose the best fit predictors. The predictive ability of each of the models was checked using the cross-validation technique on 20 other subjects. Two prediction models were developed for moment and force, respectively. The models explained 46.9% and 48.2% of the variance in back strength. No multicollinearity problem was found. The validation study showed that the observed back strength was highly correlated with the predicted back strength. Mass, height,
trunk length, grip strength and quadriceps strength are the best predictors of back strength in this study. The models developed in this study can be used for both general female low back pain patients and the pregnancy population.

Pyne DB et al. (2006) conducted a study to evaluate the utility of fitness assessment and trends in drafting of players in the Australian Football League, we analysed height, mass, skinfolds, 20-m sprint, vertical jump, agility run and endurance assessed in the 495 players attending the annual national draft camps between 1999 and 2004. Effects of player position and assessment year were expressed as standardised mean differences (Cohen effect sizes) and interpreted qualitatively. Effect of birth month on chance of being drafted, which may be important in team sports, was also analysed. Compared with midfield players, ruckmen, tall forwards and tall defenders were decisively taller (effect-size range 1.33-1.95, large) and heavier (1.30-1.63, large), but had poorer sprint speed (0.23-0.57, small), aerobic ability (0.66-1.18, moderate) and agility (0.64-1.11, moderate). The only substantial changes in fitness scores over the 5-year period were an increase in height (0.76, moderate) and an increase in 20-m sprint time (0.39, small). A majority (65%) of players attending the camps were born in the first half of a given year, but their chance of being drafted (70%) was similar to that of players born in the second half (64%). We conclude that fitness assessment is useful for differentiating between player positions and identifying some annual trends in recruitment in Australian football, and that players with a second half birth month have been disadvantaged with lower representation at the national draft camp.

S.A. Robertson et al. (2006) conducted a study in which anthropometric survey of 140 UK motorcyclists was undertaken, together with a brief questionnaire survey covering demographic details and motorcycling experience. Additionally an investigation of knee position on a static motorcycle test rig was undertaken. Six body dimensions relevant to the design of the riding package of a motorcycle were considered. It was found that the population of motorcyclists, both male and female, were taller than the general population with mean statures of 1774.0 and 1639.7 mm, respectively. The knee position study indicated that there was wide variation in the forward position of the knee (range 228 mm).
Warren B. Young et al. (2007) conducted a study to determine the relationships between selected anthropometric and fitness measures with indicators of performance in elite junior Australian football players. During the pre-season, 485 players from the elite Victorian under-18 Australian Rules football competition were tested for height, body mass, hand span, arm length, standing reach, vertical jump, 5 and 20 m sprint times, agility, predicted and sit and reach flexibility. Performance indicators included being selected for the first game of the season and the number of possessions, marks, hitouts, and the number of games where votes were awarded in the first eight games of the season. The top and bottom four teams on the ladder were also compared after eight games. Players were divided into groups on the basis of the above indicators and the groups were compared statistically by analysis of variance (ANOVA). There were several significant differences between selected and non-selected players. Players acquiring the most possessions were significantly \((p < 0.05)\) shorter (effect size: \(ES = 0.78\)), with less body mass (\(ES = 0.55\)) and possessed greater acceleration (\(ES = 0.44–0.56\)) and endurance (\(ES = 0.51\)). Body mass was significantly related to the number of marks and height was related to hitouts \((p < 0.05)\). Acceleration was the only fitness quality to discriminate between higher and lower vote winners. The players from the top four teams had a significantly greater standing reach \((p = 0.038, ES = 0.53)\), were heavier \((p = 0.032, ES = 0.55)\) but not superior in any fitness measure. Generally hand span, agility and flexibility were not related to performance indicators. It was concluded that shorter and lighter players who possess high levels of speed and endurance are more likely to acquire possessions and be awarded votes, however these attributes do not guarantee team success. The small relationships between agility and flexibility to performance might be explained by the choice of tests used to assess these qualities.

