CHAPTER-I

INTRODUCTION

“Sports records are borne not in stadia but in scientific laboratories”

……Valentine Petrovsky

“Science has revolutionized the life of the modern man. The amenities we see these days in modern life are the result of scientific innovations and inventions. No doubt, this super-civilization with its industry, automation and motorization has made man’s life enjoyable, comfortable, easier and luxurious but it has also created many complicated problems for the human life.” The life has become more competitive and faster with many social, mental, economical and emotional problems. “It has made man’s life less vigorous and comparatively inactive and sedentary because due to mechanization and lack of manual work, he does not use his limbs/organs as frequently and adequately as before.”

Today, people in civilized communities are lacking in strength and endurance because of artificial life encouraged by modern civilization, in which life is made as soft and easy as for as possible with physical effort diminished to a minimum. The average man spends more time in attending his automobiles than attending his own machine his body (Featherstone, 1965).

The need of implementation sports programmes has become all the more important in these rapidly changing conditions of life. It helps to attain and maintain health and physical fitness of the individual. It also sublimates the mental, social and emotional tensions and develops healthy and integrated personality. Keeping in view the importance of sports, there is a growing awareness among the developed countries that instead of spending money on treatment and establishment of hospitals, it is much cheaper and better to spend money on physical education and sports programmes. The old saying ‘Preventions is better than cure’ is absolutely true and surely we can overcome
the problems created with the advancement of science in this modern age with participation in games and sports activities.

The modern world appears to be much more concerned with the world of sports. The hold of sports has grown very strong on the mind of individual in the society at large. Sportsmen and spectators are very clear about the values and significance of sports. There is hardly any individual who has been left out of its impact in the countries of the present world. Now winning the competition involves national prestige as each nation strives to win a tournament in which they compete. There are certain nations/states, which try to project the superiority of their political ideology and socio-political system through spectacular achievements in the field of sports. They show their excellence by winning the maximum number of medals at the international competitions like Olympic Games, world cup and world championship etc. The participating competitors in sports, at the international level bring name, fame and laurels for their countries and raise their prestige high in the world.

Physical Education and sports have now become an integral part of the educational process as it prepares an individual for real life (Charles, 1983). It has received worldwide recognition when in 1978 UNESCO charter clearly gave great importance and held that it should be treated as one of the Fundamental Human Right by the national governments (Sharma, 1981). Increased participation in sports has resulted in competition which has become an important element of modern life. Competition provides the means by which one can show one’s worth by competing successfully. For top level performance, it is very important to spot, select and nurture a budding sportsman as it is recognized by all that athletes must possess some inherent qualities, which can be developed by means of systematized and scientific training (Frost, 1971)

Sports originated from the simple play form have gone through a process of transformation via the organized structure of game. Sports can be said to be
complex outgrowth of play. Play is a natural, spontaneous, pleasure giving and creative activity in which man finds self-expression. The natural play form gradually developed into organized game form to make it more purposive, systematic and more objective. As game become more complex, more organized, more competition-oriented, the structure become more rigid and institutionalized and transfer into sport. Coaklay defines “Sports is an institutionalized competitive activity that involves vigorous physical exertion or the use of relatively complex physical skill by individuals whose participation is motivated by a combination of intrinsic and extrinsic factors” (Bhattacharya, 1981).

Sports as it is defined, require that participants use relatively complex physical skills and physical prowess or vigorous physical exertion. From the sociological point of view, sport involves competitive physical activity that is institutionalized. Institutionalized pattern or set of behaviours sustained over a period of time from one situation to another. thus, competitive physical activity can be considered sport when it becomes institutionalized. Institutionalization occurs when there is standardization and enforcement of the rules governing the activity, emphasis on organization and the technical aspects of the activity and a formalized approach to skill development (Wuest and Bucher, 1992).

Every individual or team which participated in any sports/game want to win, as our society attaches great significance to “winning”. According to Renewes (1972), “Performance is key note of all sports its basic principles. Since the sports have become prestigious aspect to prove one’s superiority, the philosophy of participating in games and sports has undergone a great change”.

Sports performance is a multidimensional product of athlete’s capacities and their interaction with athletic environment. Being multidimensional suggests that a variety of factors are involved in actually attaining performance goals.
The term sport, in itself, encompasses the qualities of competitiveness, excitement and development of identification by sports persons with their teams at different levels. Society, at large, is becoming highly concerned for the performance of athletes at national and international levels, thereby transforming sports competition into a highly exciting enterprise. The prestige of a region and nation is frequently at stake. The athletes are under pressure to perform their best and to create records. As the timings in time oriented sports are reducing and the distance to be achieved in throw oriented sports are increasing, the scenario at international and national level parts is gradually changing.

Sometime player takes part in sport without proper guidance. It is thus sheer chance that his choice of the sport may be suitable to his inherent capabilities. If it does not suit to him because of the lack of some of the basis pre-requisites for that sport, it may be difficult for him to switch over to any other event at a belated stage. Therefore, it is most essential to provide guidance endowed with such suitable characteristics that form the basis of performance in a sport. It may prove helpful to raise the standard of the sports. Consequently, it appears more important to study those factors in order to identify the area effecting to the particular sport.

In order to give the best possible performance at any of the competitions the assistance of scientific disciplines is sought. Induction of the basic principles of science, physical education and sports has become a subject of scientific research. Now various special branches of science such as kinanthropometric, biomechanics, physiology of exercises, psychology of sports, sociology of sports etc. have been established which are connected with better performance in sports. New techniques have been evolved, based on insight and understanding of the sports researchers. Astounding performance in sports activities after revival of the modern Olympics have witnessed the result of this scientific approach adopted by the physical education and sports. Smt. Indira Gandhi had rightly said that science applied to sports has enabled
modern youth to develop physical capacities beyond anything earlier imagined. Sports have become competitive and records are being broken at an increasing rate (Gandhi, 1982).

The origin of scientific approach in physical education and sports could be traced back when Edward Hitchcock (1971) who first applied a science of anthropometry to physical education. He, thus, laid the foundation for scientific approach of investigation by physical educators of that early era and by so doing, he contributed substantially to the establishment of physical education as a science. Fitz (1980) advocated that physical education would fail to receive due recognition if it was not provided with its scientific base. His innovation is pointed towards the application of new knowledge of physical education with scientific foundation to achieve excellence in sports activities.

Harrl Dhetrich (1982) explained that at each Olympic Games and international competitions the standard of performance is raised and new records are set for human skill and endurance. Partially it is due to the improvement in sports facilities and equipment but mainly due to the development of modern training methods and adaptations of sports training on more scientific lines. Sports training has become more efficient and effective as a result of the applied and fundamental research in the area of mechanics, physiology, psychology, nutrition and sports medicine. It also aims at understanding and assessing the athlete in totality. Competition at all levels are so keen that no coach or player can afford to neglect the application of scientific training principles that can give him as advantage over or at least keen him in pace with his/her opponent.

The Indian performance in comparative to other countries in all the games and sports is deteriorated and unsatisfactory. It is a matter of great dismal and pathetic to India, the second largest country in terms of population, ranking third in scientific man power, is making tremendous progress in industrial and scientific development, however it would not make much progress in the field
of sports. Many smaller nations, much lower in the rank of developing countries like Korea, Israel, Romania, Ethiopia, Somalia, Kenya etc. Are ways ahead of India in some sports or the others. Even our country sometimes fails to qualify for prestigious important international competition. It shows that something is wrong somewhere in the management, selection or training of athletes. It put our sports scientists and trainers in a great challenge and has compelled to think how we can improve our existing standard of sports for better performance in international competitions.

Even though Indian Government has been framing national sports policies time to time to map out the short comings and show some sign of progress in this field. But the pace of improvement is very slow as compared to the pace improvement of other countries of the world. The other countries including a few small countries made giant astride by improving the performance in games and sports. It is because of their adaption of scientific principles in the field of games and sports. Our country also should give more emphasis on training programme or scientific principles. To implement the principles on a training programme, it is most urgent to find out existing situation and explore the short comings which are responsible for the poor performance in the field of games and sports.

BACKGROUND OF KHO-KHO

Kho-Kho, the game of running and chasing is an indigenous game. The popularization and development of this game has been associated with the development of Akharas and Vyamshalas in Maharashtra. Kho-Kho has played historical role during freedom form British rule. YMCA and RSS movement has played a key role to spread the game throughout India.

There were no set rules framed earlier to conduct the game but as the time passed the rules were changed time to time with advancement of game. The first code of rule was drawn up by a team of kho-kho experts appointed by the Deccan Gymkhana, Pune in 1914. The rules were remodeled by the Hind
Vijay Gymkhana, Baroda in 1924 which were again streamlined by Akhil Maharashtra Sharirik Shikshana Mandal (AMSSM) in 1928. The first book of rules was published in 1935, by the AMSSM and second edition in 1949 (Ramraj, 1993).

The kho-kho Federation of India was formed in 1960 and it organized the first kho-kho National for men at Vijayawada (A.P.) in the same year. The Championship for women was conducted at Kolhapur (Maharashtra) in 1961. The first National Junior kho-kho Championship for boys was organized in 1971 at Hyderabad and for girls in 1975 at Madhya Pradesh. The first Sub-Junior Boys/Girls Championship was held at Indore (M.P.) in 1980 (Verma, 2011).

At present various competitions are being conducted from cluster level to National Level as Sub Junior (boys and girls), Primary School Championship (boys and girls), High School Championship (boys and girls), Senior (men and women), Nehru Cup, University/Inter-varsity (men and women) and federation cup. Special awards as Eklavya, Rani Laxmibai, Veer Abhimanyu (under 18 boys), Janaki (under 16 girls) Bharat Puraskar (Sub-Junior boys), Veer Bala Puraskkar (Sub Junior girls) and Arjuna Awards are being given to kho-kho players who show excellency of their skills during the prestigious matches. The Dronacharya Award is also conferred to the coach whose team brings outstanding achievement in the prestigious competitions in the field of kho-kho (Mishra, 2007, 2011).

The efforts to include the game in Olympic Games has been continued since 1936 Berlin Olympic Games in which a request for exhibition match was made before the organizers but it could not be accepted. The exhibition matches were played in Sweden and Denmark in 1949. But due to no set rules and poor techniques, it could not make impression to the foreigners.

The exhibition matches were also played in 1982, Asian Games held at New Delhi and in SAF Games at Calcutta in 1987. The Asian kho-kho
Federation was also formed during the third SAF games, held at Calcutta competition. As a result of this, the game was included in the Asian Games Competition. The credit of this endeavour goes to All India kho-kho Federation and its affiliated State Federations. The two Asian kho-kho Championships were conducted in 1996 and 2000. Netaji Subhash International Gold Cup was also organized in 1999 (Mishra, 2007, 2011).

Now the game has become most popular in India as well as in other countries. Its popularity can be judged that now the game is looking forward for a glorious entry into INTERNATIONAL SPORTS ARENA. Its popularity can be judged in terms of international kho Kho Participation. Its popularity is known with the fact that it requires a minimum space and equipments. It can be played on any surface that suits open field sports. It is inexpensive and therefore poor players can also take part in this game. Besides this, as the game is played with different type of fast body movements which required speed, agility, strength, explosive power, muscle co-ordination, lung power and above all intelligence and quickness of thought and action during the game situation. In turn, it will endow them with many sterling benefits like development of physical, mental, moral, social characteristics which make them good citizens of the country.

EVALUATION OF PLAYING ABILITIES

In team game like kho-kho, true assessment of playing ability is done through evaluation of game performance. Objective evaluation of game performance is not found possible. It is also observed that all the abilities of the players could not be assessed through game performance evaluation. Generally the game performance is evaluated by three expert coaches through observation, which is subjective in nature. The performance during kho-kho Competition is being assessed to a certain extent, objectively, through statistical information. It is revealed that the tests which can predict the actual match performance of the player are composed of techniques of the body
movements that are requires to be performed during game. Research findings have revealed that kho-kho playing ability can be indirectly evaluated through the performance in running and chasing movements as the playing ability assessed through expert ratings was found related with performance in during game running and chasing movements.

**KINANTTHROPOMETRY AND PERFORMANCE**

The term was first used by Ross et al (1980) in the year 1972. It means the application of measurement to the study of human size, shape, proportion, compositions, maturation and gross function. The purpose is always to understand human movement in the field of growth, exercise performance and nutrition. The word Kinanthropometry is derived etymologically from Greek Words - Kineein meaning “to move” and Anthrepos meaning “man” and matrecin meaning “to measure.”

Kinanthropometry provides a convenient framework for the study of human body. It studies quantitative, interaction between human structure and human function. It is defined by international society for the advancement of Kinanthropometry (I.S.A.K.) as “a scientific specialization dealing with the measurement of man in variety of morphological perspectives its application to movement and those factors which influence movement including composition, shape and maturation, motor abilities and cardio-respiratory capacities, physical activities including recreational activity as well as highly specialized sports performance.”

Kinanthropometry is the study of human size, shape, proportion and composition maturation and gross function in order to help understand growth exercises, performance and nutrition Kinanthropometry is a vehicle for individual to contribute to basic research and application in medicine, education and government and also as a science has so far driven maximum potential of development for the science of sports and physical education. For
the high performance athletes, as Ross explains, the gross function is
represented in kind by the sport event and level by the selection as well as
relative success in the competition (Ross et al 1980).

Kinanthropometry equips us with the techniques of various body
measurements and idea about the player’s shape, size and proportions. How
does an individual look like from various directions and with respect to his
various body parts. It is essential to examine the athlete from every possible
aspect. This is in order to win in any sport or event in the Olympic as well as
other international competition. To achieve success in this, objectives have to
examine the best Olympic athlete as all perhaps the best in the world and
Olympic Games. Estimation of the kinanthropometric measures of these
athletes provides a valuable reference point in human structure and function.

Kinanthropometric investigations have been conducted on the Olympic
athletes during the recent Olympic Games. The different Kinanthropometric
c Characteristics examined include investigation of their size and shape, using
large number of variables by sport and event (Carter, 1982. 1984).

Kinanthropometric experts have analyzed various anthropometric
measurements over 1000 children in 75 cities of the United States. This was
done in order to discover possible ways of considering individual concluded
that the items that passes the greatest significance in ascertaining the amount
and quality of soft tissue relative to skeletal build in children age 7 to 12 years
and are namely hip width, chest depth, height, weight, arm girth and
subcutaneous tissue of the upper arm (Franzen and Palmer, 1934).

Identical to the mechanistic approach of human motion, anthropometry
has a rich tradition in sports sciences and sports medicine. For instance, the
physique of Olympic athletes was studied by Kinanthropometric since a long
back. Though, in different times, different terms were used like dynamic
anthropometry, sports anthropometry, biometry, physiological anthropometry,
anthropometric etc. by scientists. They tried to establish some relationships between the body structure and the specialized functions required for various tasks. They have also tried to understand the limitations of such relationships.

Kinanthropometry provides quantitative interface between human structure and function. That’s why the application of Kinanthropometric knowledge is getting tremendous importance and popularity to identify the potential talents in sports for particular event. India is a country of population with enormous sports for particular variations. There is an ample scope for Kinanthropometric study in India. Nowadays, Kinanthropometry is widely used for sports talent identification.

It is a scientific discipline that is concerned with the measurement of individuals in a variety of morphological perspectives, its application to movement and those factors which influence movement, including; components of body build, body measurements, proportions, composition, shape and maturation; motor abilities and cardio respiratory capacities; physical activity including recreational activity as well as highly specialized sports performance.

Kinanthropometry is the interface between anatomy and movement. It is the application of a series of measurements made on the body and from these we can use the data that we gather directly or perform calculations using the produce various indices and body composition predictions and to measure and describe physique.

Today, physical educators and trainers are more interested in Kinanthropometry as it pertains to the selection of some problems in the field for example, has deviation in height seriously influence performance in tests in separate areas? Should body build be reviewed to clarify standard for physical fitness tests and further programmes of physical education?
The human body size and form various in a variety of ways and depends upon age, sex, race and geography. One of the main concerns of the physical anthropology and human biology is to acquire and convey the knowledge on the true ways and reasons of individual variability and differentiation. This also applied to the whole of biology contribution taken in morphological, physiological and psychological aspects as reported by Tanner (1947). Research is aimed at obtaining knowledge of the variables, real qualities of body measurements and through their analysis or the effects on the genetic and environmental factors acting on the human body.

The world of games and sports has crossed many milestones, as results of different achievements in general and their application in the field of sports in particular. Scientific investigation in to performance of sportsman has been playing an increasingly important role in the training of athletes in the scientific way to attain excellence in performance in different spheres of sports (J.T Powell 1983).

Kinanthropometry is an oldest type of body measurements used, dating back to the beginning of recorded history. The concepts of the ideal proportion varied over period of time. For example, Polyclitus fashioned doryphorus the spear thrower as a fighter and an athlete broad shouldered thick set and square chest as the perfect man (Clarke and Clarke, 1987).

Evidence of this is a common place; observe that well proportionate physique of boxers and gymnasts, the super structure of great basketball players, the wryness of champion distance runners and the massive build of great shot-putter and discus throwers. The hurdlers have been found to have long legs and short trunk (Cureton1951, Tanner, 1964)

Mohan Singh (1978) has reviewed the literature on human physique and performance. He has emphasized that an individual differs significantly in his basic traits and his participation in physical activities will not appreciably
change his maturity, body size and physique type, these individual difference will drastically influence physical performance. Thus these traits should be considered in judging individual potential for participating in physical activities of different types.

**BODY COMPOSITION AND PERFORMANCE**

With the advent of new physical fitness test (AAHPER) the physical education teachers/coaches are more interested to find out the body composition of the athlete because it effects the performance very much and also change as the physical activity change. So, it is important to know the norms suitable for body composition on the basis of which the suitable training schedule may be constructed to improve the performance in sports and may also help to choose the event or activity according to an individual body composition.

Body composition refers mainly to the evaluation of three principle tissue component of body i.e. muscle, bone and fat. The section deals with the methods of evaluating the different components. Hydrometer, densitometry, roentgenogrammery and somatometry on anthropometry are the main methods of study in this section.

The body composition studies have been conducted very extensively on the athletes. The examination of fat and skinfold at selected sites is most important in them. It has been found that the athletes who were lean or less fatty but heavy because of a well-developed musculature were superior in performance in certain competitive sports. On the other hand the athletes who had substantial amount of adipose tissue have permanently increased energy demands owing to the inert weight of fat, this making the work more difficult to perform in such activities where the body has to be projected as in jumping movements or propelled against gravity over long distance as in distance running contrarily the long distance swimming, water polo and synchronized
swimming are sports where in moderate levels of fat may actually aid performance by providing additional buoyancy (Cater & Yuhasz, 1984) and insulation provided by the fact to be a reduced heat less.

Studies of 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 such as football, weight lifting and the shot put (Bullen, 1971). On the other hand athletes who have substantial amount of adipose tissue have creased energy demands owing to the inert weight of fat, thus rendering the work more difficult to perform in endurance activities, whereas the body has to move longer with greater weight, Sills 1953.

So, the physical structure worked out can be used as a tool of talent hunt for a particular game or sports. Training of same sports has to begin at an early age so as to have any hope of reaching to the top. Training every individual as to be a “Future champion” may be futile exercise. While selecting player for any event, physical structure of top most achievers or the profiles of high level performers of that event could be considered as a model. In the light of such a situation future champions can be selected and trained.

Now a day’s international sports competitions and their result have gained attraction in India too, although success has eluded us in the international competitions. Thus the carrying out of scientific studies on sports persons have become more important, especially in the events which have not yet been studied.

PHYSICAL FITNESS AND PERFORMANCE

Physical fitness has very serious implications for the health and wellbeing of all individuals. It is defined as the degree of task under specific ambit conditions, most authors define physical fitness as a capacity of carrying
out every day activities work and play without excessive fatigue and with
enough energy in reserve for emergencies.

Clarke (1978) has thus exhorted that physical fitness is a vital
biological need, the neglect of which handicaps the total effectiveness of the
individual.

The same degree of physical fitness is not essential for everyone. However, everyone needs a minimal amount of fitness to be healthy and
everyone is capable of achieving minimal fitness levels, all professional such as
doctors, engineers, executives and others need physical fitness. However, the
degree of fitness required would vary, depending upon the profession of the
person concerned. The level of fitness necessary depends of factors such as the
tasks you must perform and your potential for physical effort Physical Fitness
varies with the individual and with the demands and requirements of specific
task. The athlete must constantly work to improve his or her strength,
endurance flexibility, speed and cardio respiratory efficiency, whereas the non-
athlete requires less effort to maintain his or her level of physical fitness. The
physical fitness various according to the circumstances of a person at different
time in his or her life. There are varying degrees of physical fitness. Practically
anyone can improve his or her fitness status and physical activity is essential to
achieving physical fitness. There are no shortcuts physical fitness cannot be
stored up, it summer and then gives up all physical activity when autumn starts
will not remain physically fit.

People, who are physically fit look better, feel better and possess the
good health for a happy and full life physical fitness is one’s richest possession
it cannot be purchased, it has to be earned through daily routine of physical
exercise.

Physical fitness is not entirely dependent on exercise desirable health
practice also play an important role. Physical fitness affects the total person
their intellect, emotional stability, physical conditioning and stress levels. The load to physical fitness includes proper medical care, the right kinds of food in right amounts, good oral hygiene, appropriate physical activity that is adapted to individual needs and proper amounts of rest and relaxation.

Physical fitness is not to be confused with health. Both are connected but not interdependent it is necessary to be fit, but not necessary to be fit to be healthy. Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. W.H.O. (1976) declares physical fitness as an important facet of health. Research evidence suggests that when one is physically fit one is able to lead a more enjoyable life because of mental, emotional and social development as well as physical development (Taxton 1988).

Physical fitness is an important and inseparable part of sports performance and achievement. The quality of the individuals sportsman’s fitness, as a layman thinks, is directly proportional to the level of performance. Meaning thereby, that the greater the ability of a sportsman to attain higher level of performance.