Stuelcken M et al. (2007) conducted a study to describe the current anthropometric profiles of elite Australian female and male cricket fast bowlers and establish a set of reference values useful for future investigations on player selection, talent identification, and training programme development. The participants were 26 female (mean age 22.5 years, \(s = 4.5\); height 1.71 m, \(s = 0.05\); body mass 66.2 kg, \(s = 7.5\)) and 26 male (mean age 23.9 years, \(s = 3.5\); height 1.88
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m, s = 0.05; body mass 87.9 kg, s = 8.2) fast bowlers. The anthropometric profiles included the measurement of skinfolds, and segment lengths, breadths, and girths. A series of derived variables assessing the distribution of subcutaneous adipose tissue, the bivariate overlap zone, relative body size and proportionality, and somatotype were also calculated. The male bowlers had larger length, breadth, and girth measurements than their female counterparts. There were differences in proportionality between the sexes, with only the male bowlers exhibiting characteristics that could be considered "large" relative to height. The female bowlers had a higher sum of seven skinfolds (P < 0.001), were more endomorphic (F(1,50) = 30.18, P < 0.001), and less mesomorphic (F(1,50 = 10.85, P < 0.01) than the male bowlers. These reference data should be useful to practitioners and researchers interested in cricket. Further research is needed to clarify why only male fast bowlers had variables that were proportionally large relative to height.

Veale JP et al. (2008) conducted a study to compare anthropometric and physical performance data of players who were selected for a Victorian elite junior U18 Australian rules football squad. Prior to the selection of the final training squad, 54 players were assessed using a battery of standard anthropometric and physical performance tests. Multivariate analysis (MANOVA) showed significant (p<0.05) differences between selected and non-selected players when height, mass, 20-m sprint, agility and vertical jump height were considered collectively. Univariate analysis revealed that the vertical jump was the only significant (p<0.05) individual test and a near significant trend (p=0.07) for height differentiating between selected and non-selected players with medium effect sizes for all other tests except endurance. In this elite junior football squad, physical characteristics can be observed that discriminate between players selected and non-selected, and demonstrates the value of physical fitness testing within the talent identification process of junior (16-18 years) players for squad and/or team selection. Based on MANOVA results, the findings from this study suggest team selection appeared to be related to a generally higher performance across the range of tests. Further, age was not a confounding variable as players selected tended to be younger than those non-selected. These findings reflect the general consensus that, in state-based junior competition, there is evidence of promoting overall player development, selecting
those who are generally able to fulfill a range of positions and selecting players on their potential..

Gravina L et al. (2008) conducted a study to identify differences in the anthropometric and physiological characteristics of first team and reserve young soccer players (10-14 years old) at both the beginning and end of the soccer season. Body composition was calculated by measuring weight, height, skinfold, limb circumference, and joint diameter. Vo2max was estimated by Astrand's test. Sprint and jump tests were also performed. In general, first team players (FTPs) were taller and leaner. However, the most relevant difference that we found at the beginning of the season was that FTPs had shorter sprint times than reserves in the 30-m test (both flat and with 10 cones). Moreover, these differences in sprint time were more marked at the end of the season. In addition, jump test performance by the reserves declined from the beginning to the end of the season. These results indicate that sprint time is an important factor associated with selection as an FTP between the ages of 10 and 14 years. The progression of the FTPs during the course of the season is better than that of the reserves and is associated with a different degree of growth and maturity. These findings should be taken into account by trainers and coaches to avoid a bias against late maturing or younger soccer players.

Gabbett T et al. (2009) conducted a study to investigate the physical qualities of junior rugby league players competing at the elite and sub-elite level, and determine if pre-season fitness measures were significantly different for the players selected to play in the first game of the season (i.e. starters) compared to the players not selected (i.e. non-starters). Thirty-six junior sub-elite and 28 junior elite rugby league players participated in this study. All sub-elite players were registered with the same junior recreational rugby league club, while elite players were members of a National Rugby League club junior development program. Subjects underwent measurements of anthropometry (height, body mass, and sum of seven skinfolds), speed (10m, 20m, and 40m sprint), change of direction speed (505 test), estimated lower body power (vertical jump), and estimated maximal aerobic power (multi-stage fitness test) at the beginning of the competitive season. Elite players had better developed speed, change of direction speed, vertical jump, and maximal aerobic power than sub-elite players. Elite starters were taller and heavier than non-starters,
while sub-eliters starters were taller and had greater change of direction speed than non-starters. A high estimated maximal aerobic power was a common discriminator between starters and non-starters for both elite and sub-eliters competitors. These findings demonstrate that some physical qualities can discriminate starters and non-starters in elite and sub-eliters junior rugby league teams.