**PHYSICAL FITNESS DEFINED**

Actually, different definitions have been offered by the educationists, but physical fitness defined by the American Association for Health, Physical Education and Recreation is “That state which characterizes the degree to which the person is able to function. Fitness is an individual matter. It implies the ability of each person to live most effectively with his potentiality of function and depends upon the physical, mental, emotional, social and spiritual components of fitness which are related to each other and are mutually inter dependent”.

Bud Gatchell (1964), defines Physical Fitness as the “capacity of the heart, blood vessels, lungs and muscles to functions at optimal efficiency”.

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Karpovitch (1965), offered the following definition of Physical Fitness strictly speaking, Physical Fitness means that a person possessing it, meets certain physical requirements. These requirements may be anatomical, physiological or both.

Bucher (1967), defined Fitness as “the degree to which a person functions physically, mentally, emotionally and socially, all aspects of which impinge upon each other and are closely inter-woven into the fabric of the human being.

Physical fitness is an important component of total fitness. The term “Physical Fitness” means more than muscular strength and stamina. It implies efficient performance in exercise or work and a reasonable measure of skill in the performance of selected physical activities.

Thomas (1964), remarked that “physical fitness is the condition of one’s body judged in terms of age, height, weight, and chest expansion, in term of absence of defects from disease, constitutional affection or bodily infirmity pull physical development vigour, vitality and radiant health should be seen in one who is physically fit.”

Clarke (1987), “Physical Fitness is most appropriate considered as the ability to carry out daily tasks with vigour and alertness without undue fatigue with ample energy to engage leisure in pursuits and to meet emergencies situations”. The physical fitness is the ability to last to bear up to with stress and to preserve under difficult circumstances whereas unfit person would be ineffective and would quit. The definition implies that physical fitness is more than “not being sick” or merely “being well, it is a positive quality” extending on a continuum from death to abundant life. Thus living individual have some degree of physical fitness which is minimal in the severally ill and maximal in the highly trained athlete. It varies considerably in different people and in the same person from time to time.
John T. Powell (1972), says, “Fitness is not an end, it is beginning: A person must get fit to perform and will not necessarily get bit by performing. Fitness is not matter of physical capacity alone. Man is a unit training can make a person physical fit. But one should be interested in total fitness (including the realms of mental, moral, social, emotional as well as physical fitness) when coming someone reach his potential”.

Barrett (1974), reported, “Evidence is mounting that physically fit person lead longer lives, have better performance records, and participate more fully in life than those who are unfit.

According to Harre (1979) for a high level of performance physical fitness is most important. Therefore, physical fitness is considered to be fundamental criterion for developing an efficient system of selection strategy.

Physical fitness is the most important determinant of excellent performance in sports. However, importance of various components of fitness varies with different sports for better performance. Physical fitness is possible through the study of motor fitness. The motor fitness can be understood by analysis of its components like speed, strength, endurance flexibility, agility, coordination ability and balance. Although physical fitness is conditioned by heredity, physical organic and behavioral components. It is also affected by factors such as social class, socio-geographic (rural-urban) environment cultural values norms and symbols (Renson et al 1980)

The kinanthropometric and fitness variables are very important for kho-kho players because the nature of the game demands more leg explosive power, fast speed and reaction ability in chasers for putting out the maximum runners in a minimum time. The runners also require all these characteristics maximum speed, agility and endurance to defend them-selves from the chasers powerful attack.
It is found from perusal of various studies, research work and periodicals on physical education and sports that topic under research has not received particular attention at the hands of the scholar in India and thus remains explored. Because discovery of talent for particular sport at an early age and molding the player in a manner appropriate to his talent through carefully and systematically planned training programme is an important factor in producing top class performance. This can only be possible if factors contributing to particular sport are identified. Hence, the scholar has undertaken the present study to predict the playing ability of male kho-kho players of inter college level through kinanthropometric and fitness variables.

The investigator of the present study has earnestly made an attempt to expose the relationship of selected kinanthropometric variables and physical fitness with the playing ability of kho-kho players and also attempted to find the prediction equation of kho-kho playing ability which would help the coaches and trainers to select the talented players on the basis of the results of this study.

STATEMENT OF THE PROBLEM

The purpose of the study was to predict kinanthropometric and fitness variables to evaluate the playing ability of male kho-kho players of Himachal Pradesh University, Shimla. Therefore, the problem has been stated as “Kinanthropometric and Fitness Variables as Predictors of Kho-Kho Playing Ability”.

OBJECTIVES OF THE STUDY

The objectives of the present study are formulated as under:

1) To determine the relationship between selected kinanthropometric variables and playing ability of male kho-kho players.
2) To determine the relationship between fitness variables and playing ability of male kho-kho players.
3) To determine the multiple correlation of selected kinanthropometric, fitness variables and playing ability of male kho-kho players.
4) To set up the regression equation for the prediction of playing ability on the basis of kinanthropometric and physical fitness variables of kho-kho players.

HYPOTHESES OF THE STUDY

1) There would be a significant relationship between kinanthropometric variables and playing ability of male kho-kho Players.
2) There would be a significant relationship between fitness variables and playing ability of male kho-kho Players.
3) Playing ability of kho-kho players could optimally be predicted on the basis of kinanthropometric and physical fitness variables.

DELIMITATONS OF THE STUDY

1) The present study was based on 120 male kho-kho players which were playing from their respective colleges affiliated to Himachal Pradesh University, Shimla.
2) The study was confined only to male kho-kho players.
3) The study was delimited to the kinanthropometric variables, physical fitness variables and playing ability of kho-kho players.
4) The kinanthropometric variables were measured with the help of Anthropometric Rod, steel tape, Vernier caliper and lange’s skinfold caliper.
5) Physical fitness variables were tested through AAPHER Youth Physical Fitness Test (1976) pull-ups, bent knee sit-ups in 60 sec., shuttle run 10 x 4 yards, standing broad jump, 50 yards dash, 600 yards run/walk, wrest flexibility and ankle flexibility.
6) The overall playing ability of the subjects was measured with five points rating scale.

7) Body composition was calculated by using skinfold measurements i.e. biceps, triceps, sub scapular and suprailiac skinfolds.

8) For the analysis and interpretation of data, statistical treatment was confirmed to Pearson’s product movement correlation (Zero order), multiple correlation and regression equation.

9) Data was collected during morning and evening session.

10) The age of the subjects was between 18 to 25 years.

**LIMITATIONS OF THE STUDY**

1) The factors like socio-economic condition, diet, rest, daily routine, life style, habits etc. which might effect the result of the study were considered as limitation of the study.

2) The effect of weather condition during collection of data could influence the results and it was accepted as limitation of the study.

3) No special motivational technique was used during the test. Therefore, the difference that might have occurred in performance due to lack of motivation was recognized as the limitation of the study.

**THE DEFINITIONS AND TERMS USED**

The terms which are frequently used in the present study are defined as follows.

1) Kinanthropometry

2) Physical fitness

3) Playing ability

1) **Kinanthropometry:** According to Ross (1978), It is defined as the scientific study of human size, shape, proportion, composition, maturation and gross function in order to understand growth, exercise,
performance and nutrition with implication of medicine, education and
government with respect to individual right in the service of human-
kind. In other words, Kinanthropometry is the application of
measurements of human size, shape, proportion, composition,
maturation and gross function. It has the purpose of helping to
understand human movement in the context of growth, exercise,
performance and nutrition.

Kinanthropometric Variables
1) Age
2) Weight

Linear Measurements
3) Height
4) Sitting Height
5) Leg length
6) Lower leg length
7) Total arm length
8) Fore arm length
9) Foot length

Skeletal Diameters (width)
10) Shoulder diameter (Biacromial)
11) Abdominal diameter
12) Hip diameter
13) Elbow diameter
14) Femur bicondylar diameter
15) Ankle diameter

Body circumferences (Girths)
16) Chest circumference (Normal)
17) Upper arm circumference
18) Shoulder circumference
19) Thigh circumference
20) Calf circumference

**Skinfold Measurements**

21) Biceps skinfold
22) Triceps skinfold
23) Sub scapular skinfold
24) Suprailiac skinfold
25) Thigh skinfold
26) Calf skinfold
27) Chest skinfold

**Body Composition**

The body composition generally refers to the type and amount of tissues which make up the body. The most widely accepted model is the two components scale, lean body mass and fat weight. The lean body mass consists of skeleton organs and other tissues which are approximately 40 to 50 percent muscles mass, and is used to represent the active energy fat (Behnke, 1963) fat weight on the other hand, is the inactive storage tissue that, while serving as a long term energy pool, is considered excess fat weight for most activities.

The study of body composition can be approached in a number of ways: organ systems, fluid compartments, kinds of tissue and so forth (Karpovich, 1971). In the present study body composition is concerned with the kinds of tissues and consists of measurable variables such as biceps, triceps, subscapular and suprailiac skinfold measurements and estimated variables like:

1) Body Density
2) Percentage Fat
3) Fat Weight
4) Lean Body Mass
PHYSICAL FITNESS

According to AAPHER Youth Physical Fitness Test (1976) “Fitness is the ability to carry out daily task with vigorous and alertness, without fatigue and with sample energy to enjoy leisure time pursuits and to meet unforeseen emergencies.”

1) Muscular Strength : (Pull-Ups)
2) Muscular Endurance : (Bent Knee Sit-ups)
3) Agility : (Shuttle Run)
4) Muscular Explosive Power : (Standing Broad Jump)
5) Speed : (50 yards dash run)
6) Cardiovascular endurance : (600 yards run/walk/12 min. run/walk)
7) Flexibility : (Wrist and Ankle Flexibility)

Strength

- **Methew and Fox (1976)** defined muscular strength as the force, tension of the muscle that a muscle can exert against resistance in one maximum effort.
- **Phillip and Harnek (1979)** explain that the strength is the constructive power of muscles attained by a single maximum effort.

Endurance

- Endurance is the ability of circulatory and respiratory systems to adjust to vigorous exercise and to recover from the effect of exercise. *(Phillips, D. Allen et. al 1979)*
- **Hockey (1973)** has defined muscular endurance as the ability of the muscles to apply force repeatedly or to sustain a construction for a period of time.
• **Hardayal Singh (1991)** defined “Endurance is the ability to do sports movements with designed quality and speed, under condition of fatigue”.

**Agility**

• Agility is the physical ability which enables an individual to rapidly change body position and direction in precise manner (*Johnson and Nelson, 1982*).

**Explosive Power**

• **Harold M. Barrow and Rosemary (1979)** Explosive power is an action where maximum muscular force is released at maximum speed.

**Speed**

• Speed is the ability or capability of an individual to perform successive movements of the same pattern to perform successive movement of the same pattern at a fast rate or even one single movement (*Borrow, 1977*).

**Flexibility**

• **Johnson and Nelson (1982)** say that the flexibility is the ability of an individual to move the body and its part through as wide a range of motion as possible without undue strain to the articulations and muscle attachment.

**Playing Ability**

It is the prerequisite quality of players which makes capable player to achieve top level performance in a particular game and sports.

It determines the level of performance of each player during actual game. It is the judgment of a player’s in defensive (running) and offensive
(chasing) situation by the experts during the match. In the present study, the playing of kho-kho players was judged with five point rating scale by three experts during the match and average score was considered the playing ability score of an individual.

SIGNIFICANCE OF THE STUDY

Physical education and sports is becoming more and more competitive and scientific so physical and sports scientists are working hard to develop suitable methods of enhance existing level of performance. Numerous researchers are being conducted as to certain, effective and most economical methods of selecting and training of kho-kho players in order to get the best performance. The selection and training can be done better with adequate knowledge of kinanthropometric and physical fitness measurements of the successful kho-kho players. The findings of the study may contribute to the promotion of the kho-kho in the following ways:-

1) The results of the study would provide a guideline about the relationship of selected kinanthropometric variables, physical fitness variables and kho-kho performance with kho-kho playing ability.
2) The results of the study would provide criteria for the selection of talented kho-kho players.
3) The physical education teachers and coaches may be benefited to inform their trainees about the specific qualities that should be required by each kho-kho players.
4) The study may help coaches and trainers for preparation of training schedules for better performance in kho-kho game.
5) The study may motivate others kho-kho lovers to take similar studies at different levels and standard so that kho-kho could become a more scientific game in India.
6) This study may also help and guide the research scholars to undertake similar studies in different games and sports, so that the best criteria for selection of players may be constructed for better performance.

7) The finding of the study will be of significant to physical education teacher and coaches in selecting the best suitable male kho-kho players on the basis of their predicted kinanthropometric and physical fitness variables.
CHAPTER-II

REVIEW OF RELATED LITERATURE

The study of relevant literature plays an important role to get a full picture of what has been done with regard to the problem under study. Such a review brings about a deep and clear perspective of the overall field and brings new ideas, theories, comparative materials and helps the development of research procedure.

“Practically all human knowledge can be found in books and libraries. Unlike other animals that must start a new with each generation, man builds upon the accumulated and recorded knowledge of the past. Their constant editing to the vast store of knowledge makes possible progress in all area of human endeavour.” (Best, 1982)

In the field of education as in other fields, the investigator needs to acquire comprehensive information about what has been done in the particular area from which he proposes to take up a problem for research. The survey of related literature helps the investigator to find out whether the evidence already available solves the problems adequately with further investigations. It provides ideas, theories, explanations and hypothesis which help an investigator in identifying and formulating his/her problem. It also suggests methods, technique and tools to the investigator for collecting and analysing the data. The investigator can locate comparable data which are useful in the interpretation of the result of his/her investigation last but not the least the related literature contributes to the general scholarship of the investigator.

The research scholar has made every attempt to acquire literature to this study form various sources such as Journals, Periodicals, Encyclopedia and other books in some of the renowned libraries. The libraries which the scholar consulted were Punjab University, Chandigarh, Himachal Pradesh University,
The relevant literature pertaining to the present study has been abstracted in this chapter to provide the background material to evaluate the significance of this study as well as to interpret its findings.

The related studies have been presented on the succeeding pages under different headings.

(A) Reference related to playing ability

(B) Reference related to Kinanthropometry.

(C) Reference related to Physical fitness.

(D) Reference related to body composition

(A) REFERENCE RELATED TO PLAYING ABILITY

Edgren (1932) attempted to predict the actual playing ability of beginners’ basketball players through the developed motor ability and specific basketball skill tests and concluded that the potential playing ability in basketball could be predicted through the general motor ability.

Young and Moser (1934) reported that the playing ability in women’s basketball was depended upon the ability in skills ‘speed passing’, ‘accuracy in passing to moving target’, ‘bounce and shot’, ‘basketball handling skills’ and ‘jump and reach ability’ of a player.

Carpenter (1938) investigated through a study with college women and found a correlation of 0.526 between Sargent jump and track and field scores. She felt and proved that this demonstration showed a positive correlation between power and athletic performance as judges by Track and Field scores.
Eversetf (1952) tested thirty varsity baseball players of the University of low on ability to throw for distance, running speed and agility (shuttle run), ability to visualize partial relationship (Thrustone’s ‘S’ test), ability to make decision quickly (the blocks test) and motor capacity (the General Motor Capacity Score). These subjects were rated according to playing ability by the coach.

Product Moment Correlation, partial Correlation and Multiple Correlation were computed and the following conclusions were made:

1) Sargent Jump was the best single measure for selecting baseball talent.
2) The best economical combination to predict baseball-playing ability was the Sargent Jump, ‘S’ test, and Blocks test.

$$T\text{-score} = 0.92 \text{ Sargent Jump (cm.)} - 0.08 \text{ ‘S’ test (score)} - 0.23 \text{ Blocks Test (sec.)} + 16.19.$$  

Lamp (1954) investigated the volleyball playing ability of 806 junior high school students in relation to various physiological and growth factors. Statistical analysis of the volleyball tests showed them to be objective, reliable and valid measures of playing ability. Positive correlations were found between volleyball playing ability (of both boys and girls) and the factors: age, height, weight and strength. The study revealed that the volleyball tests are reasonably objective, reliable and valid. There is no significant difference between boys and girls in their ability at this age to perform the skills of volleyball. Age and weight are more closely related for girls than for boys in performance in volleyball skills. Height is more important than the other growth factors for boys in relation to volleyball skill test. For both boys and girls there is slight positive relationship between strength and volleyball playing ability. A comparison of scores and pubescent status indicates that there is a decided relationship between these fact or for junior high school boys. The more mature boy at each chronological age score higher than the less mature boy. For the
girls, all pubescent groups show an early increase in performance with age and in all groups the maximum increase appears to come between 12.75 and 13.25 years. Peak scores for the pubescent and post pubescent groups appear to come in the 14th year, followed by a decline or leveling off score.

Ikeda (1960) administered a series of tests including wrist flexibility, shuttle run and various measures of kinesthesia, such as arm forward, wrist extension, wrist flexion, target finger, spread, supination, pronation and grip pressure on 72 women students during the last two week of an eight week badminton camp. These test scores were compared to the results of the volley and clear badminton tests. There was no significant relationship between wrist flexibility, kinesthesia or agility and badminton playing ability.

Peterson (1962) tried to predict basketball performance using psychomotor, cognitive and anthropometrics measures. The sample included forty-three female basketball players. The contribution of GPA, anaerobic, leg power, fifteen yards dash, thirty-yard dash, total body RT, TRT, height and weight to basketball performance once was determined. It was found that only height ($r = 0.388$) was a significant ($p$ less than 0.05) predictor. The fifteen yard dash total body RT and power were next in order. The ‘$r$’ for the four top variables was 0.56 (‘$p$’ less than 0.01).

Holland (1965) conducted a study on the predictive value of selected variables in determining the ability to play basketball in small high schools. In order to predict basketball playing ability, he included variables such as speed, agility, upper arm strength, power, ball handling ability, reaction time, shooting ability, passing ability, height weight, age and previous experience. The criterion was the rating of basketball playing ability of each squad member by his coach. The most important variables were found to be experience, ball-handling ability, passing ability and shooting ability. The weighted index with ‘$r$’ = 0.76, basketball ball handling ability score = 1.54, number of years of
experience + 1.23, score on speed dribble + 0.26, speed on wall volley +0.15, and score on shooting test - 10.11.

Smith (1969) formed three groups of subjects, 68 beginning players, 11 varsity players and three highly skilled and experienced players in the relationship of volleyball playing ability to scores achieved in the Sargent vertical jump. Vertical jump correlated 0.35 with the Brady Test 0.55 with the judges evaluation, and 0.50 with a combination of Brady Test and judges evaluation for the beginning players. The ‘r’ between the vertical jumping ability of the varsity players and a potential playing ability raking by their coach was 0.36. It was concluded that vertical jump is not an accurate predictor of volleyball playing ability.

Gilbert (1969) conducted a study of selected variables in predicting basketball player’s ability and performance at college level. He demonstrated that at the college level a battery of four independent variables selected from total of ten variables best reflect composite basketball ability and performance. These four variables include ability criterion, arm strength, penny cup test and speed pass. However, since the desired multiple r of 0.95 was not reached, this limits the utilization of this battery as a predictive measure of basketball ability.

In the study of Knight (1970), eleven grade girls (N=120) performed at volleyball wall volleys, the volleyball pass in a game situations. Data for determining the relationship of these skills were scores from the administration of Mohr and Haverstick’s repeated wall volleys Test, Liba and Stauff’s Volleyball Pass Test, and rating by 4 judges using Suttinger’s Rating Scale. Test were administered at the end of 6-week volleyball unit. Correlations were computed between scores on each of the tests. It was concluded that Liba and Stauff’s Volleyball pass test and Mohr and Haverstick’s Repeated Wall Volleys Test at the 7-ft. restraining line may be used to predict playing ability as measured by Suttinger’s Rating Scale.
Gordon (1978) conducted a study on twenty female basketball players from the 1976-77 University of Arkansas and Northeastern Oklahoma State University Teams. The purpose of his study was to determine the value of a cardiovascular capacity measure, a leg power measure, an upper body muscular strength and endurance measure, a percent of body fat measure, and a measure of body height as predictors of basketball playing ability and to develop a statistical equation for predicting success in playing college basketball. From the result of the study, the following conclusions were drawn:

1) The cooper 12-minute run and walk are best measures for predicting basketball playing ability.

2) Measures of leg power and upper body strength and endurance are of limited value when 12-minute run and walk is used to predict basketball ability.

3) Body composition measures have some value in predicting basketball playing ability of college women.

Amusa (1979) selected 46 students, who were well-conditioned soccer players with at least two years playing experience at the college level. They were tested for running speed, power, agility, and max. VO₂, strength, anaerobic capacity and flexibility. In addition, 11 anthropometrics measurements consisting of skin fold and body diameters etc. were taken. Soccer playing ability served as the criterion and was measured by the ratings of three experienced soccer coaches based on selected soccer skills and strategies. Analysis of data was made by zero order correlation and multiple regression analysis resulting in the following conclusions: age (experience) is the best single predictor of playing ability. Weight, LBW and height were considered good predictors of playing ability. Max. VO₂ and running speed are considered important factors in soccer performance. Flexibility, agility, lactate concentration and leg power were not considered as valid indicators of playing ability.
**Gordon (1979)** predicted basketball-playing ability from cardiovascular capacity, leg power, upper body strength and endurance, body composition, and body height. Subjects were 20 women varsity basketball players from two colleges, 10 from each college separate prediction equation were developed for five criterion measures, an ability rating consisting of four offensive – defensive descriptive terms the Tutko-Richard General Personality Rating. Composite score of the two measures the Noll Comparative Rating Scale, which utilized game statistics and the rating of the players by the coach. Data were analyzed through Step – Wise Multiple Regression Programme the best prediction equation was found to be.

\[
\text{Basketball ability} = 9.053 + 1.364 \times (12 \text{ minute run}) - 0.113 \times \text{height}.
\]

**Devi (1980)** conducted a study on twenty four volleyball players to find out the relationship of selected strength and flexibility measures to playing ability in volleyball. She concluded in her study 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 but insignificant correlation to playing ability in volleyball. The American association for health, physical education and recreation has constructed a test in volleyball for boys and girls. These tests include the skills such as serving, volleying, passing and set up. They established a high degree of reliability and validity.

**Ostrovsky (1980)** after studying seventy-three basketball players with twenty-seven tests found that the following seven factors share up to 84.0 percent in the total dispersion of playing ability.

Physical qualities:

a) Speed combined with dexterity.
b) Quality of Jump.

c) Speed endurance.

Technical qualities:

d) Accuracy of long shooting.

e) Nationality of dribbling.

f) Technique of defense.

g) Accuracy of high-speed pass.

An inter-connected test battery involving all those factors was constructed and utilized by him in coaching for the four top league basketball teams.

Hachn (1980) studied the Knox basketball test as a predictive measure of overall ability in of female high school basketball players, the Knox basketball test was administrated on one hundred and ninety eight (N = 198) girls. The step-wise multiple regression procedure was used to analyze the predictive value of this test. It was found that for the selection of the players dribble shoot test was the significant predictor. The dribble shoot test also significantly correlated with the coaches ranking of junior varsity players and varsity players, the speed pass and dribble significantly predict the division between the junior varsity and varsity players. Although the comparison was significant to skill test accounted for only 11.1% to 28.31% of the total variation in the dependent variables.

Jeanette (1980) investigated the factor structure of basketball skills in the domain of human motor performance to identify the robust factors in that domain. The subjects for this study were 16 high school girls. A battery of 20 experimental variables were selected on the basis of their representation of a theoretical domain possessing the following hypothesized dimensions: (i) Shooting (ii) Passing (iii) Jumping (iv) Moving without the ball and (v) Moving with the ball.
The study concluded that hypothesized dimensions of basketball playing ability were not supported. The multidimensional model playing ability were not supported. The multidimensional model resulting from this investigation is represented by dribbling, explosive leg strength, lay-up shooting and passing.

**Datta (1984)** while investigating on selected physical, physiological and psychological variables as predictors in hockey performance founds that there was significant relationship between cardio-respiratory endurance, resting pulse rate, hand reaction time, speed of movement, response time and body composition to hockey playing ability. The relationship between percentage body fat and playing ability showed that higher percentage of body fat might be considered as an extra burden or dead weight which the individual had to carry and which consequently reduced the efficiency of the players. The hockey players who had scored better in hockey playing ability had a lower percentage of fat as compared to those who gave poor performance in hockey playing ability.

**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 among physical variables explosive power, agility and ankle flexibility were main contributors to volley ball player ability and cardiovascular endurance, lean body weight and pulse pressure among physiological variables were the best contributors to volleyball playing ability.

A study was undertaken by **Mathew (1984)** to determine the relationship of selected anthropometric measurements (height, weight, arm length and upper body length) to performance an Brady Volleyball Test. Pearson’s Product Moment Correlation (zero order) was employed to study the relationship of volleyball playing ability to each of the selected anthropometric measurements. For testing the hypothesis the level significance was set at 0.05. The finding of the study indicated that the variables of height, weight and arm
length showed significantly higher relationship to performance on Brady Volleyball Test, (height=0.764, weight = 0.795 arm length=0.792) as compared to the significant but low relationships of leg length and upper body length with performance on Brady Volleyball test (leg length=0.544, upper arm length=0.641). All the above mentioned values were found significant at 0.05 level of confidence based on the finding of the study the following conclusions were drawn:

1) The height and weight of the players contributed to a much greater extent to the performance of Brady Volleyball test and to volleyball playing ability.

2) Arm length was also found to be an advantageous factor in the performance of Brandy Volleyball Test.

3) Leg length and upper body length contributed to the performance on the said test to a very limited extent.

Joseph (1983) undertook a study to determine the relationship of power, agility, shoulder flexibility, arm length and leg length to volleyball playing ability. Thirty male volleyball players of the Lakshmibai National College of physical education, Gwalior were selected as subjects. Product moment correlation was used to compute correlation between playing ability and each of the selected independent variables. From the findings of study it may be concluded that:

1) Power is the most reliable variable in prediction of playing ability of men volleyball players.

2) Arm length and leg length are also reliable variables in prediction of playing ability of male volleyball players.

3) The variables of agility and shoulder flexibility show insignificant relationship in prediction of playing ability of male volleyball players.
Indu Majumdar and M. Advin (2000) Measured physical fitness of Basketball Players. They selected 180 male players for the test. All players participated in Maharashtra State Basketball Competition. Following four tests were conducted to measure physical fitness of Basketball players:

1) Vertical Jump;
2) 30 meter dash for running;
3) Shuttle run for agility;
4) Cooper 12 minutes run/walk test for cardiovascular endurance.

They concluded that race 30 meter dash and shooting in basket has close relation. Physical fitness and basketball playing ability have also close relation.

Chauhan, M.S. (2003) conducted a study on the prediction of sprinting ability of secondary school boys of Haryana in relation to their anthropometric measurements. He concluded that:

1) Age and body weight have highly significant and negative correlation with sprinting performance (100 meters) at 5 percent level.
2) Height, leg length, foreleg length, thigh length, total arm length, upper arm length, forearm length and foot length have significant and negative correlation with performance.
3) Shoulder, chest, abdomen, hip, thigh and calf girth have significant and negative correlations with sprinting performance of school boys.
4) Among body diameters, biacromial, ankle and bicrural diameters are significantly and negatively correlated with sprinting performance of secondary school boys.
5) Subscapular and thigh skinfolds have been found to possess significant and negative correlation with sprinting performance of school boys.
6) Lean body mass and fat weight also possesses significant and negative correlation with sprinting performance of school boys.
7) Multiple correlation of combination of three selected anthropometric variables i.e. leg length, biacromial diameter and lean body mass with sprinting performance has been found significant. The multiple correlations is of sufficient size and hence can be put in the prediction equation for the sprinting performance.

8) The square of the determinants of multiple correlation is 0.6724, which can measure 67.24% of the total performance through these three variables can be measured by other factors which affect the performance.

Bhola, G. (2004) investigated on the prediction of playing abilities of North Indian Junior Basketball players in relation to their motor fitness and selected kinaanthropometric measurements. Subjects were 200 junior basketball players of North India. He concluded that age, height, sitting height, leg length, thigh length, total arm length, upper arm length, fore arm length and hand length have significant and positive correlation whereas lower leg length, weight and foot length have significant but negative correlations with the performance of field goal speed ability of the junior basketball players. Arm, chest, thigh and knee girth have positive and significant correlations and calf girth has negative and significant correlation. Other variables have no significant correlations with performance in field goal speed ability of the subject. Elbow and femur bicondylar diameter have positive and significant correlations whereas wrist has negative but significant correlation with performance in field goal speed ability.

(B) REFERENCES RELATED TO KINANTHROPOMETRIC

Cosen (1930) in his study, “Relationship in stature and physical performance” correlated the composite scores of the six events, i.e., 13 feet rope climb, 100 yard dash, running broad jump, shot put and discus throw with age, height and weight. He concluded that height and weight were apparently
the influencing factor to some extent in these performances though the correlation was not significant enough so as to put use for prediction equation.

Johnson (1938) worked out the relationship between chest volume and other body measurements. An empirical formula was found out for getting the chest volume from the measurement of chest. He derived a correlation between chest volume and weight and the co-efficient was found to be quite high (0.734).

Espenchade (1940) offer finding the highest correlation of physical performance with age, recommended it as the basic for test norms. The quality of physical performance is related to various basic traits of boys and girls such their maturation, boys, size, shape, proportion, composition and physique. Many of these traits are acquired during the growing years through hereditary and are affected by environmental factors including motor activity. Children differ significantly in their basic traits while participating in motor activity does not change their maturity or body size appreciably in most case but the knowledge of growth of these different traits greatly influence their motor performance. These factors should be considered in judging children’s potentialities for participation in motor activity.

Cureton (1941) stated that in general, people with long legs and long arms, and relatively short and small trunks were physically weak types in long-sustained work, but they might show great speed and endurance at high levels of athletic activity. Long third class levers are noted for speed and range of action as well as for their efficiency for force.

Jones (1947) conducted a study on the relationship of strength to physique and found a combination of body size and body build and provided a fairly adequate representation of the factors determining strength. A multiple correlation of .886 was obtained between total strength and endomorphy, mesomorphy, ectomorphy, height and weight. A partial correlation of .34
between mesomorph and strength increased to 0.61 when height and weight were partialled out.

**Romar and Thomas (1947)** concluded that there are significant negative correlations of the magnitude of 0.578 to 0.274 between the performance of strenuous physical exercise and external fat on the body. The correlation with endurance running being relatively greater than for other test exercises. Fat is a real handicap in most of strenuous exercises.

**Hooks (1950)** conducted this study to determine the relationship of 29 selected structural and strength measures to success in the baseball skills of hitting, running, throwing and fielding plus over all playing ability. The structural measures tested have constantly low correlation with the criterion. The measures of strength tested have constantly high correlations with the criterion. 0.79 left shoulder flexion with hitting, 0.72 right shoulder flexion with throwing and 0.67 left shoulder flexion with total ability. Left shoulder flexion is the best single measure found to predict baseball ability.

**Telka and his associates (1951)** studied 245 finish top ranking track and field athletes and wrestlers. They did not find any appreciable differences in respect of constitution among the athletes of different branches, except in certain extreme groups. Moreover, during 1954, the same workers again reported various body measurements to performance. Throwers were tallest in this material and they seemed also to benefit most from their height. The correlation between the relative shoulder breadth (with stature) and performance was significant in throwers and long distance runners. The correlation between the relative chest circumference (with stature) and performance was negative and highly significant in case of sprinters, positive and significant in case of throwers.

**Pare et al (1954)** reported the top ranking track and field athletes and related various body measurements to performance. Throwers were the tallest
in this material and they seemed also to benefit most from their height. On the basis of study the following inferences were drawn:

1) The correlation between the relative upper limb length (with stature) and performance was significant in throwers and long distance runners.

2) The correlation between the relative shoulder breadth (with stature) and performance was negative and highly significant in case of throwers.

3) The correlation between the relative chest circumference (with stature) and performance was negative and highly significant in the case of sprinters, and positive in case of throwers.

Rasch (1954) in a relationship study correlation the length, strength and weight of the arm with the maximum speed of voluntary movement of the arm. From the experimental findings recorded, there was found no statistically significant correlation between the speed of voluntary movements of the hand, fore-arm and upper-arm and weight, length and strength of the arm and its segments.

Clarke (1957) conducted a study to find out the relationship of strength and anthropometric measurements with physical performance of 53 unselected non-disabled male students at the University of Oregon, involving the trunk and legs. He concluded that correlation among some of the anthropometric variables were especially high, i.e., between standing height and leg length (0.91) between foot length and leg length (0.88) between body weight and both hip width and thigh girth (0.87) between height-strength test and trunk flexion and extension (0.65). Multiple correlation were found significant for leg lift (0.74) with body weight, ankle dorsal flexion strength, back lift (.071) with knee extension, strength hip width, trunk flexion strength and knee flexion strength and for standing broad jump (0.66) with adipose tissue over the abdomen (negative) and hips extension strength (positive).
**Hammes (1960)** conducted a study on the relationship of selected anthropometric measures to the vertical jump of high school girls. He has reported that measurements of total height, sitting height, foot length, metatarsal phalangeal to calcaneous and medial malleolus to calcaneous length had no relationship to vertical jumping ability, using 146 girls as subjects. There was a relationship but not of predictive value of weight, total leg length and lower leg length with vertical jumping ability.

**Degutis (1960)** carried out a relationship study between the standing broad jump and various maturities, structural and strength measures at twelve years old boys in which the subjects were 81 twelve year old boys in the Medford Oregon Public Schools. The correlation between the standing board jump as criterion and 16 maturity, structural and strength test variables were determined. The following multiple correlations were obtained; anthropometry -0.408 with body weight, leg length and lungs capacity, coordinated strength - 0.393 with strength index back lift and leg lift; cable tension strength -0.520 with elbow flexion and hip extension; combined variables -0.694 with elbow flexion strength body weight, hip extension strength, ankle planter flexion strength and leg strength.

**Tanner (1960)** and his colleagues conducted a study on the anthropometric measurements of the Olympic players in 1960 at Rome. They studied the different races as well as the same event, in an attempt to study their height, weight and other body measurements. They were compared with each race as the whites were compared with the Negroes. It was found that Negroes were larger than the whites in some measurements, their arms were longer than the whites.

**Piscopo (1962)** conducted a study to establish norms and to compare skinfold and other anthropometric measurement of pre-adolescent boys from three ethnic groups. The subjects were 647 Hallian, Jewish and Negro pre-adolescent boys. The skinfolds were measured at five sites, other measurements
included height, weight, bi-iliac dimensions and selected girths. Correlations were determined between skinfold and selected body build components. Inter skinfold r’s ranged from moderate to high values. The largest percentile scores were found within the Jewish groups. Analysis of variance was employed to compare body fat, height and weight of each group. Significant differences were found relative to certain skinfolds and weight between ethnic groups at 0.01 level.

**Wear and Miller (1962)** studied the relationship of physique and developmental level, as determined by the wetzal grid, to performance in fitness tests, or junior high school boys. They found that subjects who were medium in physique and normal in developments, to be the best performers and the subjects of heavy physique to be the poorest in performance.

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

**Margaret (1964)** studied body structure and design factors in the motor performance of college woman. Pure speed the Sargent jump, 600 yard dash run/walk, back strength, leg strength and the strength index were studied in relation to 43 measurements of body structure and design. All these measurements were secured by means of photogrammetric technique including measures of length, depth, area as well as non-linear expressions of body structures and design. Multiple correlation co-efficient obtained for each of the criterion measured were as given:
<table>
<thead>
<tr>
<th>Criterion</th>
<th>R</th>
<th>Selected Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure Speed</td>
<td>0.52</td>
<td>Leg length, (leg BI/Trunk BI) Bitrochantric diameter.</td>
</tr>
<tr>
<td>Sargent Jump</td>
<td>0.677</td>
<td>Shape index, ponderal index ectomorph</td>
</tr>
<tr>
<td>600 yard run/walk</td>
<td>0.427</td>
<td>(Upper leg length/lower leg length) Depth of thigh at gluteal fold.</td>
</tr>
<tr>
<td>Leg Lift</td>
<td>0.628</td>
<td>Area of dorsal upper trunk (upper leg) length/lower leg length), Area of lateral leg.</td>
</tr>
<tr>
<td>Back lift</td>
<td>0.632</td>
<td>Depth of thigh at gluteal fold, endomorphy, (upper trunk length/lower trunk length).</td>
</tr>
<tr>
<td>Strength Index</td>
<td>0.650</td>
<td>Area of dorsal upper trunk, lower trunk area, lateral leg area.</td>
</tr>
</tbody>
</table>

These multiple correlations were significant at 0.01 percent level and the highest consistent relationship was found between area measurements and experimental combination of variables.

**Baacke (1964)** utilized data from 87 male students of high school to determine the relationship of selected anthropometric and physical performance measures to performance in running hop-step and jump. He concluded that all the variables, as measured in the study, showed significant relationship with criterion beyond the 0.05 level of confidence.

In an extensive monograph, **Tittel (1965)** made a comparative study on the bodily structure of the best athletes in 100 mt. track, high jump, broad jump, discus throw and shot put, based upon measurements taken on the best competitors in the German Democratic Republic on the one hand and data from athletes competing in corresponding events at the Olympic Games in Rome and Toyko on the other hand. By using single and multiple regression technique, he found mathematical expressions for determining the degree of relationship between certain body measurements and athletic performance.
**Hirata (1966)** collected anthropometric data for 31 variables on 457 athletes, 309 males in 20 sports and 148 females in 10 sports. The descriptive statistics was used for 12 male sports and 5 female sports. The physique of athletes was analyzed through examination of absolute and relative size, somatotype, body composition and factor analysis of Montreal (1976), Mexico (1968) Olympic athletes. The male athletes from Montreal are larger than those from Mexico City on most measures of body size. The mean somatotypes of the athletes from both Olympic samples were almost identical. The athletes on most size variables, except that the male athletes are lighter and have smaller skinfolds. The athlete of both sexes are less endomorphic and more mesomorphic than the students. In term of proportions, male athletes compared to students have similar mass and tend to have slightly longer limb segments, greater bone breadths (but narrower hips) and upper body girths lower skinfolds and greater bone muscle and residual masses. The exceptions are greater proportional mass in judo competitors, weight lifters and wrestlers, as well as few differences fencers and field hockey players when compared with the students. Among the female sports canoeists, rowers and swimmers have similar proportions, masses to the students but track and field and gymnasts’ athletes are proportionally lighter. The female athletes have proportionally narrower hips, larger girth (except for jumpers and smaller skinfolds but larger muscles mass than the students.)

**Leuback and Meconville (1966)** conducted a study on relationship between flexibility, anthropometric measurements and somatotype of college men and reported low correlation between flexibility and anthropometric measurements and between somatotype and flexibility. A high negative correlation was obtained between body fat and flexibility, somatotype components were found to be highly correlated with certain anthropometric measurements. In a later stage the same author reported many significant correlations between strength and anthropometric measurements. Mesomorphy
the only somatotype component was found to correlate significantly with muscle strength.

Johnson’s (1968) study explored the relationship of balance, strength, height, arm and leg length to success in collegiate wrestling. The subjects (N=208) for this investigation were collegiate wrestlers with at least 2 years varsity experience who had wrestled in 50% of their teams bouts during the 1966-67 school year. Subjects were classified as successful, average and unsuccessful according to their win-lose-percentages. A second classification was made by weight (light weight, middle weight, and heavy weight). All subjects were measured for arm and leg length and tested for RT, MT, static elbow flexion, strength, explosive leg strength and dynamic balance. Treatment of the data by ANOVA showed no difference among the wrestlers in the 3 weight divisions on dynamic balance, explosive leg strength and RT. In elbow flexion, strength the middle weights were stronger than the light weights. The light weights and middle weights were faster in MT and RT than the heavy weights. The unsuccessful wrestlers had longer legs than the average and successful wrestlers. Analysis by multiple R and regression showed that no combination of the independent variables was useful in predicting success.

Terrel (1968) studied the relationship of pre and post puberty anthropometric measurements and physical fitness test scores of American Negro and Caucasian females. To measure the physical fitness, AAHPER Youth Fitness Test was used.it was concluded that the Negroes are better than the Caucasians in 50-yard dash and soft ball throw for distances, because they have significantly longer legs, longer arms and hands, longer feet and wider shoulder girdle and narrower pelvic girdle that the Caucasians.

Berg (1969) conducted a study to determine the relationship between age, height, weight, height trochanter (distance from the greater trochanter to the floor), thigh length, leg length, foot length and performance in the standing broad jump. Boys (231) in the fourth, fifth and sixth grades were used as
subject. All correlations were found to be statistically significant at 0.05 percent level. Although significant r’s were low and body segment size could be eliminated as a determinable factor in predicting the success one might achieve in performing the standing broad jump.

**Voll (1970)** determined if ability in basic modern dance skill could be predicted by means of selected anthropometrics and physical fitness measurements. Data for this study was collected on 24 female students participating in one of three No-Eastern Pennsylvania Colleges. Measurements of height, weight, sitting vertex height, left trochanterion height, left tibiae, upper leg length, flexibility, abdominal strength, leg strength, cardio-vascular fitness, and somatotype was taken. As results of statistical treatment, a regression equation with a multiple R of 0.8678 was presented by the author for the prediction of ability in basic modern dance skills and prediction tables for its computation were developed. The author concluded that ability in modern dance skill could be predicted from selected anthropometrics and physical fitness measurements.

**Hoffman (1971)** in his study aimed to look for the best relation between the leg length and frequency of a sprinter’s strides, taking into account the length of his leg. The measurements were taken exclusively during competitions. The result showed that the leg length was correlated more with the athletes running ability than height.

**Bowmen’s (1971)** study investigated the relationship between 29 biographical, physiological and psychological factors and success in wrestling. The purpose of this study was to identify independence variables that were significantly related to wrestling success. One hundred and thirty six high school wrestlers were tested during 1969-70 wrestling season. The data was analysed using multiple correlation and regression analysis. The findings of the study were:
1) All twenty nine independent variables, the biographical variables and the physiological variables were significantly related to wrestling success at .05 level.

2) Seven actors-age, years of wrestling experience, hand grip strength, upper body strength, cardiovascular endurance, desire to achieve and desire to experiment-were significantly related to wrestling success at the .05 level.

**Lancy (1973)** studied the relationship between dynamic balance, measured by stabilometer at difference stance width and 17 anthropometric and strength variables determined for a group of 96 collage women. Co-efficient of correlations were computed for day one performance, day two performance, performance of the 15 inch width and performance at 10 inch stance width. The anthropometric variables under consideration were weight, height, sitting height, biacomial breadth, bicristal breadth, arm span, subischial length, height index, sitting height-weight index, biacromial breadth index and ponderal index. The coefficient of correlation between stabilometer performance at the 10 inch stance width and five of the anthropometric variables (i.e., weight, bicristal breadth, subichial length index, bicristal breadth / biacromial breadth index and ponderal index) were significant at 0.05 level of confidence. No relationship was found between any strength variable.

**De Garey, Levine and Carter (1974)** after an intensive study of anthropometric measurements of Mexico Olympic athletes concluded that top level performance in particular event demands particular size of body and shape, other aspects being similar. They established strong relationship between the structure of an athlete and specific task (event) in which he excelled. Clear physical prototype exist for optimal performance at Olympic level.

**Spragus (1975)** examined several ways of the relationship of swimming speed to physical measurements in all four competitive swimming strokes. The
actual 100 yard free style times and the age predicted residuals of those times were used as dependent variables. The physical measurements were height, weight, sitting height, lower leg length foot length, arm length, fore arm length, waist girth, chest girth, hip girth, upper arm girth, thigh girth, wrist girth, ankle girth, hip width, shoulder width, chest thickness, biceps skinfold, scapular skinfold, shoulder flexion, ankle flexion, knee extension, elbow extension, vital capacity and centre of gravity. Other variables recorded including length of time in competitive swimming, months per year spend in workouts, number of workouts per week, amount of participation in other competitive sprints and age. The stepwise method of multiple regressions was used in all analysis. The most consistent variable overall was time in competitions. It was statistically significant in all fourteen analysis. The most consistent physical measures were foot length and biceps size. Each was found significant in at least one analysis for each of three strakes. In each case longer feet were associated with slower timer and larger biceps were associated with faster timer.