Franck le Gall et al. (2010) compared anthropometric and fitness performance data from graduate male youth players from an elite soccer academy who on leaving the institution were either successful or not in progressing to higher standards of play. Altogether, 161 players were grouped according to whether they achieved international or professional status or remained amateur. Measures were taken across three age categories (under 14, 15 and 16 years of age). Players were assessed using standard measures of anthropometric and fitness characteristics. The skeletal age of players was also measured to determine maturity status. Multivariate analysis (MANCOVA) identified a significant ($p < 0.001$) effect for playing status. Univariate analysis revealed a significant difference in maturity status in amateurs and professionals versus internationals ($p < 0.05$), in body mass in professionals versus amateurs ($d = 0.56$, $p < 0.05$), in height ($d = 0.85$, $p < 0.01$) and maximal anaerobic power ($d = 0.79$, $p < 0.01$) in both professionals and internationals versus amateurs. There was also a significant difference in counter-movement jump ($d = 0.53$, $p < 0.05$) and 40-m sprint time ($d = 0.50$, $p < 0.05$) in internationals versus amateurs, as well as a significant main effect for age and playing position ($p < 0.001$). Significant differences were reported for maturity status, body mass, height, peak concentric torque, maximal anaerobic power, and sprint and jump performance with results dependant on age category and playing position. These results suggest that anthropometric and fitness assessments of elite youth soccer players can play a part in determining their chances of proceeding to higher achievement levels.

Knechtle B et al. (2010) examined the relationship of anthropometric and training characteristics with race time in 39 male and 24 female open-water ultra-endurance swimmers in a 26.4 km open-water ultra-swim, using bi- and multivariate analyses. For the men, body height, Body Mass Index, length of arm, and swimming speed during training were related to race time in the bivariate analysis. For the women, swimming speed during training was associated with performance in the
bivariate analysis. In the multivariate analysis for the men, Body Mass Index and swimming speed during training were related to race time.

Kevin Till et al. (2011) conducted a study to determine whether differences existed for anthropometric and performance characteristics between regional and national selection in high performance UK junior Rugby League players, and to identify variables that discriminated between these selection levels. Regional representative (n = 1172) selected junior players (aged 13–16 years) undertook an anthropometric and fitness testing battery with players split according to selection level (i.e., national, regional). MANCOVA analyses, with age and maturation controlled, identified national players as having lower sum of 4 skinfolds scores compared to regional players, and also performed significantly better on all physical tests. Stepwise discriminant analysis identified that estimated maximum oxygen uptake, chronological age, body mass, 20 m sprint, height, sum of 4 skinfolds and sitting height discriminated between selection levels, accounting for 28.7% of the variance. This discriminant analysis corresponded to an overall predictive accuracy of 63.3% for all players. These results indicate that performance characteristics differed between selection levels in junior Rugby League players. However, the small magnitude of difference between selection levels suggests that physical qualities only partially explain higher representative selection. The monitoring and evaluation of such variables, alongside game related performance characteristics, provides greater knowledge and understanding about the processes and consequences of selection, training and performance in youth sport.

Y. Polat et al. (2011) conducted a study to examine the anthropometric values and the somatotypes of male children from different branches in physical education lessons and regular movement training. Two hundred and eighteen volunteer subjects at the age of 16, namely, 68 soccer players, 89 persons practising fitness and 70 sedentary have participated in the study. In the research, sitting height, crawl length, body width parameters, body environment and somatotypic parameters of the subjects are measured. In this work, the highest humeral width value is achieved by the soccer group, where it is found to be no different from the fitness group (\( P > 0.05 \)) and to be significantly higher than the sedentary group (\( P < 0.05 \)). When femur width parameter is examined, it is
determined that the soccer group is higher than the other two groups and that the fitness group is significantly higher than the sedentary group. In the study, while the highest endomorph value is obtained from sedentary group, it is found to be significantly higher than the other two groups ($P < 0.05$). While the highest mesomorph value is achieved from soccer group and the lowest value is achieved from sedentary group, it is determined that each of these three groups is significantly different from one another ($P < 0.05$). While the highest ectomorph value is achieved from fitness group ($P < 0.05$), it is found to be significantly higher than the other two groups ($P < 0.05$). Consequently, it can be said that the soccer players have more optimal dimension, environment and somatotypical structure when compared to those practising fitness and the sedentary group ($P < 0.05$).

Davor Šentija et al. (2011) conducted a study to investigate the relationship between anthropometric parameters and the preferred transition speed (PTS) in human locomotion, in both genders. Previous studies exploring body measures as possible determinants of the PTS were biased toward longitudinal body dimensions, while the relationship between the PTS and transverse body dimensions has so far not been examined. Longitudinal and transverse anthropometric parameters were measured in 48 physical education students (21 males, 27 females), and an exercise test was performed for determination of the PTS. The relationship between the PTS and the anthropometric variables was determined using Pearson product-moment correlations and stepwise multiple regression analysis. Weak to moderate correlations between several body size and body shape variables and the PTS were found. In males, significant negative correlations ($p < .05$) between transverse body dimensions scaled to body height (calf girth, shoulder, bicristal and bitrochanteric diameters) and the PTS were found ($r = −.51$ to $−.63$). In females, calf girth and thigh girth scaled to height were significantly negatively correlated with the PTS ($r = −.61$ and $−.42$, respectively; $p < .05$). The results of the study suggest that gait transition speed in humans is related to both transverse and longitudinal body dimensions, and that sexual dimorphism in body size and shape should be taken into consideration for a proper interpretation of the PTS.