Johnson (1976) investigated 200 collegiate wrestlers. Subjects were classified as successful and unsuccessful according to their win-loss percentages. A second classification was weight, light weight, middle weight heavy weight. All the subjects were measured for height, arm length and leg length. The unsuccessful wrestlers had longer legs than the average and successful wrestlers. Analysis of multiple regression showed that no combination of the independent variables was successful in predicting success.

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

**Khan Eraj Ahemad (1978)** – swami Vivekananda, the philosopher saint of India advocated that our country wants muscles of iron and nerves of steel. He further stated that first of all our young men must be strong, religion would come afterwards. The ancient India system of yogic exercises also emphasis. That physical wellbeing besides mental and spiritual attainments. The Ramayana and the Mahabharata justify that physical fitness was given lac of performance during those periods.

**Murugesan (1981)** established the relationship of height, agility and vertical jump to spiking in volleyball. Thirty male volleyball players of lakshmibai National collage of physical education, Gwalior were selected as subjects. For estimating standard height, agility, vertical jumping ability and spiking ability, the following tests were employed. Height was measured against wall in centimeters and spiking ability test with the use of five point rating scale respectively. Zero-order correlation was used to compute correlation between spiking and each selected variables i.e. height, agility and vertical jump. The findings indicate that the vertical jump is a very reliable variable for predicting spiking ability of male volleyball players. The order of merit was a combination of three variables, i.e. height, agility and vertical jump. The value of multiple correlation obtained was 0.65 and it was proved to be the most reliable combination because the value of multiple correlation 0.65 obtained was maximum. Therefore, this is the best combination which can be used for predicting spiking ability of male volleyball players.

**Tanaka and Matsura (1982)** studied the anthropometric and physiological variables of 114 Japanese young middle and long distance
runners and concluded that the anthropometric attributes would predict the distance running performance to about the same degree as physiological attributes. As a result of factor analysis and the multiple regression analysis three factors i.e., linearity of physique, girth of physique and subcutaneous fat were extracted and the first two factors were nearly equally related to the 800 meters, 1500 meters and 5000 meters performances, 10,000 meters, however, was best accounted for the second factor.

Sodhi et al (1984) conducted a study selected kinanthropometric characteristics of Indian volleyball players, during the coaching camps held at Kurukshetra, Karnal and Patiala. The data of 97 volleyball players were divided into four groups-National men (N=12), State (N=21), National University (N=27) and District (N=25) groups. The volleyballers in each group were compared with control group (N=25), as well as the champions reported elsewhere. Each subject was examined with 12 anthropometric measurements and 10 tests of performance. The latter consists of block jump, vertical jump, three successive jumps, 20 mt. dash, agility, basketball throws, 30 sec. sit ups maximum sit ups, flexibility and 2.4 km run. The statistical analysis was carried out to calculate the mean, standard deviation, analysis of various and test of significance.

Chouhan, M.S. (1986) studied the relationship between selected anthropometric variables and endurance running performance. He concluded that height, leg length, thigh length, total arm length, shoulder, chest, abdomen, hip and knee girths, thigh and calf skin folds, and lean body mass had significant and negative correlations with 1500 meters endurance running performance, whereas 10,000 meters running performance had statistically insignificant correlations with linear segments, girths and diameter measurements, except with skinfold measurements (triceps, suprailiac, midaxillary, thigh and calf skin folds) and body composition variables (i.e. body density, fat percentage, fat weight and lean body mass).
Multiple correlations of 1500 meter running performance with combination of selected anthropometric variables were significant. Similarly the multiple correlations of 10,000 meter running performance with combination of selected skinfold and body composition variables were significant. But the multiple correlations were not of sufficient size to put them into the prediction equation.

Kishore (1986) conducted a study in which he took 30 intervarsity weight-lifters. Their anthropometric measurements such as arm length, leg length, thigh length, trunk length, thigh girth, calf girth, upper arm girth forearm girth, and skin-fold were measured. He concluded that there were significant relationship between thigh girth, trunk length, upper arm girth, forearm girth, lean body mass and weight lifting performance. There was negative relationship between leg length, thigh length and weight lifting performance. There was no significant relationship between arm length, foreleg length, calf girth and weight lifting performance.

Chouhan, M.S., Sharma, V.P. and Sharma, J.C. (1987) Conducted a study on the relationship between selected anthropometric variables and performance in standing broad jump of collegiate women and concluded that age and foot breadth had positive correlation with performance in standing broad jump, whereas hip girth, thigh and calf skin folds, fat weight and lean body mass had significant but negative correlation with the performance in standing broad jump. Further, the multiple correlation of the combination of selected anthropometric variables i.e. age, weight, foot breadth, hip girth and thigh girth with performance in standing broad jump was found to be significant at 0.05 percent level. The multiple correlation found was not sufficient enough to be used in the predication of performance.

Chauhan (1988) conducted a study on the correlation of anthropometric variables with success in putting the shot by college women. He concluded that age, height and biacromial diameter had positive and significant correlations
with success in putting the shorts, whereas sub scapular, thigh and calf skinfolds; body density, and fat weight had negative and significant correlations with the success in putting the shot of college women. Further the multiple correlation ($R=0.575$, $P < 0.05$) of the combination of selected anthropometric variables i.e., age, height, total arm length, foot length, hip girth, thigh girth and biacromial diameter with success in putting the shot of college age women was found significant at 5 percent level, but the multiple correlation was not sufficient size to put in the prediction of success in putting the shot.

**Vaz. L.W. (1994)** investigated some of the selected anthropometric characteristics and physical fitness components as predictors of performance in Judo. He found in his study that anthropometric variable namely height, weight, calf-girth, arm girth and ponderal index were related to Judo performance in various weight categories, but leg length, arm length, thigh girth and crural ratio were not seen significantly related to Judo performance.

Combined contribution of anthropometric variables and physical fitness variables to Judo performance in various weight categories were showing significant relations. Multiple regression analysis indicated that predications regarding Judo performance, on the basis of anthropometric and physical fitness variables, can be made with reasonable degree of accuracy.

**Keogh J. (1999)** this study was conducted to determine if anthropometric and fitness testing scores can be used to discriminate between players that were 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 condition part in determining selection in elite junior Australian Rules football teams.

**Thomas Domic (1999)** study the relationship of motor components and anthropometric variables to the velocity of basketball throw. Motor fitness components chosen were wrist strength, waist and shoulder flexibility, and speed movement of arm. Anthropometric variables were upper arm length, lower arm length, total arm length, sitting height, leg length and weight. Twenty five male basketball players in the profession of physical education were chosen as subjects for the study. Analysis of the data showed that there is a significant correlation between the velocity of long and hook basketball passes and the anthropometric variables.

**Singh, S. Singh, J., Singh, H. (2002)** studied on the relationship of body height and body weight with selected physical fitness variables in untrained female children of 10 to14 year’s age groups, with body weight and height, standing broad jump, thirty meters sprint, medicine ball put, six into ten meters shuttle run. Standing vertical jump and eight hundred meters run test were used to assess to the fitness level. They concluded that:

1) There is positive and significant relationship between height and body weight in all age groups except in 13 year’s group.
2) Height is 10 and 11 years groups is found to be significant related to body weight, 30 meters run, medicine ball put, standing vertical jump and standing broad jump test performance.
3) There is no significant relationship between height and selected motor tests in the age group of thirteen years.
4) A significant relationship does not exist between height and 800 meters run and 6×10 meters shuttle run.
5) A negative relationship exists between body weight and performance in standing vertical jump and standing broad jump.
6) A significant relationship exists between body weight and shoulder strength in age group 11 and above.
7) A significant but negative relationship exists between body weight and 800 meters test in age group 10 to 13.
8) Agility shows a significant relationship with body weight in 10 and 13 years age group.

Chauhan, M.S. (2003) conducted a study on the relationship of anthropometric variables and middle distance running performance and concluded that age, height, leg length, thigh length, arm length, shoulder, chest, abdomen, hip, thigh, knee girth, ankle diameter and calf skinfold have positive and significant correlation with middle distance running performance. Lean body mass also has positive and significant correlation. The multiple correlation of combination of anthropometric variables i.e. height, thigh girth, biacromial, thigh skinfold with middle distance running performance is significant at 1% level, but multiple correlation is not of sufficient size so the regression equation cannot put in to prediction of the running performance.

Chauhan (2004) studied on the prediction of performance of university throwers in relation to the anthropometric measurements. He concluded that:

1) Age, body weight, height, sitting height, trunk length, leg length, foreleg length, thing length, total arm length, upper and fore-arm length all have positive and significant correlations with performance of university level throwers.
2) The circumferences, i.e. shoulder, chest, abdomen, hip, arm and thigh circumferences have significant and positive correlations with the throwing performance.
3) Biacromial, biocristal and elbow diameters possess positive and significant correlation with the performance in throwing event.
4) Among skinfold measurements, biceps, subscapular, suprailiac and calf skinfolds have positive and significant correlations with performance in throwing event.

5) Body density and lean body mass have negative and significant but fat percent and fat weight have positive and significant correlations with throwing performance.

6) Multiple correlations of body weight, height and total arm length collectively have significant correlations with the throwing performance.

7) The size of the multiple correlations is quite sufficient and hence the regression equation can be used for the prediction of throwing performance of university level throwers.

Kumara, M.H. (2004) studied to find out the relationship of selected volleyball skills i.e attack, block and service with stature, age, spike jump and reach, block jump and reach, experience and weight at international level. He concluded that:

1) Jumping strength determine success rate in attack, block and service.

2) Height, age experience and weight of the player have not much to do with the performance in attack, block and service.

3) A change in performance in one factor leads to change in other factor is confirmed in case of spike jump, reach and block jump reach.

4) A significant relation exists between age and experience.

Singh and Chauhan (2011) examined the correlation between the selected kinanthropometric variables and explosive leg strength and also to develop the regression equation for the prediction of explosive leg strength basketball players between the age range of 18 to 25 years. They found that height, sitting height, trunk length, leg length, thigh length, shoulder, chest, abdomen, hip girth, elbow, hip, knee diameters, biceps, sub scapular skin folds, fat weight and lean body mass have positive and significant correlation with explosive leg strength at 0.01 level of significance. The size of the multiple
correlations was also sufficiently large and hence regression equation developed for the prediction of the explosive leg strength of Basketball players.

(C) **REFERENCE RELATED TO PHYSICAL FITNESS**

**Barnam (1960)** studied the AAHPER youth fitness test battery and administered the test to 78 girls in grade VIII at Methell Junior High School. The girls were classified by the Nielson-Conzens classification index and compared with national norms. The girls were above the average in sit-ups, standing broad jumps, 600 yards run/walk, 50 yard dash and shuttle run but below in the softball throw and modified pull-ups. The differences were attributed to their Physical education programmes.

**Pierson and Phillip (1960)** conducted a study that Bruce Physical Fitness Index as a predictor of performance in trained distance runners. Eleven (N=11) high school cross-country runners were taken as the subject of the study. An effort was made to determine the relationship between score and performance. Lean Body Mass was calculated according to Rathbum – Pace and Cawgill formula. The inter-correlation of the selected anthropometrics and physiological measurements were recorded during the investigation. The mean score of 32 found for the subjects were considerably above the 26 considered characteristics of athletes on the Bruce Continuum. The man with best performance (9.56 min.) made the highest score (40) on the Bruce Physical Fitness Index, but the man with poorest performance (11.39 min) made the second highest score (37).

When performance of all subjects was correlated with their Bruce Physical Fitness Index ‘r’ was found to be 0.47, which was not statistically significant. The correlation between performance of the total heart count for the first three minutes. Immediately after exercise was ‘r’= 0.52 which was also not significant.
Ponthieux and Barker (1965) reported significant correlation between socio-economic status and performance on the AAHPER test in a mixed racial sample of fifth and sixth grade children. The significant relationships, however, did not consistently favour either the high or the low socio-economic groups. Three of the more commonly measured performance items (the broad jump, 50-yard dash, and throw for distance) showed significant correlation with the socio-economic status. The dash and throw were significantly related to lower socio-economic status for both sexes, while the broad jump was significantly related to upper socio-economic status for girls only. Pull-ups and sit-ups, on the other hand, had a significant relationship with higher socio-economic status.

Mequi (1966) compared physical fitness of Philippine students with Japanese and American students. He found that the Philippine students had, generally lower performance in pull-ups, soft ball throw and sit-ups as compared to the Japanese and the American students.

Bone (1967) administered AAHPER youth fitness test to 100 rural and 100 urban boys. The urban boys were found superior to the rural boys and the difference was significant at 0.01 level. The two samples were weaker on the same components of physical fitness.

Vincent (1967) measured 37 college women enrolled in eight physical education activity courses in attitude, strength and efficiency. Partial and multiple correlations were calculated between these independent variables and success in physical education activities. Regression equations consisting of various combinations of the three independent variables were formulated and tested by analysis of variance. All prediction batteries were significant in the prediction of success in physical education activities, and the following conclusions were drawn.
1) Success in physical education activities can be predicted from the various items under consideration.

2) Among the variables studied as possible contributors to success in physical education activities, the attitude measures were of the highest significance.

3) The use of attitude item alone can be considered as adequate while the inclusion of the strength item is desirable in the prediction of success in physical education activities.

Ellen Burg (1971) conducted a study to predict selected physical variables in determining competitive performance in high school basketball player in 1969. The performance data were collected by performance rating chart Pearson’s Product Moment Correlation, Multiple Correlation and Multiple Regression Equation were used. The results of the study were as follow:

1) Out of the variables used in the study, thirty seconds shooting test and vertical jump were most reliable predictors for the performance used in the study.

2) Height, handgrip, vertical jump, wall volley and thirty-second shooting tests were most important variables contributing to a player’s performance.

3) The five items battery consisting of height, handgrip, vertical jump, wall volley, thirty second shooting test can be a practical and useful instruments in predicting basketball performance of high school basketball players.

Childress (1972) conducted a factor and discriminate analysis to identify and determine the effectiveness of selected physical variables in predicting successful basketball performance. Twenty-four test items were selected through a review of literature as a valid measure of components of high school basketball ability. The test items were administered to 106 high
school basketball players and the resultant data were analyzed through factor analysis. Seven factors were isolated and six were identified as agility, speed, relative muscular endurance, basketball speed manipulation, gross muscular strength, total body movement time and manual dexterity. Two test batteries were constructed, the first consisting of seven test items and the second was composed of the ten test items. The result of the study showed that the component of basketball ability could be isolated, measured and utilized to construct and evaluation tool for classifying and evaluation tool for classifying players into two populations identified as successful and unsuccessful.

**Huntly (1974)** made a study on physical fitness and motor ability to find out the effect of these selected physical activities in 1961. Subject selected at random from first, second and third grade students, who were involved in this study: out of three experimental groups within each grade. An analysis of the results revealed that both physical fitness and motor ability attributes, excluding body reaction time can be significantly improved by structured physical education programme consisting of basic movement and rhythmic activities, games and gymnastics. The best contribution to physical and motor ability resulted from participation in games and related activities.

**Ronald (1975)** found the contribution of selected fitness variables to college football game performance. Thirty members of the South Eastern State Collegiate Football Teams were selected for this study. From the Multiple Correlation Coefficient, it was found that best predictor of game parentage for defenders were lateral movement for the forwards the best predictor of game percentage was bench step. For combined group the best predictor of game percentage score was vertical jump. For total group it was found that vertical jump and 12 minutes run was two best predictors.

**Craig (1976)** compared the physical fitness levels of Canadian and South-African school boys. He used AAHPER physical fitness test battery. The
results showed that physical fitness levels of South-African high school boys were higher than those of Canadian high school boys.

Mookerjee (1978) made a comparative study of physical fitness of young rural and urban boys in the age group of 13-17 years and also of less active boys of the same age group. The result of this study was that, there is no doubt that regular physical activity contributes significantly to the enhancement of physical status. Physical fitness of rural active subjects were, definitely, of superior level than that of the boys living in the city. Pure food, fresh unpolluted air, and reasonable regular physical hardship are chief contributory factors in promoting physical fitness.

Robson and associates (1978) administered the simple physical fitness test battery to study the physical fitness of elementary school children of defense and non-defense personnel. One hundred and fifty boys and girls from five Kendriya Vidyalaya of Gwalior were selected at random, as subjects for the study. To assess the physical fitness, the subjects were administered the simple physical fitness test battery for elementary school children which was constructed at the Lakshmibai National College of physical education, Gwalior, in the year 1977. The test battery composed of six items (50-meter dash, 4x10 meter shuttle run, sit-ups, modified pull-ups, vertical jump and 600 meters run/walk) was administered to both boys and girls. The boys and girls belonging to the defense personnel had shown statistically significant higher performance in physical fitness as compared to boys and girls of the non-defense personnel.

Ray (1979) conducted a study to compare the physical fitness of the tribal and the urban students in Tripura. He administered the AAHPER youth fitness test on sixty tribal and sixty urban students studying in MBB College, Agartala. Their age ranged from 16 to 20 years. The mean difference between the physical of urban and tribal students was not found statistically significant at 0.05 level of confidence. It was found that urban students were better in pull-
ups and soft ball throw for distance and their performance was statistically significant at 0.05 level of confidence. But in the remaining five test items i.e. 50-meter dash, 600-meter run/walk, sit-ups, shuttle run and standing broad jump, the performance of none of the groups was found, statistically significant at 0.05 level of confidence.

Cassell (1979) measure and compared the motor abilities and physical characteristics of collegiate soccer players by the four positions of play, forwards, half backs, full backs and goalkeepers one hundred and twelve college soccer players in the state of Ohio volunteered as subjects. Subjects were somatotyped according to the Health-carter anthropometric somatotyping method and their percent of body fat estimated through the Sloan weir Body Composition Nomogram by Skinfolds of subscapula and thigh. The motor ability item included an agility test (SEMO), a leg power test (Margaria-Kalemen), a soccer ability test (Johnson wall volley), on upper body strength test (pull-ups), a test for speed (40 years sprint) and a test of endurance (1.5 mile run). One way analysis of variance showed that within the limitations and delimitations of the study, difference do exist in relation to motor abilities and physical characteristics between some of the positions.

Bhatnagar (1980) conducted a study on 23 rural sportsmen (athletics-8, volleyball-8, Kabaddi-7) of Madhya Pradesh (India) pertaining to their weight, height, sitting height and subcutaneous tissue folds at biceps, triceps, suprailiac and sub-scapular region. They were found to be lighter, shorter and with less amount of fat as compared to normal urban Punjabis. Morphological differences pertaining to sportive activities indicated that volleyball players were the lightest, the shortest with maximum amount of fat as compared to kabaddi players and athletes, whereas kabaddi players were the heaviest and the tallest among all the rural sportsman of Madhya Pradesh.

Saha (1980) made a study to compare the selected physical fitness variables and anthropometric measures of tribal and non-tribal students of
Tripura. They were tested with selected item of AAHPER youth fitness test i.e. 50-yard run, 40-yards shuttle run and 600-yards run/walk and selected anthropometric measurements i.e. chest girth, height, weight, upper arm girth, thigh girth and calf girth. In all tests and measurements, the composite mean scores of tribal students were higher than their non-tribal counter parts but none of the differences in the means were found statistically significant at 0.05 level of confidence.

Toner (1982) examined the relationship of physical fitness skill and mood variables with success in female high school basketball candidates being chosen to become varsity players. McNair’s profile of mood states, Copper’s 12 in. run and walk test, AAHPER Jump and Reach Test, AAHPER Shuttle Run Test, 30 yard dash, AAHPER Under Basket Shot Test, AAHPER Speed Pass test, and the AAHPER Speed Dribble Test were administered on 81 female high school basketball players. At the end to the testing and evaluation period, the jury of coaches, on the basis of their observations during drills and scrimmage competition independently rated each player as either successful or unsuccessful performance. Discriminate analysis procedures supported the following hypothesis:

(a) The fitness factor, skill tests and personal factors (Know together as pre-season variables) Were successful indicators of groups member ship while the POMS variables were to a lesser extent and
(b) The battery of tests preseason and POMS variables did correlate with coach’s rating.

Taddonio (1982) reported physical fitness of public school students from economically deprived areas with national norms. Within the limit of this study, (i) there was no difference in the physical fitness of boys and girls from the economically deprived sample and boys girls represented by the 1975 national norms and (ii) within the sample, there was no difference in physical
fitness of boys and girls from high poverty areas and boys and girls from low poverty areas.

**Walker (1982)** conducted a study on white and black female student at Northern High School. 50 white female 10 grade students were randomly selected as the subject. AAHPER youth physical fitness test was used on item. Statically analyzed it was concluded that the black subjects scored significantly higher than the shite subjects on leg power, (M=44.6% and 31.2%) and (M=57.8% and 39.1%) respectively. The white subjects performed significance higher than black subjects on abdominal strength (M=31.5% and 24.7%). No other comparisons were significant.

**Barbanti (1983)** established physical fitness norms far Brazilian school children. In the physical fitness test battery he included sit and reach test, modified sit-ups-test, nine minute run, twelve minute run, 50 meters dash and standing long jump. The test were administered to 2,342 school boys and girls and he comprised the selected kinanthropometric measurement of their students and produced the reliable norms.

**Sinha (1984)** conducted a study on selected motor traits and anthropometric variables of AAHPER Basketball skill test and indicated that performance in AAHPER Basketball skill test was significantly related to agility, cardio-vascular endurance, explosive strength, height and crural index, whereas performance in AAHPER Basketball test was not significantly related to speed, grip strength, back flexibility, weight and ponderal index.

**Goslin and Barden (1986)** evaluated physical fitness characteristics of South African high school children. AAHPER Test Battery was administered to 98 white, 92 coloured and 32 black subjects. The white subjects were the tallest, heaviest and most active of the three groups. The black subjects were the strongest of the three groups both relative to body mass and in an absolute sense, despite their smaller stature (p<0.05). White subjects and greater upper
body and lower body power and higher aerobic output compared to coloured and black students (p 0.05). There was no difference between the groups in balance, upper body endurance, agility and flexibility.

**Dey and Dey (1987)** conducted a study on 40 players of football. The players were divided into two groups i.e. offensive and defensive players according to their position in game during practice. They concluded in their study that:

1) Offensive players in football possess higher cardiovascular endurance and explosive leg strength than those of the defensive players.

2) Defensive players in football have significantly higher leg length, thigh girth, height, weight and crural index than those at offensive players.

3) There are no significant differences in speed calf girth, ponderal index of offensive and defensive players.

**Uppal and Datta (1988)** studied the motor fitness components as predictors of hockey performance. The purpose of the study was to identity those motor fitness components, which could predict the performance in the game. Seventy-four (n=74) male hockey players from different universities of India served as subject for the study. The motor fitness components included were speed, strength, power, agility, dynamic balance, flexibility and kinesthetic perception. Strait Field Hockey Rating Scale served as criterion measure to evaluate the hockey playing ability.

**Ignico (1990)** evaluated physical fitness levels of children enrolled in daily (five classes per week) and weekly (one class per week) physical education programmes. The AAHPERD Physical Fitness Test was administered to 218 elementary schools children (grades 1-5) from two schools of similar size. And inspection of means indicated that the daily physical education school participants were superior on all four test items across the five grades. Univariate main effect analysis indicated that females were more
flexible, males were faster on the mile run/walk, and females had more subcutaneous fat.

**Rhoda (1990)** studied three methods of teaching physical fitness and their effect on strength, flexibility and cardiovascular endurance. Students were enrolled in one of the following classes based on the teaching style and methods utilized by the teacher: Style A (Group A), Health Related Aerobic (Group B), Militaristic Anaerobic, Style C (Group C), Traditional Calisthenics. The statistical data indicated that aerobic activities were important for the attainment of leg strength, flexibility and cardiovascular endurance. Anaerobic activities were important for the attainment of strength, flexibility and cardiovascular endurance; and calisthenics/tam sports games were important for the attainment of leg strength and flexibility.

**Kanwal Jeet et al., (1991)** in their study of prediction of physical fitness on the basis of cognitive style, an important aspect of personality. For the purpose of study a sample N=60) consisting of male and female sports participants and non-participants were taken. The participant’s level of participation ranged between inter-university and national. Different cognitive styles were studied through their ‘locus of control’, ‘personal causation’, ‘self-efficacy’ and ‘engagement style’ by employing standardized test batteries. Physical fitness was measured with the help of AAHPER test. The data were analyzed with help of step-wise multiple regression equation. The value of F-ratio showed that engagement style (4.88), personal causation (3.33), self-efficacy (2.87) and influence of powerful others (2.86) were having significant contribution at 0.5 level in predicting physical fitness.

**Kumar (1992)** conducted a study of motor fitness components as limiting factors in handball performance. Indian male (N=85) handball players were taken as the subject of the study. The age ranged between 20 to 30 years. Five motor fitness components were selected as the predictor through Wherry-Doolittle test selection method. The selected predictors were arm strength, back
strength, spine flexibility, standing broad and 50-meter sprint. Further in order to examine relationship between selected motor fitness components and handball performance, data were analyzed through Pearson’s Product Moment Coefficient of Correlation, partial correlation of 1st, 2nd, 3rd and 4th order, the regression equation was finally made through Wherry-Doolittle test selection method. The result of the study reveals that prediction equation of \( X_{c} = 3.419 X_3 + 0.265 X_6 - 0.141X_{16} - 0.185X_{12} + 2.565X_{14} + 0.693 \) may be considered as valid predictor of performance in handball.

Chandel (1993) conducted a comparative study on physical fitness, physiological and anthropometrics variables between the tribal and the non-tribal 260 tribal and 220 non-tribal students were selected to act as subjects of the study. AAHPER Youth Fitness Test Battery consisting of six test items i.e. sit ups, Standing broad jump, 50 Yard dash, Shuttle run, 600- Yard run/walk were used to measure physical fitness of the subjects. Selected physiological parameters such as pulse rate, blood pressure, and hemoglobin were measured and some anthropometrics measurements were also took. The following conclusions were drawn:

1) A significant difference in mean score of anthropometrics 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.

2) The tribal were found superior in all aspect on physical fitness variables as significant mean difference was found in their favour in sit ups, 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, and endurance than their counterparts.

3) The tribal were superior to non-tribal in physical fitness, cardiovascular endurance and anthropometrics measurements.
Raman (1993) conducted test on 30 male cricket players from graduate and undergraduate course at Lakshmibai National College of Physical Education, Gwalior in order to determine the relationship of grip strength, leg power, agility and hand and foot reaction time to performance in cricket. Data was collected on grip strength (grip dynamometer), leg power (standing broad jump), agility (40 yard shuttle run), Hand and foot reaction time (electronic reaction timer) and performance was average of subjective rating of three experts during practice and match situations. Pearson Product Moment Correlation was employed to statistically treat and data. It was concluded that:

(i) Hand and foot reactions time is the most important variables in the prediction of cricket playing ability.
(ii) Leg power was another important variables in the prediction of performance in cricket.
(iii) Grip strength was also as important variable of prediction in cricket playing ability.
(iv) Agility was not an important factor in the prediction of performance in cricket.

Micheal (1994) in his study examined whether cardiovascular endurance, body composition, flexibility, and leg power had any relationship on how well golfers perform. The results showed a significant correlation at the 0.05 level between golf scores and balance and power. But the correlation coefficients balance (r = - 0.3161) and power (r = - 0.3597) were not reliable correlations.

Toor (1996) conducted a study to investigate physical, physiological and anthropometrics 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 anthropometrics measurements were taken.
Pearson’s Product Moment Coefficient Correlation was used to analyze the data to assess the relationship of performance of sprinters, jumpers and throwers with physical, physiological and anthropometrics variables. Multiple step wise regression was applied to assess the combined contribution of physical, physiological and anthropometrics variables with performance. In order to assess the limited factors for top performance, the regression equation was worked out. On the basis of the study he found that:

1) The sprinters performance was significantly related to physical variables namely sit ups, Sargent jump, standing broad jump, back lift and 50 yard dash, physical variables namely recline pulse and sitting pulse rate and anthropometrics variables namely age and calf circumference.

2) The performance of jumpers was found significantly related to physical variables i.e. sit ups, Sargent jump and standing broad jump, anthropometrics variables namely age and biceps skin fold.

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

Lolage (1997) defined cardiovascular endurance is characterized by moderate contractions of large muscle groups for relatively long period of time during which maximal adjustment of cardiorespiratory system are necessary. It is the basic components of physical fitness and complex in nature. In understanding cardiovascular endurance, the stamina of the body to maintain a run involve in a definite aerobic expenditure was aptly use as an illusions of the component of physical fitness.

Sethi, Parmod Kumar (2004) investigated physical fitness component as a predictor in the performance of male weightlifter. The subjects of the study were one hundred male weightlifters studying in different universities of India and who had participated in the All India inter-universities weightlifting championship in 2002. He studied seven physical fitness component i.e. speed,
strength, cardiovascular endurance, static balance, agility, power, flexibility which were measured by test items i.e. back full squat test, military press test, sit-ups stick drop test, 50 yard run test, Harvard step test, stork stand test, squat thrust test, standing broad jump, shoulder rotation test and forward bend and reach test respectively. The criterion measure was performance in weight lifting skill performance in snatch and clean and jerk during the championship.

The data were analyzed using the Pearson’s Product Moment Coefficient of Correlation(r) for reassessing the relationship of weightlifting performance to each of the physical fitness components and Regression equation for predicting the weight lifting performance from fitness components. On the basis of the study he found that:

(i) The physical fitness components namely speed, maximum strength, explosive, strength, strength endurance, agility, power were significantly related to snatch in weight lifting.

(ii) Among physical fitness component maximum strength, explosive strength, endurance, agility powers were significantly related to clean and jerk.

(iii) Trunk and shoulder flexibility speed (acceleration ability) cardiovascular endurance and static balances was not found to be significantly related to snatch.

(iv) The relationship of trunk and shoulder flexibility, speed (acceleration and speed of movement) cardiovascular endurance, static balance to clean and jerk respectively was partial led out.

Gopinathan and Helina (2009) determine the relationship of anthropometric and physical fitness variables with handball performance. Results revealed that the anthropometric variables of height, weight, arm length, leg length, palm span and sum of four skinfolds and physical fitness variables of speed, agility, explosive power, shoulder strength, strength endurance and endurance were having significant relationship with handball
performance and only flexibility was not having significant relationship with handball performance.

**D) REFERENCE RELATED TO BODY COMPOSITION**

One aspect of the scientific approach which is receiving greater attention is that of body composition. More specifically the measurement of the athletes' body composition to achieve an optimal playing weight (OPW) is gaining significance in the total training programme. By achieving this optimum playing weight (OPW), the athlete can minimize the negative effect of excess body fat on activity without sacrificing the required nutrition for successful performance (Brozek and key, 1963).

Relationship between total body density, total body potassium, skinfold thickness measurements and AAHPER YOUTH FITNESS TEST performance were determined on 49 pre-pubescent boys, 8 to 11 years old age. Zero order correlation between body composition measures and performance scores were low or moderate, however, using multiple regression analysis it was found that body composition measures significantly (p<.05) increased the variance accounted for above that explained by age, height and weight and in predicting all performance items except sit ups. In general, body density, body potassium and skinfold thickness predicted performance equally well when age, height and weight were held constant. A canonical correlation analysis of the relation between the AAHPER test items and the physical development variable demonstrated that there was a large proportion of common variance between the two sets of variables and significant relationships existed along two independent dimensions. It was concluded that not only variation in body size, but also variation in body composition should be considered when interpreting results of the AAHPER test for individual children and for comparison of groups of children who differ in body composition.
Too often the judgment concerning optimal playing weight is made on a trial error basis with reference to body weight along disregarding the individual’s physique and composition. Behnke’s two component models of body composition appears to offer the best scientific approach at present for assessing an athlete’s optimal playing weight. This method partitions the body weight (BW) into the lean body mass (LBW) and fat weight (FW). The ratio of FW to BW is the relative fat content (%fat) and is inversely proportional to the hydrostatistically determined body density (Brozek and keys 1963).

Body composition, according to Behnke et al (1963) keys and Brozek (1953) and Novak (1968) is the proportion of lean fat free body mass and depot fat and is one of the human organisms. The relative proportion of these components, while different in males and females through much of the life span are dynamically dependent on developmental level and thus one of interests to those concerned with human growth and development. Furthermore the significant interaction between body composition and energy turnover is among other things, closely related to the function capacities of the consequence in physical fitness and performance of children and adults (key and Brozek; 1953; Parizkova, 1961; and Parizkova , 1963).

Researchers have tried to measure body composition through laboratory method or field method to study the effect of exercise on body composition.

Pierson (1962) investigated the relationship of height, weight lean body mass and body fat to overall speed as determined by sprint start and found no relationship between the bodily measurements and speed. In another study by Pierson (1962), it was reported that “the speed with which an untrained individual can voluntarily react to a visual stimulate has little relationship to his body size or composition.” The subjects, used for this study were medical students classified as short and heavy, short and light, tall and heavy and tall and light.
Lauback (1972) conducted a study on “body composition in relation to muscle strength and range of joint motion” and found high correlation between total lean body mass and measures of high grip strength. The multiple regression equations for the predication of the physical performance from anthropometric and body composition measurement yielded multiple correlation that ranged from .506 to .747 and these equations accounted for only 26 percent to 56 percent of the variance in performance.

Slaughter, Lohman and Misner (1977) conducted a study to determine the association of somatotype, body composition and physical performance in 7 to 12 years old boys. Body composition was estimated as fat and lean body mass from k40 (potassium 40) measurements and from two skinfold thickness measures. Physical performance measures consisted of one mile run, 600 yards run and 50 yards dash, standing broad jump and vertical jump. It was found that in general somatotype components had lower correlation with running and jumping variables than had body composition or body size variables, such as height, weight and percent fat.

In their study relating to somatotype and body composition to physical performance on seven to twelve years old boys, Slaughter and associates (1977) concluded that somatotype components were not highly related to physical performance. However, ponderal index correlated better with performance scores. Somatotype components had lower correlations with running and jumping variables body composition or body size variables.

Sidhu and Sodhi (1979) worked on the effect of physical activity on body composition of elite Indian Hockey Player undergoing coaching for the Asian Games of 1974. The players in the investigation were divided into three main groups in accordance with the load of exercise on different players which has maximum in group I and decreased gradually in the case of the group II and group III players. Groups I consisted of left in, right in and centre half; group II, left out, centre forward and right half; group III, right back, left back
and left half. The group I players registered the maximum decrease in body fat after 52 days of intensive training. Similarly, the group III players who underwent the minimum load of physical stress had shown increases in the amount of body fat. The group II players manifested a decrease but to a smaller extent than group I. After taking account of the varied degree of physical activity of different players, they suggested a need of differential conditioning for players specializing at different field position.

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

Grewal (1984) made an attempt to study the physique and body composition, of Indian Sports Women in different Games. The subjects were 492 sports women and 81 controls ranging in age from 17 to 23 years.

The results of his study regarding volleyball game, he staged that the volleyball players are very tall and heavy, though less than the throwers. They possess short trunk, long upper extremities, broad shoulders, big knees and big bodily circumference including well developed calves. They have longest lower extremities as compared with the other categories of players at different level of competition. The amount of subcutaneous tissue in upper extremities and trunks is more than all other players except throwers, their mean somatotype is $3.71 - 3.15 - 2.97$. They possess muscular arms, fore-arms and calves.
Uppal and Roy (1986) conducted a study on ‘Relationship of selected strength and body composition variables to performance in shot put and Javelin Throw’ and revealed that the arm strength, grip strength and explosive leg strength were significantly related to performance in shot put. There was a significant relationship between arm strength, explosive leg strength and lean body weight to performance in Javelin throw. The relationship of selected body composition variables namely, body density, lean body weight and percentage of fat to performance in shot put was not significant. Grip strength, body density and fat percentage were not significant related to performance in Javelin throw.

An attempt has been made by Kansa, Giri and Giri (1987) to study the physique and body composition of Indian national volleyball players and to compare the same with that of Olympic volleyball players. The subjects of the study include 14 players of national men volleyball team and 14 players of national (combined) universities volleyball team. Selected anthropometric measurements namely body weight, height, sitting height, humerus and femur bicondylar diameters; upper arm, chest and calf circumferences as well as biceps, triceps, subscapular, supra-iliac, thing and calf skinfolds were taken on all subjects with standard techniques. Somatotyping was done by both original Health & Carter (1967) method and Kansal’s modified Health and Carter method (1985). Percentage body fat was computed by Durnin and Rahaman (1974) formula data on Olympic volleyballers reported by Hirata (1979) and Carter (1982) were used for comparisons. Except skinfolds percentage fat and somatotyping, the mean values of all measurements including weight, height, skeletal diameters and circumferences are found to be highest in Olympic, medium in national India and least in University volleyball players. The average of five skinfolds is 7.8 mm for both Olympic and university players while that of national Indian players is 6.8 mm. However, when the skinfold is observed in percentage of body weight, the Olympic players are found to possess minimum value (9.12), followed by national Indian team (9.25) and
Indian universities team (11.47). Similar trend is seen in percentage body fat, the mean value being 11.4 in national Indian and 12.9 in universities team while the respective values of Olympians were not available.

**Toriola, Adeniran and Ogunremi (1987)** comparatively assessed the body composition and anthropometric characteristics of elite male basketball (n=15) and volleyball (n=15) players and male none athlete (n=20) at the University of Ife, Nigeria. The ages of the subjects ranged from 19 to 29 years. Analysis of variance and Newman-Muls post hoc method were used to be determine significant differences in the physical characteristics of the groups. The basketball players were significantly taller and had markedly larger humerus width than the volleyball and non-athletic groups (p<0.05). The non-athletes had significantly higher percent body fat values than both the groups of athletes (p<0.05). The basketball (4.30) and volleyball (4.40) players who were predominantly ectomesomorph had significantly higher ectomorphic component (p<0.05) than the non-athletes (2.5). The differences observed between the athletic groups are related to the morphological factors which influence the basic components of competitive sports performance.

**Benny (1988)** conducted a study of anthropometric measurements and body composition variables on judo players. Nine anthropometric variables and three body composition variables were taken for this study. Judo performance was taken as the criterion measure and all the variables were taken as the independent variables Pearson’s Product Moment correlation was used to find out the relationship between anthropometric measurements and criterion measure. A multiple correlation was computed to find out the combined effect of the anthropometric measurements to Judo performance. He concluded that; (i) Performance of Judo was positively and significantly related to chest girth, (ii) Judo performance was negatively and significantly related to Ponderal Index which mean that for better Judo performance Judoka should possess greater body weight in proportion to body height, (iii) lean body mass, upper
arm / forearm ratio and sitting height were the most important predicting variables.

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

Sodhi et al. (1991) Examined body composition of 635 elite Indian Sportsmen. Study includes athletes, wrestlers, boxers, basketball players, badminton players, volleyball players and weight lifters. Study also includes, light class wrestlers (n=20), medium class wrestlers (n=26), and heavy class wrestlers (n=13) and found heavy weight wrestlers possessing maximum muscle mass (42.04 kg) and bone mass (13.83 kg). Percentage body fat is also maximum in heavy weight wrestlers (21.24%). Light weight wrestlers are the group with lowest bone mass (10.62 kg) muscles mass (26.05 kg) and percentage body fat (12.23kg).

Singh, A.K. (1999) studied on the inter relationship of body composition aerobic and anaerobic capacities of volleyball players of different levels of performance. The subjects were 50 male university level volleyball players. On the basis of the result of the study, the following conclusions were made:
1) There was a significant relationship between the body composition and aerobic capacity; and body composition and anaerobic capacity of university level volleyball players.

2) There was no significant relationship between aerobic capacity and anaerobic capacity of university level volleyball players.

3) Aerobic capacity showed higher relationship with body composition when partial contribution of each seen through positive correlation in university level volleyball players.

Tsunawake et al. (2003) evaluate the body composition and cardio respiratory function (VO$_2$ max and O$_2$ debt) in 12 members of the women’s volleyball team and 11 members of the women’s basketball team that won the championship in the Japan Inter-high school meeting. They reported that volleyball players are taller, heavier and more fat percentage than the basketball players. No significant difference was observed in any measured item of the physique, skinfold thickness, or body composition between the volleyball players and basketball players. The VO$_2$ max and O$_2$ debt max were 22% and 28% higher in the basketball players than in the volleyball players.

Noel et al. (2003) assessed body composition of Division I football players (n=69) and compared the findings with previously reported data to ascertain whether the increase in player total body mass that has been observed over the past 10 years has been accompanied by an increase in body fat. Body fat varied significantly across playing position, with the defensive backs, offensive backs, and receivers being the leanest and the offensive linemen and tight ends the most fat. There was no significant relationship between body composition and playing year or scholarship status, nor were any differences observed between ethnic groups.

Ajit (2004) studied on the relationship between body composition, somatotyping, skinfold variables and springing ability of athletes. The subjects were 35 male students of D.P.Ed and M.P.Ed Kurukshetra University. Within
the limitation identified and on the basis of the results of the study, the following conclusions were drawn:

He concluded that:-

1) The anthropometric variables weight, biceps skinfold, suprailiac skinfold, thigh skinfold have positive significant relationship with sprinting ability.

2) The body density and lean body mass have positive and significant correlation with sprinting ability.

3) The two variables, the fat percentage and fat weight have negative and significant correlation with sprinting ability. It suggests that when that fat percentage and fat weight go no decreasing, the time which is the measure of performance also goes on decreasing. Hence the performance increases.

4) The value of $R^2 = .29$ indicates that .29% of the variance in sprinting ability scores of the athlete is counted for by the two skinfold variables, i.e. suprailiac and thigh skinfolds, while the remaining 71% of the variance in their performance is still not accounted for or cannot be predicted on the basis of these two variables.

From the above studies of related literature it is clear that physique and body composition and physical fitness has significant contribution in achievement of better performance in the field of games and sports. So, it becomes necessary on the part of the physical educationist and sports scientists in the field to investigate such variables and combination of kinanthropometry and physical fitness variables which are essential ingredients for better performance of participants. If the investigator may become able to find such relations and is in such a position to develop regression equation for the performance than it will be a great contribution to the profession without wasting much energy and time, the suitable physique, body composition and
physical fitness may be evolved for the particular participants in the particular games and sports.

**Cavas et al. (2004)** investigate the anthropometric parameters and body composition in handball, basketball, badminton, volleyball and underwater rugby players who are students in Physical Education and Sports Department in Turkey. 49 female and 51 male athletes have taken part in this study. The skinfolds of rear thing in female players are significantly higher than those of other female and male skinfold values. Minimum skinfold value has been observed in subscapular and chest of female and male athletes, respectively. Although estimated percentage body fat and body fat weight values in female athletes are significantly higher than those of male athletes, fat free body mass in male athletes is significantly higher than those of female athletes.

**Moreno et al. (2004)** assess body composition in young male football players (n=239) and compare the results with those of reference population (n=453). Body mass index do not showed any significant difference between football (soccer) and reference groups in any age category. The percentage of total body fat was significantly lower in the football (soccer) group than in the reference group at 9, 11, 12 and 14 years.

**Marta et al. (2008)** evaluated the body composition and body image of a group of top flight soccer players and compare the results with those of a group of university students used as controls subjects. A total of 56 individual took part in the study; half of them were soccer players and half university students. They did not find significant differences in body image satisfaction between the soccer players and the control subject. However, “the university students perceived their image much more precisely than the soccer players. The body composition study revealed that the soccer’s had more muscle mass and less fat than the control subjects; that is, they were thinner and more defined than the volunteer group. While the control subject tendered to want a more muscular body with the same amount of fat and less than they had, the
soccer players expressed that they wanted more muscle mass, but also more body fat.