Lago-Peñas et al. (2011) conducted a study to establish the anthropometric and physiological profiles of young soccer players according to their playing
position and to determine their relevance for competition success. Three hundred and twenty-one young male soccer players participated in the study. Players, age 15.63 (±1.82) years, range 12-19 years, were classified into the following groups: Goalkeepers (n = 35), Central Defenders (n = 53), External Defenders (n = 54), Central Midfielders (n = 61), External Midfielders (n = 46), and Forwards (n = 72). The anthropometric variables of participants (height, weight, body mass index, 6 skinfolds, 4 diameters, and 3 perimeters) were measured. Also, their somatotype and body composition (weights and percentages of fat, bone, and muscle) were calculated. Participants performed the 20-m progressive run test to estimate their relative \( \text{O}_2\text{max} \), a sprint test (30 m flat), and 3 jump tests (squat jump, countermovement jump, and Abalakov test). External Midfielders were the leanest and shortest. In contrast, Central Defenders and Goalkeepers were found to be the tallest and heaviest players. They also had the largest fat skinfolds. In general, the results show that heavier and taller young soccer players performed better in vertical jumps and 30-m sprint, whereas leaner players performed better in the 20-m progressive run test. Players were classified into 2 groups according to the final ranking of their teams at the end of the season. Players from successful teams performed slightly better than players from unsuccessful teams in the physiological test, but these differences were not statistically significant. Moreover, players from successful teams were found to be leaner and more muscular than their unsuccessful counterparts.

Ingebrigtsen, et al. (2011) conducted a study to investigated aerobic capacities and anthropometric characteristics within a group of 29 elite female soccer players. The purpose was to identify and establish aerobic capacities and anthropometric characteristics for these players and to look for possible positional differences between keepers, defenders, midfielders, and attackers. We did this by measuring standard anthropometrical variables and maximal oxygen \( \text{O}_2\text{max} \) and anaerobic threshold (AT). One-way analysis of variance revealed no significant differences among anthropometric or physiological variables. However, a trend \( (p = 0.062) \) toward positional differences was found within running speed at AT. A subsequent Tukey post hoc test showed differences \( (p = 0.04) \) between keepers and defenders, with the latter running faster (\( \sim 1.7 \text{ km.h} \)) at
AT. The present results suggest that few anthropometric and physiological differences exist between playing positions in elite female soccer players. Furthermore, the current results indicate that present elite players' physiological characteristics are similar to those previously shown, despite the rapid changes of the female soccer game. Based on well-established knowledge that different playing positions within a soccer team ought to have distinct capacities, we recommend regular testing programs to be able to construct and implement tailored training programs for players' physical capacities with respect to the demands of their playing positions.

Watts AS et al. (2011) conducted a study to identify whether relative shape and size characteristics of world-class sprinters have changed over time, and whether any anthropometric parameters characterize the most successful world-class sprinters. The results suggest that body mass index, reflecting greater muscle mass rather than greater adiposity, is an important factor associated with success in both male and female world-class sprinters over time. However, in female athletes the reciprocal ponderal index (RPI) has emerged as a more important indicator of success over several decades, with taller, more linear sprinters achieving greater success, as measured by sprint speed. In male sprinters it is only in the most recent decade that RPI has emerged as an important predictor of success. We speculate that the prominence of the RPI and an ectomophic somatotype being typical of the most successful world-class sprinters might be explained, in part, by the influence of stride length on sprint speed. In conclusion, these results suggest that coaches, selectors, and sports scientists should consider body shape when selecting potential athletes for sprint events, encouraging more linear athletes with a high RPI.