Kundu and Bose (2009) investigate the somatotype and body composition differences between north zone and east zone university level Indian women basketball players. The result revealed that the somatotype of both north-east zone women basketball players possessed mesomorphic-endomorpic except the champion university. The physique of the champion team (GNDU) was ectomorphic-endomorph. North zone women basketball players possessed less % fat, less weight of body fat, higher LBM, taller and heavier than the east zone players. GNDU possessed less amount of % fat than the other Universities. Punjabi University players were the taller than other. Endomorphic component, ectomorphic component, % fat and the height of the north zone women basketball players were significantly differ than that of the east zone basketball players.
CHAPTER –III

METHOD AND MATERIAL

“A research design is the arrangement of conditions for collection and analysis of data in a manner that aim to combine relevance to the research purpose with economy in procedure”.

(Jahoda and others)

In any research one of the most important prerequisite is the collection of appropriate data without which no worthwhile study can be possible. In this regard, Mouley (1964) remarks, “Scientific problem can be resolved only on the basis of data and a major responsibility of the scientist is to set up a research design capable of providing data necessary to the solution of the problem, while the unity of the research makes it impossible to say that one aspect is more crucial than other, the collection of data is of paramount importance in the conduct of research science, obviously, no solution can be more adequate that the data on which it is based.

To achieve the objectives of a study the investigator has to plan the entire process of the work in the terms of research design suited to the study, therefore, the design of present study is presented systematically under following heading:

SELECTION OF SUBJECTS

To accomplish the study random sampling technique has been used to select the subjects. The subjects were one hundred twenty male inter college level Kho-kho players between 18 to 25 years of age. These students were studying in various affiliated colleges and various departments of Himachal Pradesh university, Shimla. All the players used as a subject had participated in
the Himachal Pradesh inter college Kho-kho competition for men during the month of December year 2012.

All the subjects were ensured about their health status from college and department health record, which was regularly maintained by their respective colleges and departments, and it was found that all the selected subjects were medically fit for going through the testing procedure.

Prior to the administration of test, the requirements of the testing procedure were explained to them in details, so that there was no ambiguity in their mind regarding the efforts required of them and the strain that they had to endure in addition to their participation in the competition. All the subjects agreed voluntarily to cooperate in testing procedure explained to them in the interest of scientific investigation and enhancing their own performance. Though no special techniques were used to motivate the subjects to put in their best efforts, the subjects were enthusiastic and cooperative throughout the project.

**SELECTION OF VARIABLES**

In consultation with the experts of the field, reviewing the literature and considering the feasibility specially from the point of view of availability of equipments and time factor, the following kinanthropometric variables and physical fitness variables which seemed to be related to the performance of Kho-kho players in competition situation, were selected for the study.

**A. Independent Variables**

1. Age
2. Body weight

**Linear Measurements**

3. Height
4. Total arm length
5. Fore arm length
6. Leg length
7. Sitting height
8. Lower leg length
9. Foot length

**Skeletal diameters (width)**
10. Shoulder diameter (biocromial)
11. Abdominal diameter
12. Hip diameter
13. Elbow diameter
14. Femur bicondylar diameter
15. Ankle diameter

**Body Circumferences (Girths)**
16. Shoulder circumference
17. Chest circumference (normal)
18. Upper arm circumference
19. Thigh circumference
20. Calf circumference

**Skin fold Measurements**
21. Biceps skin fold
22. Triceps skin fold
23. Chest skin fold
24. Sub scapular skin fold
25. Suprailiac skin fold
26. Thigh skin fold
27. Calf skin fold
Body Composition variables

28. Body density
29. Percentage fat
30. Fat weight
31. Lean body mass

Physical fitness components

32. Muscular strength
33. Muscular endurance
34. Agility
35. Muscular power
36. Speed
37. Cardiovascular endurance
38. Flexibility

TOOLS USED

1. The average score of the three experts was considered to judge kho-kho playing ability.
2. For measuring the height and weight the anthropometer rods, weighing machine were used.
3. A flexible steel tape was used to measure the circumferences.
4. The lange’s skinfold caliper was used to measure the skinfold.
5. Diameters were taken with the help of vernier caliper and anthropometer compass.
6. All the kinanthropometric measurements were taken on the right side of the individual. Standard technique described by Weiner and Lourie’s (1969) was followed for measurement. The necessary anatomical landmarks and the sites for skinfolds were marked with a sketch pen. All measurements were recorded to the nearest of centimeter but only
skinfolds measurements were recorded to the nearest of millimetre. Each side was measured twice.

7. To collect the data for physical fitness of **AAHPER YOUTH FITNESS TEST (1976)** was used.

**The original batteries are as follows:**

1. Arms/shoulder muscular endurance - Pull ups
2. Muscular strength + endurance - Bent knee sit ups (in 60 sec.)
3. Speed and agility - shuttle run (10 x 4 yards)
4. Explosive strength of legs - standing broad jump
5. Speed and explosive strength - 50 yards dash
6. Cardiovascular endurance - 600 yards run/walk
7. Flexibility - Wrist and Ankle flexibility

**B. Dependent Variables**

Overall kho-kho playing ability of each player was evaluated by three kho-kho coaches/experts on the basis of individuals running and chasing skills and the average score was taken as final score.

**RELIABILITY OF DATA**

The reliability of data was ensured by establishing the instrument reliability.

**Instrument Reliability**

Measuring steel tape, skinfold caliper, vernier caliper, anthropometric rod and stop watches used in the study were obtained from standard firm and most of the instruments were available in the research laboratory of department of physical Education, Himachal Pradesh University, Shimla. Their calibrations were accepted as accurate enough for the purpose of the study.
RELIABILITY OF MEASUREMENTS

To ensure that the investigator was well versed in the techniques of conducting the tests he had a number of practice sessions in the testing procedure under the guidance of the expert Dr. Ramesh Kumar Chauhan, Chairman, Department of physical education, Himachal Pradesh University, Shimla. The measurements for different sites that are linear circumferences, diameters and skinfolds were taken and recorded. After two days, the same measurements were taken on the same subjects and under the similar conditions. Then the coefficient of correlation by person’s product moment method was calculated which provide the reliability.

Co-efficient of correlations of measurements of equipments used are shown in the following tables:

Table 3.1 (Reliability Co-efficient of correlation)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Variables correlated</th>
<th>Co-efficient of correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Linear Measurements</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Weight</td>
<td>0.99</td>
</tr>
<tr>
<td>2.</td>
<td>Height</td>
<td>0.99</td>
</tr>
<tr>
<td>3.</td>
<td>Sitting Height</td>
<td>0.98</td>
</tr>
<tr>
<td>4.</td>
<td>Leg Length</td>
<td>0.96</td>
</tr>
<tr>
<td>5.</td>
<td>Lower Leg Length</td>
<td>0.98</td>
</tr>
<tr>
<td>6.</td>
<td>Total Arm Length</td>
<td>0.98</td>
</tr>
<tr>
<td>7.</td>
<td>Fore Arm Length</td>
<td>0.98</td>
</tr>
<tr>
<td>8.</td>
<td>Foot Length</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td><strong>Skeletal Diameters (Width)</strong></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Shoulder Diameter (Biacromial)</td>
<td>0.99</td>
</tr>
<tr>
<td>10.</td>
<td>Abdominal Diameter</td>
<td>0.99</td>
</tr>
<tr>
<td>11.</td>
<td>Hip Diameter</td>
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</tr>
<tr>
<td>12.</td>
<td>Elbow Diameter</td>
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</tr>
<tr>
<td>No.</td>
<td>Measurement</td>
<td>Value</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------------------</td>
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</tr>
<tr>
<td>13.</td>
<td>Femur Bicondylar Diameter</td>
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<tr>
<td>14.</td>
<td>Ankle Diameter</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td><strong>Circumference Measurements</strong></td>
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</tr>
<tr>
<td>15.</td>
<td>Chest circumference (normal)</td>
<td>0.98</td>
</tr>
<tr>
<td>16.</td>
<td>Upper arm circumference</td>
<td>0.95</td>
</tr>
<tr>
<td>17.</td>
<td>Shoulder circumference</td>
<td>0.99</td>
</tr>
<tr>
<td>18.</td>
<td>Thigh circumference</td>
<td>0.97</td>
</tr>
<tr>
<td>19.</td>
<td>Calf circumference</td>
<td>0.92</td>
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<tr>
<td></td>
<td><strong>Skinfold Measurements</strong></td>
<td></td>
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<tr>
<td>20.</td>
<td>Biceps skinfold</td>
<td>0.89</td>
</tr>
<tr>
<td>21.</td>
<td>Triceps skinfold</td>
<td>0.88</td>
</tr>
<tr>
<td>22.</td>
<td>Sub scapular skinfold</td>
<td>0.89</td>
</tr>
<tr>
<td>23.</td>
<td>Suprailliac skinfold</td>
<td>0.98</td>
</tr>
<tr>
<td>24.</td>
<td>Thigh skinfold</td>
<td>0.99</td>
</tr>
<tr>
<td>25.</td>
<td>Calf skinfold</td>
<td>0.99</td>
</tr>
<tr>
<td>26.</td>
<td>Chest skinfold</td>
<td>0.88</td>
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<td></td>
<td><strong>Physical Fitness Measurements</strong></td>
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<td>27.</td>
<td>Pull ups</td>
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<tr>
<td>28.</td>
<td>Bent knee set-ups (in 60 second)</td>
<td>0.98</td>
</tr>
<tr>
<td>29.</td>
<td>Shuttle run (10 x 4 yards)</td>
<td>0.90</td>
</tr>
<tr>
<td>30.</td>
<td>Standing broad jump</td>
<td>0.84</td>
</tr>
<tr>
<td>31.</td>
<td>50 yards dash run</td>
<td>0.98</td>
</tr>
<tr>
<td>32.</td>
<td>600 yards run/walk</td>
<td>0.93</td>
</tr>
<tr>
<td>33.</td>
<td>Wrist flexibility</td>
<td>0.99</td>
</tr>
<tr>
<td>34.</td>
<td>Ankle flexibility</td>
<td>0.99</td>
</tr>
</tbody>
</table>

N=10 df= 8 significant at 0.01% level,  \( r = 0.765 \)  
significant at 0.05% level,  \( r = 0.632 \)

As is evident from table 3.1 the co-efficient of correlation are significant at 5% level. It is evident that tester reliability was significantly high. This established the competency of the scholar to administrate the test.
RELIABILITY OF SUBJECT

The above test retest co-efficient of correlation method also established that subject reliability was significant at 0.5% level of confidence, as the same subjects were used under similar conditions by the same tester and no motivational techniques were used nor any training was given.

COLLECTION OF DATA

The necessary data were collected by administering the tests for the chosen kinanthropometric variables, physical fitness variables and kho-kho playing ability. All the tests were administered during H.P. University kho-kho (Men) championship held at G.C. Karsog in December 2012.

The subjects were given a chance to practice the prescribed test so that they might become familiar with the tests and knew exactly what was to be done. All the tests were conducted in three days. To ensure uniform testing conditions the subjects were tested only during the morning and evening sessions. The use of apparatus was explained to them prior to the administration of tests.

An assistant was also trained for recording the data, which was well versed with the chosen kinanthropometric measurements. He accompanied the investigator to all places in connection with collection of data. Standard equipments were used to collect the data. Necessary instructions and demonstrations were given to the subjects before the conduct of the test.

All the kinanthropometric measurements were taken on the right side of the individual. Standard technique, described by Weiner and Lourie’s (1969) was followed for measurements. The necessary anatomical landmarks and the sites for skinfolds were marked with a sketch pen. The body weight was recorded to the nearest of half a kilograms, linear measurements,
circumferences, diameters to the nearest of 1/10 of a centimeter and skinfold measurements to the nearest of a millimeter.

**ADMINISTRATION OF TESTS**

**Independent Variables**

The technique used for taking various kinanthropometric measurements were as follows:

1. **Age**

   **Objective:** To record the chronological age of the subject.
   **Equipment:** School Record
   **Procedures:** The Age of each subject was calculated by subtracting date of birth of the players from the date of observation. The reading thus obtained was converted into year.
   **Scoring:** The age of the subject was recorded in years.

2. **Body Weight**

   **Objective:** To measure the total body weight of the subject.
   **Equipment:** Weighing machine.
   **Procedures:** The subject, wearing minimal clothes, stood erect in the center of the scaled platform of a standard portable weighing machine and the weight was recorded to the nearest half of kilograms. The zero of the scale was checked before taking each measurement.
   **Scoring:** The weight was recorded from the reading scale of the weighing machine in kilograms.
Linear Measurements

3. Height

Objective: To measure the height of the subject.

Equipment: Anthropometer Rod.

Procedures: It is the vertical distance from the vertex to the horizontal ground. The stature was measured with an anthropometric rod. The measurement was taken with the subject standing straight against an upright wall, touching it with heels, buttocks and back. The head was oriented in the Frankfurt plane, and the heels were together, and the hands were hanging downwards. The subject was stretched upward by a gentle traction on the mastoid region, taking care that the heels were kept on the ground. The anthropometer was held vertically in front of the subject in mid sagittal plane and the horizontal movable bar was brought down to touch the point vertex.

Fig. 3.2

Scoring: The height was recorded to the nearest of a centimeter.
4. **Total arm length**

   **Objective:** To measure the length of arm.

   **Equipment:** Anthropometer Rod.

   **Procedures:** It is the distance between acromion point and dectylion point. The subject was asked to stand in a comfortable position. One end of the anthropometer was fixed at a acromion point and the anthropometric was adjusted upto dectylion point.

   ![Fig. 3.3](image)

   **Scoring:** The reading was recorded up to nearest 1/10 centimeter.
5. Fore arm length

Objective: To measure the vertical distance between the radial and stylion.

Equipment: Anthropometer Rod.

Procedure: It is the straight distance between the points radials and stylion, measured with the anthropometric upper segment while the individual stood erect with his arms hanging down freely.

![Image of measurement](image)

Fig. 3.4

Scoring: The forearm length was recorded to the nearest centimeter.
6. Leg length

Objective: To measure the length of legs.

Equipment: Anthropometer Rod.

Procedure: The distance between the anterior superior iliac spine and the standing surface was measured with the anthropometric rod with the subject in the same position as that for stature.

Fig. 3.5

Scoring: Length of leg was recorded to the nearest centimeter.
7. Sitting height

Objective: To measure the sitting height of the subject.

Equipment: Anthropometer Rod.

Procedure: It is the vertical distance from the point vertex to the sitting plane. The subject was asked to sit erect on a table with his feet unsupported, the hands resting on the thighs. The head was oriented in the frankfurt plane, gentle upward traction was erected on the mastoid region and the distance between the vertex and the table top was measured with an anthropometric rod touching the back of the subject at the sacral and inter scapular regions in the mid sagittal plane.

Fig. 3.6

Scoring: The sitting height reading was recorded up to 1/10 of a centimeter.
8. Lower leg length

Objective: To measure the vertical distance between tibia and Spherion.

Equipment: Anthropometer Rod.

Procedure: It is the straight distance between the superior surface of the medial condyl of the tibia and the floor. The subject was asked to stand in an erect position. The distance between the tibial and the standing surface was measured with anthropometer rod.

Fig. 3.7

Scoring: The result was recorded from the reading scale of the anthropometer rod in centimeter.
9. Foot Length

Objective: To measure the straight distance of foot.

Equipment: Anthropometer Rod.

Procedure: It is the distance between the tip of the most tarsal phalange and the most posterior part of the calcaneus. The measurement was taken with the help of Anthropometer Rod. The subject was asked to stand in a comfortable position with feet slightly apart.

Fig. 3.8

Scoring: Results was recorded from the reading scale of Anthropometer Rod in centimeter.
Skeletal diameters (width)

10. Shoulder diameter (biacromial)

Objective: To measure the diameter of the shoulder.

Equipment: Anthropometer Rod or Rod Compass.

Procedure: With the individual standing in a relaxed position and arms hanging down freely, the distance between the most lateral points of acromial processes on either side was measured with the help of Anthropometer Rod upper segment by standing behind the subject.

Scoring: Results was recorded form the reading scale of the Anthropometer rod or Rod Compass in centimeter.
11. Abdominal diameter

Objective: To measure the abdominal diameter of the subject.

Equipment: Anthropometer Rod or Rod Compass.

Procedure: It measures the minimum girth of abdomen above the navel cavity. The Anthropometer Rod was wound around the place where right and left abdomen wall are most sunk between costal bow and iliac edges.

Fig. 3.10

Scoring: The measurement was recorded in centimeter by the unit of 1/10 centimeter.
12. Hip diameter

Objective: To measure the diameter of the Hip.

Equipment: Anthropometer Rod and Rod Compass.

Procedure: The individual was asked to stand in an erect position with feet together. The measurement was taken with the help of anthropometer compass. The anthropometer upper segment was adjusted on the hip of the level of greater trochanter of the two sides.

Fig. 3.11

Scoring: Measurement was record to the nearest centimeter.
13. Elbow diameter

Objective: To measure the diameter of the Elbow.

Equipment: Sliding caliper

Procedure: The individual was asked to stand in an erect position. The elbow was raised horizontally and forearm at 90° the distance between the medial and lateral epicondyles, was measured with the help of sliding caliper with slight pressure on the cross bar.

Fig. 3.12

Scoring: Measurement was recorded to the 1/10 of a centimeter.
14. **Femur bicondylar diameter**

**Objective:** To measure the straight distance between the outermost points of the condyles on the lower end of Femur.

**Equipment:** Sliding Caliper

**Procedure:** With the individual seated on a table and the knee bent at a right angle, greatest distance between the lateral and medial epicondyles of the femur was measured with the help of Sliding calipers with slight pressure on the cross bar.

![Fig. 3.13](image)

**Scoring:** Results was recorded from the reading scale of the Sliding Caliper in centimeter.
15. **Ankle diameter**

Objective: To measure the diameter of the Ankle.

Equipment: Sliding Caliper

Procedure: It is the straight distance between the medial tibia and lateral malleolus of the fibula. The Sliding Caliper was used to measure the ankle diameter.

![Fig: 3.14](image)

Scoring: Results were recorded from the reading scale of the Sliding Caliper in centimeters.
Body Circumferences (girths)

16. Shoulder circumference

Objective: To measure the circumference of the shoulder.

Equipment: Flexible Steel Tape.

Procedure: It was measured along laterally at the maximal protrusion of the deltoid muscles and anteriorly at the articular prominence of the sternum and second rib. The subject was asked to stand in comfortable position. Measurement was taken with the help of a flexible steel tape. The tape was applied in such a manner that it touched the maximal protrusion of the deltoid muscles and the articular prominence of the sternum and second rib.

![Fig. 3.15](image)

Scoring: Result was recorded from the reading scale of the steel tape in centimeter.
17. **Chest circumference (normal)**

Objective: Measure the chest circumference of the subject is breathing normally.

Equipment: Flexible Steel Tape.

Procedure: It was measured along with nipple at mid tidal volume. The subject was asked to stand in easy position and measurement was taken in a relaxed phase. The flexible steel tape was applied in such a manner that it touched the lower angle of shoulder blades in the back and was directly above the nipple in front.

![Fig. 3.16](image)

Scoring: Value was recorded to the nearest centimeter.
18. Upper arm circumference

Objective: To measure maximum circumference of the upper arm.

Equipment: Flexible Steel Tape.

Procedure: It is the perimeter distance of the right arm parallel to the long axes of the humerus when the subject stands erect and the relaxed arm hangs by the sides. The tape was held at the measured and marked mid-acromiale radiale distance.

Fig. 3.17

Scoring: Result was recorded to the nearest centimeter.
19. Thigh circumference

Objective: To measure the circumference of the thigh at the lowest point in the gluteal furrow and horizontal to the thigh.

Equipment: Flexible Steel Tape.

Procedure: It was measured just below the gluteal fold or maximal thigh girth. Subject was asked to stand in a relaxed position with feet slightly apart and weight equally distributed on both the feet. Steel tape was located horizontally around the left thigh at a point of greatest girth.

![Fig. 3.18](image)

Scoring: Result was recorded from the reading scale of the steel tape in centimeter.
20. Calf circumference:

Objective: To measure the circumference of the calf muscles.

Equipment: Flexible Steel tape.

Procedure: The maximum circumference of calf was measured with the help of steel tape, when the subject was standing with his feet slightly apart and his weight equally distributed on both legs.

Fig. 3.19

Scoring: Results was recorded from the reading scale of the steel tape in centimeter.
Skinfold measurement

Body fat was estimated through skinfold measurement which was taken with the help of an Indian version Lange’s skinfold caliper.

The measurements of skinfold are based on the knowledge, that approximately fifty percent of depot fat is stored in special cells with in subcutaneous areas. Skinfold is a fold consisting of two layers of skin and subcutaneous structures, which can be picked up with the help of thumb and index finger. The thickness of the fold will depend upon the amount of stored fat and can be measured with a special instrument called a skinfold caliper. A caliper is designed to exert a pressure on caliper force of 10 grams per square millimeter. The calipers are actually designed for measuring the thickness of double layer of skin and interposed layer of fat. There are only slight differences between individuals in the thickness of the skin, so the resulting value is an indirect estimate of individual differences in the thickness of subcutaneous fat. When measuring skinfold thickness, it is essential to determine precisely the location of the site. Likewise it is important to hold the skinfold firmly and maintain a constant distance between the caliper and the thumb and finger holding the site. The number of sites at which skinfold can be measured are practically limitless, but only a few have been found to be of value in estimating body density, percent fat, fat weight and lean body mass. In the present study the following skinfold measurement were selected:-

i) Biceps skinfold  
ii) Triceps skinfold  
iii) Chest skinfold  
iv) Sub scapular skinfold  
v) Suprailiac skinfold  
vi) Thigh skinfold  
vii) Calf skinfold.

All the measurements were taken on the right side of the body with subjects in the standing position. Each side was measured twice, whenever these were a discrepancy of more than one percent between the two values, a third measurement was taken. To eliminate the possibility of experimenter bias,
the first series of measurements was completed prior to starting the second series of measurements so that there was no recollection of the previous measurements for any one site. The mean of the measurements scores was taken as score of individual players.

21. Biceps skinfold

Objective: The biceps skinfold is measured on the mid-upper arm over the biceps muscles.

Equipment: Skinfold Caliper.

Procedure: The skinfold was measured by raising a vertical fold at the marked mid acromial radial line on the anterior surface of the arm. The subject stood with the arms hanging down freely. Special care was taken not to grasp the underlying muscular tissues.

Scoring: Result was recorded from the circular reading scale of the skinfold caliper in millimeter.

Fig. 3.20
22. Triceps skinfold

Objective: The triceps skinfold measured on the back of the left upper arm over the triceps muscles.

Equipment: Skinfold Caliper.

Procedure: The skinfold was measured in the midline of the posterior aspect of the arm, over the triceps muscle, at a point midway between the lateral projection of the acromion process of the scapula and the inferior margin of the colcannon process of ulna.

![Image of triceps skinfold measurement](image)

Fig. 3.21

Scoring: The reading was noted in millimeter.
23. **Chest skinfold**

**Objective:** The Chest skinfold is measured on the site just lateral to the nipple.

**Equipment:** Skinfold Caliper.

**Procedure:** The chest skinfold was measured using a skinfold with its long axis directed to the nipple. The skinfold was picked up on the anterior auxiliary fold as high as possible; the thickness was measured one cm inferior to this.

![Fig. 3.22](image)

**Scoring:** Measurement was recorded up to 1/10 of a millimeter.
24. **Sub scapular skinfold**

Objective: To measure the sub scapular skinfold of the subject.

Equipment: Skinfold Caliper.

Procedure: The skinfold was picked up on a diagonal inclined infero-laterally approximately 45 degree to the horizontal plane in the natural cleavage lines of the skin. The thickness of the fold was measured with the help of skinfold caliper.

![Fig. 3.23](image)

Scoring: Measurement was recorded upto 1/10 of a millimeter.
25. Suprailiac skinfold

Objective: To measure the Suprailiac skinfold of the subject.

Equipment: Skinfold Caliper.

Procedure: It is the measurement of the skinfold immediately superior to the iliac crest at the mid-auxiliary line. The skinfold was held firmly between the thumb and index finger at 45 degree to the anterior suprailiac spine on a diagonal line going downwards and inwards and measurements was taken with the help of caliper.

Fig. 3.24

Scoring: Result was recorded from the circular reading scale of the skinfold caliper in millimeter.
26. Thigh skinfold

Objective: The thigh skinfold is measured on the mid-thigh region of the subject.

Equipment: Skinfold Caliper.

Procedure: The thigh skinfold was measured in the midline of the anterior aspect of the thigh, midway between the inguinal crease and the proximal border of the patella. The thickness of a vertical fold was measured in millimeter while the subject stood relax.

Scoring: Result was recorded from the circular reading scale of the skinfold caliper in millimeter.
27. Calf skinfold

Objective: The medial calf skinfold is measured on the medial side of the calf muscles.

Equipment: Skinfold Caliper.

Procedure: The vertical fold was picked up on the posterior side of the lower leg at the level of the maximum girth of the calf and measurement was recorded.

Scoring: Result was recorded from the circular reading scale of the skinfold caliper in millimeter.

Fig. 3.26
Estimation of Body Composition

The four skinfold measurements were used to estimate body density, percent fat, fat weight and lean body mass as the main constituents of body composition. The description of these variables and the method of their estimation are given below.

28. Body Density

This indicates the weight in grams per cubic centimeter of body tissues. Body density is estimated from the sum of four skinfold measurements (Biceps, Triceps, Subscapular and Superailiac). In the present study body density was estimated using Durnin and Rehman’s Equation (1967). The formula is as follows:-

\[
\text{Body Density (y) = 1.1533 - 0.0643 X}
\]

(where X = sum of four skinfold in millimeters converted in logarithms).

29. Percent fat

Percent fat is the amount of fat in 100 Kg. of body weight. It was calculated from body density using Siri’s (1951) formula which is given as under:-

\[
\text{Percent fat} = \left(\frac{4.95}{\text{Body Density}} - 4.50\right) \times 100
\]

30. Fat Weight

This is the weight of the overall body fat, which is deposited in the subcutaneous area of the body. About fifty percent of the depot fat is stored in specialised cells under the skin, the thickness of which depends upon the amount of fat in the body. This is calculated from the weight of the body and percent fat. The formula of Durnin and Rehman was used to estimate fat weight which is given below:

\[
\text{Fat weight} = \text{Body weight} \times \frac{\text{Percent Fat}}{100}
\]
31. Lean body mass

This is the amount of muscle mass in the body. Lean body mass is considered to be divisible into biological constant proportions. These would include water (70-72%), minerals (7%) and organic substances including an undermined but probably constant percentage (2-3%) of essential liquids in bone marrow, the central nervous system and other organs. In other words, the lean body mass includes the weight of the essential fat (Bahnke and Wilmore, 1974). This is calculated by subtracting the fat weight from the total body weight. Again Durnin and Rahman’s formula is used to estimate the amount of lean body mass.

\[
\text{Lean body mass} = \text{Body weight} - \text{fat weight}
\]

Physical Fitness

To achieve the objectives of the present study, following physical fitness test were used.

1. Arms/shoulder muscular endurance - Pulls ups
2. Muscular strength + endurance - Bent knee sit ups (in 60 sec.)
3. Speed and agility - Shuttle run (10 x 4 yards)
4. Explosive strength of legs - Standing broad jump
5. Speed and explosive strength - 50 yards dash
6. Cardiovascular endurance - 600 yards run/walk
7. Flexibility - Wrist flexibility & Ankle flexibility
32. Muscular Strength (Pull-Ups)

Objective: The objective of this test was to measure arms and shoulder’s strength of kho-kho players.

Equipment: A wooden bar or metal bar approximately 1.5 inches in diameter and a stop watch and lime powder.

Procedure: A horizontal bar was fixed high enough so that the subjects could hang with their arms legs fully extended and their feet being off the floor. The subject were asked to use the over hand grasp (palms facing away from face) on the bar. After assuming the hanging position, the subject raised his body by his arms until his chin crossed over the bar and then lowered his body to a full hang, as in the starting position. The exercise was repeated as many times as possible.

Additional Pointer:

1. The Swing of the body was not allowed during the execution of the movement.

2. The raising of the knees and kicking of the legs were not permitted.

Scoring: Maximum numbers of completed pull-ups are recorded in final score.
33. Muscular Endurance (Bent Knee Sit-Ups)

Objective: To measure the muscular endurance of the abdominal muscles of Kho-kho players.

Equipment: Mat, pen, paper and stop watch.

Procedure: The subjects were asked to assume a supine laying position on the floor with knees bent to an angle, a little less than 90 degrees and hands clasped behind the neck. The feet were held down by a partner. The subject brought his head and elbows forward in a curl-up motion, touching this position, the subject would go back to his starting position i.e. supine position.

Fig. 3.28

Additional Pointer:

1. The fingers remained locked behind the neck throughout the exercise.
2. The feet were held firmly by the partner at one position.

Scoring: The number of correctly executed bent knee sit-ups performed in one minute, were recorded as his score.
34. Agility (Shuttle Run)

Objective: To measure speed and agility of the subjects.

Equipment: Two wooden blocks of size 2”×2”×4” a stop watch and lime powders.

Procedure: Two parallel lines, 30 feet apart were marked on the ground. Blocks of wooden were placed on one of the lines. The subjects started from behind the other linen. On the sound of the clapper, the subject ran to the blocks, picked up one, ran back to the starting lines and placed the behind the lines. He then ran back picked up the second block, which he carried back across the starting line. As soon as the block was placed on the grounds, timekeeper stopped the watch and recorded the time.

Additional Pointer

1. Two trails were allowed with an interval during which another pair of students were tested.

Scoring: The maximum time taken by subject to place both the blocks behind the starting line will be recorded as the final score for this test.
35. Muscular Power (Standing Broad Jump)

Objective: To measure explosive strength of legs.

Equipment: Measuring tape and jumping pit.

Procedure: The subject stood with the feet comfortably apart and the toes just behind the take-off line. Preparatory to jump the subject swung the arm backwards and bent the knees. The jump was accomplished by simultaneously extending the knees and swinging the arms forward.

Additional Pointer

1. Measurement was taken from the take-off line to the heel or other part of the body that touched the pit nearest to the take-off line.
2. Running or stepping was not permitted.

Scoring: The best out of three trials was recorded in centimeter as his score.
36. **Speed (50 Yard Dash)**

**Objective:** The purpose of this test to measure the sprinting speed of the subject.

**Equipment:** Clapper and stop-watches.

**Procedure**

On the track, a 50 yard distance was marked with the starting and the finishing lines. After a short warm up, the subjects took their position behind the starting line. On the sound of the clapper, the subjects started their race and ran as fast as possible up to the finishing line.

![Fig. 3.31](image)

**Additional Pointer**

1. The subjects were not allowed to touch or cross the starting line.
2. Stop watch was stopped as soon as the subject touched the tape.

**Scoring:** The time was recorded to the nearest one tenth of a second.
37. Cardiovascular Endurance (600 Yard Run/Walk)

Objective: To measure cardiovascular endurance of the subject.

Equipment: Stop watch, wooden clapper, measuring tape, marking powder.

Procedure: The test was conducted in 100 yards and 200 yards track as sufficient space was not available in many of the college instructions were given to all the subjects about starting and the number of laps they had to complete. Four to eight subjects ran at a time. The subjects used standing start. At the sound of the wooden clapper, the subjects started running/walking.

Additional Pointer:

1. The subjects were permitted to complete the test by running or walking or both.

2. Without getting the signal “Go” Subjects should not cross the starting line.

Scoring: Time was recorded in minutes and seconds as one’s score.
38. Wrist Flexibility

Objective: The purpose of this test was to measure the wrist flexibility of the subjects.

Equipment: Double armed goniometer, bench, and table.

Procedure: The subject was asked to sit on a bench putting his fore arm forward on the table with hand in the ‘shake hand’ position, with finger and thumb close together. The elbow was kept flexed. The fixed arm of the goniometer was placed on the radial bone and moving arm in line with the thumb so that axis of the goniometer fell on the wrist joint.

The subject was asked for complete flexion his wrist and then extension his wrist to the maximum. Moving arm of the goniometer moved along with the thumb on the protector.

![Fig. 3.33](image)

Scoring: The angle through which the wrist moved from flexion to extension was measured of the both hands of subject separately and the average score was recorded in degree.
39. Ankle Flexibility

Objective: The purpose of this test was to measure the ankle flexibility of this subject.

Equipment: Double armed goniometer, bench.

Procedure: The subject was asked to sit on a bench putting his leg straight and easy on the bench. The fixed arm of the goniometer was placed on the shin bone (tibia) and moving arm in line with the greater toe of the foot so that the axis of the goniometer fell on the ankle joint.

The subject was asked to dorsiflexion and then planter flexion the foot to the maximum. Moving arm of the goniometer moved along with the foot on the protector.

Scoring: The angle through which the foot moved from dorsiflexion to planter flexion was measured of the both feet of the subject separately and the average score was recorded in degrees.
Dependent Variable

Kho-Kho Playing Ability (Five point rating scale)

Objective: The purpose of this test was to judge the playing ability of Kho-kho Players.


Procedure: The Kho-kho playing ability was judged in the light of the five point rating scale by a panel of three judges who had sufficient experience in the game of Kho-Kho. (Five point rating scale is given in the appendix). For this the total eighteen subjects were divided into two equal teams. They were put in a real game situation and the experts on the basis of five point rating scale, assessed each individual according to their performance of the techniques and tactics during play.

Fig. 3.35

Scoring: The score was the average of the three expert’s ratings.
STATISTICAL DESIGN FOR ANALYSIS OF DATA

The relationship between kinanthropometric variables, physical fitness variables (independent) and Kho-Kho playing ability (dependent variable) were established, by computing Pearson’s product moment coefficient of correlation i.e.

\[
r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2]} [n\Sigma y^2 - (\Sigma y)^2]}
\]

Where x and y are the raw scores for independent and dependent variables, N is number of subjects tested.

The independent variables for the computation of multiple regression analysis, were selected by using the Wherry-Doolittle Test selection method as used by Garrett (1981) for Kho-Kho playing ability test separately.

Multiple correlations and corresponding multiple regression equations were computed using Wherry-Doolittle Method to find out the combined effect of independent variables, and for the prediction of Kho-Kho playing ability test (Clarke, H.H. and Clarke, D.H. 1972).

The multiple regression equation utilized is as under:

\[
Y_c = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + \ldots + B_nX_n
\]

Where \(X_1, X_2, X_3, \ldots X_n\) independent variables, \(Y_c\) is predicted performance \(B_1, B_2, B_3, \ldots B_n\) are regression coefficients \(B_0\) is constant.

Standard error of estimate was computed using following formula:

\[
\text{S.E. of Estimate (} \sqrt{\text{est}} \text{)} = \sqrt{C \sqrt{1 - R^2}} - C(X_1X_2X_3)
\]

Where \(\sqrt{C}\) is standard Error of Criterion Variable Score i.e. Playing Score
And \( R_c(X_1X_2X_3) \) = Coefficient of multiple correlation between criterion variables and independent variables \( X_1, X_2, X_3 \) etc.

The percentage contribution of each independent (predictive) variables towards \( R^2 \) (Multiple coefficient of Determination) was calculated using following procedure (Garrett, 1981).

In the multiple regression equation

\[
\bar{Y}_c = B_0 + B_1X_1 + B_2X_2 + B_3X_3
\]

The regression coefficients \((B_xS)\) give the weights to be attached to the scores \( X_1, X_2, X_3 \) independent variables or in other words \( B_xS \) tells us the amount by which score in \( X_1, X_2, X_3 \) must be multiplied in order to give the best prediction of \( \bar{Y}_c \). But these weight \((B_xS)\) do not give us the relative importance or contribution of \( X_1, X_2, X_3 \) etc. in predicting the Playing Ability \( \bar{Y}_c \). The contribution of each independent variable is given by ‘Beta Weight’ also called ‘Beta Coefficient’ which may be calculated directly from regression coefficient \((B_xS)\) as follows:

\[
\text{Beta Coefficient (B_x)} = B_x \times \frac{\sqrt{X}}{\sqrt{\bar{Y}_c}}
\]

Where \( B_x = \text{Regression Coefficient of independent variable X} \)

\( \sqrt{X} = \text{S.D. of independent variables score X and} \)

\( \sqrt{\bar{Y}_c} = \text{S.D. of dependent (criterion) variables score.} \)

Also \( R^2 \) the multiple coefficient of determination can be expressed in terms of Beta Coefficient i.e.

\[
R^2 = B_{1x1}Y_c + B_{2x2}Y_c + B_{3x3}Y_c \ldots
\]
Where \( B_1, B_2, B_3 \) are Beta Coefficient of independent variables \( X_1, X_2, X_3 \) and \( r_{1x} Y_c, r_{2x} Y_c, r_{3x} Y_c \) are coefficient of correlation of independent variables \( X_1, X_2, X_3 \) with the criterion variables \( Y_c \).

The terms \( B_{1rx} Y_c, B_{2rx} Y_c \) and \( B_{3rx} Y_c \) denote the contribution of each independent variable towards \( R^2 \). So \( B_{1rx} Y_c \times 100, B_{2rx} Y_c \times 100 \) and \( B_{3rx} Y_c \times 100 \) give us percentage contribution of each independent variable towards the calculation of \( R^2 \). This value of \( R^2 \) denotes the proportion of the variance of the criterion measure (\( Y_c \)) attributable to the joint action of independent variables \( X_1, X_2, X_3 \) etc.

The statistical parameters like means, S.D. ‘S, S.E. ‘s, r’s (Coefficient of correlation between variables and Playing ability) and between the variables (inter correlations) Multiple Regression Analysis to find out the value of coefficient of multiple correlation (R’s), the multiple coefficient of determination (\( R^2 \)) Regression Coefficient and S.E. of Estimates etc. were computed using the Electric Computer Super-32 available at the Computer Center, Punjab University, Chandigarh.

The statistical parameters, like Beta Coefficients and the percentage contribution of each independent variables were calculated using simple calculator. All the computer programmes were first developed, tested, verified and applied to the present data.
CHAPTER-IV

ANALYSIS AND INTERPRETATION OF DATA

In the present chapter, the analysis and interpretation of data to presented in following parts:

1. Correlation between selected kinanthropometric variables and playing ability of kho-kho inter-college players.
2. Correlations between physical fitness variables and playing ability of kho-kho inter-college players.
3. Multiple correlations of selected kinanthropometric variables and physical fitness variables with playing ability of kho-kho players.
4. Prediction of multiple regression equation for the playing ability of kho-kho players with the selected kinanthropometric and physical fitness variables.

The analysis of data collected on one hundred twenty kho-kho players of Inter college level, discussion of the findings and hypothesis are presented in this chapter.

The data on the selected kinanthropometric and physical fitness variables along with the playing ability in kho-kho test was analyzed by computing Pearson’s Product Moment Method of coefficient of correlation in order to find out the relationship of these kinanthropometric variables and physical fitness variables to playing ability.

Multiple correlations between selected kinanthropometric and physical fitness variables (independent) of playing ability in kho-kho (dependent) variables were computed to assess the combined effect of kinanthropometric and physical fitness variables with kho-kho playing ability, using Wherry Doolittle method to find out coefficient of multiple correlations.
LEVEL OF SIGNIFICANCE

The level of significance to check the relationship obtained by Person’s Product Moment correlation, multiple correlation, step-wise regression equation ‘t’ ratio and ‘f’ ratio was set at 0.05 level of confidence which was considered appropriate because the research processes adopted did not involve highly sophisticated equipment demanding the application of more stringent levels of significance. In using the product moment correlation, a value of 0.174 was needed to be significant at the 0.05 level of confidence for 118 degree of freedom.

FINDINGS OF THE STUDY

The relationship between kinanthropometric and physical fitness variables with kho-kho performance, combined contribution of selected kinanthropometric and physical fitness variables with kho-kho performance and other statistics denoting their relationships are presented in a set of nine tables each. For example the relationship between kinanthropometric and physical fitness variables with performance in kho-kho players is presented in tables 4.1 to 4.9 and so on.
Table 4.1

Relationship of age and weight with playing ability of Kho-Kho players

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Variables</th>
<th>Coefficient of correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
<td>0.074</td>
</tr>
<tr>
<td>2</td>
<td>Weight</td>
<td>0.084</td>
</tr>
</tbody>
</table>

N = 120  
$r$ = 0.174  
$df$ = 118

Table 4.1 clearly shows that age and weight were found positive but not significant at any level of significance with playing ability of kho-kho Players. Hence, it is show that age and weight do not contribute to the playing ability of kho-kho players.
Table 4.2

Relationship of linear kinanthropometric variables with playing ability of kho-kho players.

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Variables Correlated</th>
<th>Coefficient of correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Height</td>
<td>0.245*</td>
</tr>
<tr>
<td>2</td>
<td>Total arm length</td>
<td>0.312*</td>
</tr>
<tr>
<td>3</td>
<td>Forearm length</td>
<td>0.161</td>
</tr>
<tr>
<td>4</td>
<td>Leg length</td>
<td>0.010</td>
</tr>
<tr>
<td>5</td>
<td>Sitting height</td>
<td>0.124</td>
</tr>
<tr>
<td>6</td>
<td>Lower leg length</td>
<td>-0.079</td>
</tr>
<tr>
<td>7</td>
<td>Foot length</td>
<td>0.002</td>
</tr>
</tbody>
</table>

N = 120 *significant at 5% level r=0.174

Table 4.2, indicates that height (0.245) and total arm length (0.312) had positive and significant correlation at 0.05% level with playing ability of kho-kho players. Other variables of linear kinanthropometric i.e. forearm length, leg length, sitting height, lower leg length and foot length had no significant correlation with the playing ability of kho-kho players.

Diagram No- 4.2

Variables Correlated

<table>
<thead>
<tr>
<th>Coefficient of correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
</tr>
<tr>
<td>Total Arm Length</td>
</tr>
<tr>
<td>Fore Arm Length</td>
</tr>
<tr>
<td>Leg Length</td>
</tr>
<tr>
<td>Sitting Height</td>
</tr>
<tr>
<td>Lower Leg Length</td>
</tr>
<tr>
<td>Foot Length</td>
</tr>
</tbody>
</table>
### Table 4.3

Relationship of skeletal diameters (width) with playing ability of Kho-Kho players

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Variables Correlated</th>
<th>Coefficient of correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shoulder diameter (biocromial)</td>
<td>0.053</td>
</tr>
<tr>
<td>2</td>
<td>Abdominal diameter</td>
<td>0.109</td>
</tr>
<tr>
<td>3</td>
<td>Hip diameter</td>
<td>0.134</td>
</tr>
<tr>
<td>4</td>
<td>Elbow diameter</td>
<td>-0.003</td>
</tr>
<tr>
<td>5</td>
<td>Femur bicondylar diameter</td>
<td>0.011</td>
</tr>
<tr>
<td>6</td>
<td>Ankle diameter</td>
<td>-0.233*</td>
</tr>
</tbody>
</table>

N = 120  
* significant at 5% level \( r=0.174 \)  
\( \text{df} = 118 \)

It is evident from table 4.3, that Ankle diameter (-0.233) has negative and significant correlation at 5% level with playing ability of kho-kho players. Other variables of skeletal diameter i.e. shoulder diameter, abdominal diameter, hip diameter elbow diameter, and femur bicondylar diameter have no significant correlation with the playing ability of kho-kho players.

![Diagram No- 4.3](diagram.png)
Table 4.4

Relationship of Body circumferences (girths) with playing ability of kho-kho Players.