Hurd WJ et al. (2011) conducted a study to evaluate the effects of normalizing muscle strength using a spectrum of anthropometric parameters. Cross-sectional design. Laboratory setting. 50 uninjured high-school-age baseball pitchers. Shoulder-rotation strength was tested at 0° and 90° abduction with a handheld dynamometer. Muscle force was normalized to parameters including subject height, weight, height × weight, body-mass index (BMI), forearm length, and forearm length × height. Statistical analysis included evaluating the coefficient of variation, skewness, and kurtosis of the nonnormalized and normalized muscle force. The
most effective normalization method was determined based on the scaling factor that yielded the lowest variability for the data set and promoted the most normal distribution of the data set. Using body weight to scale muscle force was the most effective anthropometric parameter for normalizing strength values based on the group of statistical measures of variability. BMI, height × weight, and forearm length × weight as scaling factors also yielded less variable values for muscle strength compared with nonnormalized strength, but less consistently than body weight. Height and forearm length were least effective in reducing the variability of the data set relative to nonnormalized muscle force. This study provides objective support for scaling muscle strength to subject body weight. This approach to normalizing muscle strength uses methods readily accessible to clinicians and researchers and may facilitate the identification of differences in strength between individuals with diverse physical characteristics.

Platanou T et al. (2011) conducted a study to examine the relationship between the anthropometric, the physiological, as well as performance related characteristics of elite female water polo players and the two important technical game parameters such as throwing velocity and on water jump. Thirty-three female professional water polo players (age: 21.7±5.4 years, height: 171.5±5.8 cm, body mass: 65.5±8.0 Kg) members of the top four teams of the Greek A1 women league were assessed for anthropometric and body composition characteristics, for physiological and performance related characteristics as well as technical characteristics. All tests were completed a month prior to an extremely important sport event. The percentage of body fat was 23.6±7.0 % and lean body mass was 50.0±5.6 kg. VO\(_2\) peak was 47.5±5.8 ml·kg\(^{-1}\)·min\(^{-1}\), La peak 7.50±1.50 mmol·l\(^{-1}\) and the swimming speed at 25-m sprint test as an indicator of the anaerobic power was 1.76±0.1 m·s\(^{-1}\). The throwing velocity was 15.54±0.71 m s\(^{-1}\) and vertical jump on water 61.65±3.68 cm. External-internal rotator muscles torque showed about a 1:1 ratio. Body lengths, swimming speed, internal-external torque of shoulder muscles as well as VO\(_2\) were significantly correlated with ball throwing velocity (r=0.36 to r=0.70, P<0.05). Body composition and swimming speed were associated with the on-water jump (r=0.34 to r=0.72, P<0.05). Knowledge of the physiological and anthropometric features that correlate
with the two mainly used techniques in water-polo (throwing velocity and on water jump) can be used by coaches to implement effective training programs.

Till K et al. (2011) conducted a study to determine whether differences existed for anthropometric and performance characteristics between regional and national selection in high performance UK junior Rugby League players, and secondly to identify variables that discriminated between these selection levels. Regional representative (n=1172) selected junior players (aged 13-16 years) undertook an anthropometric and fitness testing battery with players split according to selection level (i.e., national, regional). MANCOVA analyses, with age and maturation controlled, identified national players as having lower sum of 4 skinfolds scores compared to regional players, and also performed significantly better on all physical tests. Stepwise discriminant analysis identified that estimated maximum oxygen uptake (VO2max), chronological age, body mass, 20 m sprint; height, sum of 4 skinfolds and sitting height discriminated between selection levels, accounting for 28.7% of the variance. This discriminant analysis corresponded to an overall predictive accuracy of 63.3% for all players. These results indicate that performance characteristics differed between selection levels in junior Rugby League players. However, the small magnitude of difference between selection levels suggests that physical qualities only partially explain higher representative selection. The monitoring and evaluation of such variables, alongside game related performance characteristics, provides greater knowledge and understanding about the processes and consequences of selection, training and performance in youth sport.

Karalejic M et al. (2011) conducted a study to describe the anthropometric characteristics and technical skills in children aged 12 and 14 taking part in competitive basketball; to compare the mean scores between these two groups; and to detect the relationship between anthropometric characteristics and basketball skills. At the sample of total of 118 young basketball players, 54 of 14 (± 0.5) year old and 64 of 12 (± 0.5) year old, 18 anthropometric variables were measured: five longitudinal measures, two transversal measures, body mass, four circumferences, six skinfolds and 3 derived variables: Body Mass Index (BMI), sitting height/stature ratio (SH/ST ratio) and sum of skinfolds (SUM SKF). Also, they did four basketball field tests: speed spot shooting, passing, control dribble and defensive movement.
Values of most of anthropometric variables were significantly higher in 14 year old players as compared to 12 year old, except in SH/ST ratio and BMI which were similar. Only values of SUM SKF were significantly lower in 14 year old players. In variables: control dribble, passing and defensive movement 14 year old players have better scores than 12 year old players. The players presented very high values of anthropometric dimensions, especially longitudinal and very good technical skills. The correlation between certain field tests and some anthropometric parameters indicates that some anthropometric measures might have moderately negative influence on test results in technical skills in 14 year old players.