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Variables Correlated</th>
<th>Coefficient of correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shoulder circumference</td>
<td>0.071</td>
</tr>
<tr>
<td>2</td>
<td>Chest circumference (normal)</td>
<td>0.134</td>
</tr>
<tr>
<td>3</td>
<td>Upper arm circumference</td>
<td>-0.016</td>
</tr>
<tr>
<td>4</td>
<td>Thigh circumference</td>
<td>0.013</td>
</tr>
<tr>
<td>5</td>
<td>Calf circumference</td>
<td>0.115</td>
</tr>
</tbody>
</table>

N = 120  * significant at 5% level r=0.174  df = 118

Table 4.4, indicates that coefficient of correlation of shoulder circumference, chest circumference, thigh circumference and calf circumference were found positive but not significant at any level of significance with playing ability of kho-kho players. Upper arm circumference had negative correlation with playing ability of kho-kho players was also not found significant. Its shows that these body circumferences do not contribute to the playing ability of kho-kho players.
Table 4.5

Relationship of skin fold measurements with playing ability of kho-kho players

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Variables Correlated</th>
<th>Coefficient of correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biceps skin fold</td>
<td>0.230*</td>
</tr>
<tr>
<td>2</td>
<td>Triceps skin fold</td>
<td>0.016</td>
</tr>
<tr>
<td>3</td>
<td>Chest skin fold</td>
<td>0.040</td>
</tr>
<tr>
<td>4</td>
<td>Sub scapular skin fold</td>
<td>0.045</td>
</tr>
<tr>
<td>5</td>
<td>Suprailiac skin fold</td>
<td>0.087</td>
</tr>
<tr>
<td>6</td>
<td>Thigh skin fold</td>
<td>0.064</td>
</tr>
<tr>
<td>7</td>
<td>Calf skin fold</td>
<td>-0.016</td>
</tr>
</tbody>
</table>

N = 120

* significant at 5% level r=0.174

df = 118

From Table 4.5, it is clearly evident that biceps skinfold (0.230) has positive and significant correlation at 5% level with the playing ability of kho-kho players. Other skinfold measurement variables i.e. triceps skinfold, chest skinfold, sub scapular skinfold, suprailiac skinfold, thigh skinfold and calf skinfold have no significant correlation with playing ability of kho-kho players.
Table-4.6

Relationship of body composition variables with playing ability of kho-kho players.

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Variables Correlated</th>
<th>Coefficient of correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Body density</td>
<td>-0.088</td>
</tr>
<tr>
<td>2</td>
<td>Percentage Fat</td>
<td>0.080</td>
</tr>
<tr>
<td>3</td>
<td>Fat weight</td>
<td>0.086</td>
</tr>
<tr>
<td>4</td>
<td>Lean body mass</td>
<td>0.062</td>
</tr>
</tbody>
</table>

N = 120

* significant at 5% level r=0.174
df = 118

Table 4.6, indicates that coefficient of correlation of percentage fat, fat weight and lean body mass were found positive but not significant at any level of significance with playing ability of kho-kho players. Body density had negative correlation with playing ability of kho-kho players was also not found significant. It shows that these body composition variables do not contribute to the playing ability of kho-kho player.

![Diagram No- 4.6](image-url)
### Table 4.7

Relationship of physical fitness variables with playing ability of kho-kho players

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Variables Correlated</th>
<th>Coefficient of correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Muscular Strength</td>
<td>-0.104</td>
</tr>
<tr>
<td>2</td>
<td>Muscular endurance</td>
<td>-0.014</td>
</tr>
<tr>
<td>3</td>
<td>Agility</td>
<td>0.268*</td>
</tr>
<tr>
<td>4</td>
<td>Muscular power</td>
<td>-0.061</td>
</tr>
<tr>
<td>5</td>
<td>Speed</td>
<td>-0.215*</td>
</tr>
<tr>
<td>6</td>
<td>Cardiovascular Endurance</td>
<td>0.123</td>
</tr>
<tr>
<td>7</td>
<td>Wrist flexibility</td>
<td>0.169</td>
</tr>
<tr>
<td>8</td>
<td>Ankle flexibility</td>
<td>0.273*</td>
</tr>
</tbody>
</table>

N = 120 * significant at 5% level r=0.174

df = 118

From Table 4.8, shows that coefficient of correlations of speed component of physical fitness had negative but significant correlations with playing ability of kho-kho players at 5% level. Agility and ankle flexibility had positive and significant correlations with playing ability of kho-kho players at 5% level. Other components of physical fitness, i.e. muscular strength, muscular endurance, muscular power, cardio-respiratory endurance and wrist flexibility have no significant correlation with playing ability of kho-kho players. It suggests that agility, speed and ankle flexibility have inverse relations with playing ability of kho-kho players.

![Diagram No. 4.7](image-url)
Table: 4.8
Combined contributions of selected Kinanthropometric and Physical Fitness Variables with playing ability of kho-kho players

<table>
<thead>
<tr>
<th>Dependent (Criterion) variable (Yc)</th>
<th>Selected Independent Variables for Multiple correlation (X’s)</th>
<th>Coefficient of Multiple correlation (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Playing ability of Kho-Kho</td>
<td>Total Arm Length (X₄)</td>
<td>0.723</td>
</tr>
<tr>
<td></td>
<td>Sitting Height (X₇)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ankle Diameter (X₁₅)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agility (X₃₄)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Speed (S₃₆)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ankle Flexibility (X₃₉)</td>
<td></td>
</tr>
</tbody>
</table>

N = 120 * significant at 5% level, R=0.374
df = 113

It is evident from table 4.9, that the combined contributions R(0.723) of total arm length, sitting height, ankle diameter, agility, speed and ankle flexibility has significant multiple correlation at 5% level with the playing ability of kho-kho players, as the calculated value of R(0.723) is more than the tabulated value of (0.374) at 5% level. It shows that the combined contribution of these selected kinanthropometric and physical fitness variables taken together contribute to the playing ability of kho-kho players. Hence the regression equation of playing ability of kho-kho players could be developed by these six kinanthropometric and physical fitness variables i.e. total arm length, sitting height, ankle diameter, agility, speed and ankle flexibility.
Table: 4.9
Multiple Regression Analysis of Selected Kinanthropometric and Physical Fitness variables with playing ability of Kho-Kho players

<table>
<thead>
<tr>
<th>Dependent (Criterion) variable (Yc)</th>
<th>Selected Independent Variables for Multiple correlation (X’s)</th>
<th>Regression coefficient (Bx)</th>
<th>Coefficient of Multiple correlation (R)</th>
<th>Multiple Coefficient of Determination (R²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Playing ability of Kho-Kho</td>
<td>Total Arm Length (X₄)</td>
<td>0.309</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sitting Height (X₇)</td>
<td>0.206</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ankle Diameter (X₁₅)</td>
<td>-0.231</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agility (X₃₄)</td>
<td>0.271</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Speed (S₃₆)</td>
<td>-0.215</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ankle Flexibility (X₃₉)</td>
<td>0.203</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bo (constant) = - 6.258  
S.E. of Estimate = 2.430

\[ P_{cx} = (\text{Beta weight}) \times (r) \times (100) \text{ where Beta weight} = Bx \times \frac{SD\ of\ X}{SD\ of\ Y} \]

And r= coefficient of correlation between X and Y

From table 4.9, clearly shows that the multiple regression analysis performed to develop equation for the prediction of playing ability of kho-kho players on the basis of i.e. Total Arm Length (X₄), Sitting Height (X₇), Ankle diameter (X₁₅), Agility (X₃₄), Speed (X₃₆), and Ankle Flexibility (X₃₉) in the score form is as follows:

\[ Y_c = Bo + B_1X_4 + B_2X_7 + B_3X_{15} + B_4X_{34} + B_5X_{36} + B_6X_{39} \]
Yc = -6.258 + 0.309 (total arm length) + 0.206 (sitting height) + -0.231 (Ankle diameter) + 0.271 (Agility) + -0.215 (Speed) + 0.203 (Ankle Flexibility).

Where Yc is = predicted playing ability of kho-kho players, \(X_4\) = Total Arm Length, \(X_7\) = Sitting Height, \(X_{15}\) = Ankle diameter, \(X_{34}\) = Agility, \(X_{36}\) = Speed, and \(X_{39}\) = Ankle Flexibility.

The value of determination of multiple correlation (\(R^2 = 0.523\)) indicates that 52.3 percent of variance in playing ability of Kho-Kho players is accounted by these six kinanthropometric and physical fitness variables i.e. total arm length, sitting height, ankle diameter, agility, speed and ankle flexibility while the remaining only 47.7 percent of the variance still to be accounted for other variables.

The standard error (S.E.) of estimate (2.430) as shown in the table (4.9) that 72.3 percent of the obtained strength plying ability scores lies within ± 2.430 of the playing ability score.

The multiple correlation obtained is of sufficient size so the equation developed can be put into the regression equation for the evaluation of the playing ability of kho-kho players with this degree of accuracy.

**DISCUSSION OF THE RESULTS**

The findings obtained from the present study are discussed taking into consideration their correlations, multiple correlations and regression equations of the related playing ability of kho-kho ho players. The discussion is given as under:

From the table 4.1, analysis of the result, it is clear that age and weight have no significant correlation with playing ability of kho-kho ho players, hence, age and weight do not contribute to playing ability of kho-kho players.
Table 4.2, it is evident that the linear kinanthropometric measurements i.e. height and total arm length have positive and significant correlations with the playing ability of kho-kho players at 0.05 percent level of confidence. It shows that height and total arm length contribute to the playing ability of kho-kho players. Other variables of linear kinanthropometric have insignificant correlation with the playing ability of kho-kho players.

The skeletal diameter i.e. ankle diameter has significant and negative correlation at 5% level as shows in the table 4.3. Other variables of skeletal diameter have no significant correlation with the playing ability of kho-kho players.

Table 4.4 shows that among the body circumference (girth) measurements have got insignificant relationship with playing of kho-kho players so, these variables do not contribute in the playing ability of kho-kho players significantly.

Further out of the skinfold measurement i.e. biceps skinfold has positive and significant correlation with playing ability of kho-kho players at 0.5% level of confidence as the calculated value of co-relations shown was more than that of the table value as shown in the table 4.5. Other skinfold measurements have no significant correlation with playing ability of kho-kho players. It shows these skinfold measurements do not contribute to the playing ability of kho-kho players.

Table 4.6 shows, that among the body composition variables i.e. percentage fat, fat weight and lean body mass have no significant correlations with playing ability of kho-kho players. Body density has negative but insignificant correlation with playing ability of kho-kho players. It shows, that these body composition variables do not contribute to the playing ability of kho-kho players.
From table 4.7, shows that coefficient of correlations of agility and ankle flexibility had positive and significant correlations with playing ability of kho-kho players at 0.5% level. Speed component of physical fitness has negative but significant correlation with playing ability of kho-kho players at 0.5% level. Other components of physical fitness have no correlations with playing ability of kho-kho players. It suggests that agility, speed and ankle flexibility have inverse relation with playing ability of kho-kho players.

Table 4.8, indicates that multiple correlation (R=0.723) of six selected kinanthropometric and physical fitness variables taken together with playing ability of kho-kho players have been found significant at 0.1% level. It suggests that the combined effect of these variables improves the playing ability of kho-kho players. These variables are good ingredients for better playing performance of kho-kho players. The multiple correlations is of sufficient size, so it can be put in to prediction equation.

From table 4.9, it is clear that these variables collectively contribute to the prediction equation of the playing ability of kho-kho players. Moreover, the value of multiple correlation of determination ($R^2=0.523$) which indicates that 52.3% of variance of performance score could be predicted on the basis of these variables. The remaining variance of performance is due to other factors i.e. psychological, sociological, physiological and environment factors. So the multiple regression equation developed could be put into prediction equation for the playing ability of kho-kho players.

DISCUSSION OF THE HYPOTHESIS

Hence, on the basis of the results obtained, the hypotheses framed in the present study are concluded as under:

The first hypothesis that there exist significant correlations between kinanthropometric variables and playing ability of kho-kho players has been partially accepted and partially rejected as some of the kinanthropometric variables are related to playing ability and some of them are not found to be significantly related.

The second hypothesis that there exist significant correlation between physical fitness variables and playing ability of kho-kho players has been partially accepted and partially rejected as some of the physical fitness variables are related to playing ability and some of them are not found to be significantly related.

The third hypothesis that playing ability in kho-kho could optimally be predicted on the basis of kinanthropometric and physical fitness variables has been accepted because kinanthropometric and physical fitness variables are found to be predictor of playing ability and multiple regression equations could be used for the prediction of playing ability of kho-kho player.
CHAPTER-V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

In this chapter, the summary of the previous chapter, introduction, review of literature, methodology and discussion are included. The conclusions drawn on the basis of the results obtained and the recommendations for further research have also been included:

SUMMARY

Sports performance is a multidimensional product of athlete’s capacities and their interaction with athletic environment. Being multidimensional it suggests that a variety of factors are involved in actually attaining performance goals.

Although successful athletes generally have typical performance characteristics, the pattern of these performance characteristics vary: from athlete to athlete. When an athlete is low in some such trait or traits, he compensates by another.

But among all performance factors, physical fitness development is prerequisite for all the athletes. However, importance of various components of fitness varies with different sports. Harre (1979) said, for a high level of performance physical fitness is most important and fundamental criteria.

Keeping in view of the significant contribution of kinanthropometric and physical fitness variables in the playing ability of a number of sports. An attempt was made to identify the important kinanthropometric and physical fitness variables to predict the physical ability of male kho-kho players.
OBJECTIVES OF THE STUDY

The objectives of the present study are formulated as under:

1) To determine the relationship between selected kinanthropometric variables and playing ability of male kho-kho players.
2) To determine the relationship between fitness variables and playing ability of male kho-kho players.
3) To determine the multiple correlation of selected kinanthropometric, fitness variables and playing ability of male kho-kho players.
4) To set up the regression equation for the prediction of playing ability on the basis of kinanthropometric and physical fitness variables of kho-kho players.

HYPOTHESES OF THE STUDY

1) There would be a significant relationship between kinanthropometric variables and playing ability of male kho-kho Players.
2) There would be a significant relationship between fitness variables and playing ability of male kho-kho Players.
3) Playing ability of kho-kho players could optimally be predicted on the basis of kinanthropometric and physical fitness variables.

DELIMITATIONS OF THE STUDY

1) The present study was based on 120 male kho-kho players which were playing from their respective colleges affiliated to Himachal Pradesh University, Shimla.
2) The study was confined only to male kho-kho players.
3) The study was delimited to the kinanthropometric variables, physical fitness variables and playing ability of kho-kho players.
4) The kinanthropometric variables were measured with the help of Anthropometric Rod, steel tape, Vernier caliper and Lange’s skinfold caliper.

5) Physical fitness variables were tested pull-ups, bent knee sit-ups in 60 sec., shuttle run 10 x 4 yards, standing broad jump, 50 yards dash, 600 yards run/walk, wrist flexibility and ankle flexibility.

6) The overall playing ability of the subjects was measured with five points rating scale.

7) Body composition was calculated by using skinfold measurements i.e. biceps, triceps, sub scapular and suprailiac skinfolds.

8) For the analysis and interpretation of data, statistical treatment was confirmed to Pearson’s product movement correlation (Zero order), multiple correlation and regression equation.

9) Data was collected during morning and evening session.

10) The age of the subjects was between 18 to 25 years.

**LIMITATIONS OF THE STUDY**

1) The factors like socio-economic condition, diet, rest, daily routine, lifestyle, habits etc. which might effect the result of the study were considered as limitation of the study.

2) The effect of weather condition during collection of data could influence the results and it was accepted as limitation of the study.

3) No special motivational technique was used during the test. Therefore, the difference that might have occurred in performance due to lack of motivation was recognized as the limitation of the study.

**SAMPLE:**

To accomplish the study, the researcher used random sampling techniques to select the subjects. The subjects were one hundred twenty male inter-college level kho-kho Players, who were studying in various affiliated
colleges and different departments of Himachal Pradesh University, Shimla and these subjects had participated in the Himachal Pradesh University inter-college kho-kho Competition for men which was held at Govt. College Karsog, Mandi Himachal Pradesh respectively in the month of December 2012. The subjects were in the age group of 18 to 25 years.

SELECTION OF VARIABLES:

A) Independent Variables:

1) Age
2) Body weight

Linear Measurements
3) Height
4) Total arm length
5) Fore am length
6) Leg length
7) Sitting height
8) Lower leg length
9) Foot length

Skeletal Diameters (Width)
10) Shoulder diameter (biocromiab)
11) Abdominal diamenter
12) Hip diameter
13) Elbow diameter
14) Femur bicondylar diameter
15) Ankle diameter

Body Circumferences (girths)
16) Shoulder circumference
17) Chest circumference (normal)
18) Upper arm circumference
19) Thigh circumference
20) Calf circumference

**Skin Fold Measurements**

21) Biceps skin fold
22) Triceps skin fold
23) Chest skin fold
24) Sub scapular skin fold
25) Suprailiac skin fold
26) Thigh skin fold
27) Calf skin fold

**Body Composition Variables**

28) Body density
29) Percentage fat
30) Fat weight
31) Lean body mass

**Physical Fitness Components**

32) Muscular Strength
33) Muscular Endurance
34) Agility
35) Muscular power
36) Speed
37) Flexibility Wrist Ankle flexibility

**B) Dependent Variables**

Overall kho-kho playing ability of each player was evaluated by three kho-kho caches/experts on the basis of individuals running and chasing skills and the average score was taken as final score.
TOOLS USED

1. The average score of the three experts was considered to judge kho-kho playing ability.
2. For measuring the height and weight, the anthropometer rods and portable lever actuated weighing machine were used.
3. A flexibility steel tape was used to measure the circumferences.
4. The lange’s skinfold caliper was used to measure the different skin fold measurements.
5. Diameters were taken with the help of vernier caliper and anthropometer compass.
6. The components of physical fitness and test items chosen to represent in the AAHPER YOUTH FITNES TEST (1976) were follows.

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Physical Fitness Components</th>
<th>Test Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Muscular Strength</td>
<td>Pull ups</td>
</tr>
<tr>
<td>2.</td>
<td>Muscular Endurance</td>
<td>Bent knee sit ups (in 60 sec.)</td>
</tr>
<tr>
<td>3.</td>
<td>Agility</td>
<td>Shuttle run (10x4 yards)</td>
</tr>
<tr>
<td>4.</td>
<td>Muscular Power</td>
<td>Standing broad jump</td>
</tr>
<tr>
<td>5.</td>
<td>Speed</td>
<td>50 yards dash</td>
</tr>
<tr>
<td>6.</td>
<td>Cardiovascular endurance</td>
<td>600 yards run/walk</td>
</tr>
<tr>
<td>7.</td>
<td>Flexibility</td>
<td>Wrist and Ankle Flexibility</td>
</tr>
</tbody>
</table>

COLLECTION OF DATA

All the body measurements were taken on the right side of the body of the subject.
Linear measurements, body circumferences, diameters and skinfold measurements were measured with the help of anthropometer rod, flexible steel tape, vernier caliper and skinfold caliper respectively.

Body composition variables were calculated using sum of biceps, triceps, subscapular, suprailiac skinfold, body density fat weight and lean body mass were calculated by using Durnin’s and Rehman’s (1967) method and percentage fat was calculate by using Siri’s (1956) formula. Body weight is measured by using portable weighing machine for all subjects. To measure the physical fitness of kho-kho players pull-ups for muscular strength, bent knee sit-ups (in 60 second) for muscular endurance, shuttle run (10 x 4 yards) for agility, standing broad jump for muscular power, 50 yards dash for speed, 600 yards run/walk for cardiovascular endurance, ankle flexibility and wrist flexibility for ankle and wrist joints movement were used.

To collect the data for playing ability, five point rating scale tests for players were utilized.

To achieve the objectives of the present study, the correlation by product moment method and multiple correlation and regression prediction equation by Wherry-Doolittle Methods were utilized.

**ANALYSIS OF DATA**

Person’s product moment coefficient of correlation was used to analyze the data to assess the relationship of overall Kho-Kho playing ability of male players with each of the kinanthropometric and physical fitness variables and multiple step-wise regression technique was used to identify the meaningful kinanthropometric and physical fitness test variables to predict playing ability of male kho-kho players.
CONCLUSIONS

On the basis of the discussion of the results in the 4th chapter, the following conclusions were made.

Results of male kho-kho players in relation to tested kinanthropometric and physical fitness variables.

1. Age and weight have no significant correlation with playing ability of kho-kho players. Hence, no age and weight contributes to playing ability of kho-kho players.

2. Height and total arm length have found positive and significant correlations with the playing performance of kho-kho players. Fore arm length, leg length, sitting height, lower leg length and foot length have no significant correlation with playing ability of kho-kho players.

3. Ankle diameter has found significant and negative correlation with the playing ability of kho-kho players and other variables such as shoulder diameter, hip diameter, elbow diameter and femur bicondylar diameter have no significant correlation with the playing performance of kho-kho players.

4. Shoulder circumference, chest circumference, upper arm circumference, thigh circumference and calf circumference have no significant correlations with the playing performance of kho-kho players.

5. Biceps skin fold has found positive and significant correlation with the playing performance of kho-kho players. Triceps skin fold, chest skin fold, sub scapular skin fold, suprailiac skin fold, thigh skin fold and calf skin fold have no significant correlations with the performance of kho-kho players.

6. Body density, percentage fat, fat weight and lean body mass have no significant correlations with the performance of kho-kho players.

7. Agility and ankle flexibility have found positive and significant correlations whereas speed has found negative and significant correlation with the playing performance of kho-kho players. Muscular
strength, muscular endurance, muscular power, cardiovascular endurance and wrist flexibility have no significant correlation with playing ability of kho-kho players.

8. Multiple correlation of various variable i.e. total arm length sitting height, ankle diameter, agility, speed and ankle flexibility, taken together had significant correlation with playing ability of kho-kho players. Multiple correlations is very high and hence the regression equation developed by this variables could be used for the prediction of the playing ability.

SUGGESTIONS AND RECOMMENDATIONS

In the light of the findings of the present study, the following recommendations are made to the coaches, physical educators, sports scientists and players.

1. The results of the study can be used by the coaches, physical education teachers and trainers as an aid in screening and selecting prospective kho-kho players.

2. On the basis of results, coaches and trainers might develop their training program laying more emphasis on the related kinanthropometric and physical fitness test variables proved to be important for the performance.

3. It is recommended that the similar study may be conducted by selecting subjects belonging to different age groups and levels of achievement other than those employed in the present study.

4. Similar studies may be conducted on various other sports and games.

5. It is recommended that similar study may be conducted on psychological variables and motor fitness variables.

6. To improve the standard of kho-kho players in India a talent hunt scheme should be launched specially for the rural area and players should be selected on the basis of their kinanthropometric and physical fitness parameters and given training.
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