INTRODUCTION
CHAPTER I

INTRODUCTION

1.1 Theoretical Orientation of the Problem

The hammer throw is said to have its roots in Scotland and Ireland history. Folklore claims an Irish hero named Cuchulain whirled a chariot wheel with an axle attached to it around his head and released it as the first person to throw a hammer (Black, 1989; Dziepak, 1998). People are familiar with the Scottish Highland Games, where events like the sheaf toss, weight throw for distance, and tossing the caber are the events and highlight the strength and power of the participants.

Another competition at these games finds men throwing the working sledge hammer or long hammer (Black, 1989). The long hammer is a metal ball attached to a 3/8” x 4 foot long wooden handle. The predecessor to this implement was a quarry rock attached to varying lengths of wooden handles (Black, 1989; Dziepak, 1998). Organizers eventually made a standard for the length of the hammer handle. The event evolved and split into two different forms: the working sledge hammer throw and the modern hammer. Both forms continue today.

One of the biggest improvements was the addition of turns during the event. Turns were introduced by A.J. Flanagan
in the 1890’s (Black, 1989). Prior to the introduction of turns, athletes delivered the hammer from a stationary position using an overhead motion to throw the hammer (Black, 1989; Dziepak, 1998). Throw distance increased dramatically as a result of the revolutionary addition of the turns. The wire hammer was legalized in 1896 (Dziepak, 1998). The last modification was the addition of a ball bearing swivel to a lead ball (Black, 1989; Dziepak, 1998). Equipment modifications improve performance results only so much. In reality, the ultimate success in athletics is defined by who is able to run the fastest, jump the highest, or throw the farthest.

The modern hammer currently is thrown currently at all levels of track and field. The modern hammer throw first appeared in the 1900 Olympics for men, but Women’s hammer throw was not introduced to the sporting world until 1995. Women’s hammer throw was finally included in the World Track and Field Championships in 1999 and the Olympics in 2000.

1.1.1 Physical characteristic

The modern hammer throw is a track event entailing speed, power and control. In hammer throwing, body mass and strength particularly in the legs, trunk, and arms are the most contributors to increasing the speed of the hammer at the release. The goal of the event is to throw the hammer the
farthest distance possible while maintaining the rules governing the event. A throw is built upon four components, each part being equally critical to the success of the throw (Woicik, 1980). A throw is accomplished by performing a series of winds, an entry into the turns, followed by three to four turns, ending in the release of the implement. Athletes alternate between single and double foot support as they move through the turns of the throw (Black, 1989). Errors in any of the four components negatively affects the distance the implement is thrown (Woicik, 1980). Proper technique is crucial to each throw. This depends upon some qualities i.e. speed, quickness of legs and coordination combined with a gymnastic type application of power are the major qualities vital to this event. (Jabs Rolfgunter, 1965; Ecker Tom, 1974; Jarver Jess, 1977; Tancred & Carter, 1980; Italy Pedomonte Jimmy, 1985; Boundertchuk, 1987). The technique used in the shot put today is aimed at increasing speed by using complimentary rotation and translation across the ring to move the implement forward at a high rate (Hay, 1993).

Understanding the physical characteristic of hammer thrower, technique and implement modifications helped to improve distances. Too tall persons do not fit in this event because of the problem of speed and coordination. An average
hammer throwers in the international class may possess a
weight about 100kg and plus but height should be about 190cm
(Vidyasagar, 1979). The important characteristics of hammer
throwers are the supplied hips and shoulders, length of the arms.
Height and long arms help make for a longer effective radius.
Bear in mind that centrifugal force is a function of turning speed
and the hammer radius; a shorter thrower will have to turn fast
than taller (Jabs Rolfgunter, 1965; Boundartchuk, 1987).

Science tells us there are specific factors helping
determine success in any event. These factors are
anthropometric and physical fitness qualities occurring in the
right combinations for the athlete. Johnson (1969) generalized
that it is dangerous heavier to increase loading above these
levels until the growth points or epiphyses of the long bones
have closed growth has ended. This occurs at approximately 16-
18 years. The optimum age for learning the skills and developing
speed is between 8-13 years. The loading they are expected to lift
are kept to less than 60% of maximum. Such lifting stimulates
both skeletal and muscular growth.

It should be remembered that younger athletes need
longer recovery times between work efforts in training than do
adults. Osolin & Markov suggested that one average the best
ratios of general training, to special training, to competition oriented training.

10-14 years - 62% General training, 17% special training and 21% competition oriented training. 15 to 17 years - 55% General training, 22% special training and 23% competition oriented training.

Anthropometrics are the physical characteristics including: segment length, segment weight, overall height, overall weight, body type, body composition. Physical fitness refers to maximum strength, explosive and reactive power, sprinting speed, low load and heavy load speed strength, special and specific strength unique to each individual. Anthropometrics and Physical fitness has helped to establish the current world records. Current world records in the hammer throw are as follows: 86.74 meters by Yuriy Sedykh in 1986 for the men and 77.41 meters by Tatyana Lysenko in 2006 for the women. Comparisons are made frequently between performance levels based upon sex. Each sex has characteristics contributing to success within their sport or event. The gap occurring between sex performance levels is decreasing in most sports (Ransdell and Well, 1999). For females, sex specific characteristics are helping to narrow the performance level gap (Alexander, Linder and Whalen, 1996; Ransdell and Well, 1999). Technique wise,
the similarities between the sexes include the length of the glide, the height of the center of gravity at the start of the throw, the height of the center of gravity at the end of the throw, and the angle of release (Alexander, Linder and Whalen, 1996). However, men being taller, larger framed, and having greater muscle mass are at an advantage in throwing the shot put farther.

Hammer throwers need to be strong like the shot putters; however they must be quick and technically sound due to the complexity of the event. Distinct anthropometrics differences occur between the sexes throwing the hammer. The differences in mass and size between the sexes has a distinct relationship on hammer throw technique. The time for overall throw, distance throw and time for each individual turn are variables anthropometric differences will affect (Baronietz, Barclay and Gathercole, 1997). Men being larger and throwing a heavier implement have to overcome larger amounts of inertia, centripetal and centrifugal forces to achieve throw success. Men throw an implement weighing 7.26 kg. Women throw an implement weighing 3.26 kg. less than the men. The difference in implement weight does factor into the amount of force needed to overcome inertia and to balance against the centripetal forces. The men have greater differences in time for each individual turn as they progress through the throw (Bosen, 1984). Due to larger
amounts of inertia, men begin slowly and increase their speed at a greater rate than women early in the throw (Baronietz, Barclay and Gathercole, 1997; Bosen, 1984; Romanov, et. al., 1998). Men turn more rapidly during the last two turns than women (Gutierrez, Soto and Rojas, 2002).

Another anthropometric characteristic is the location of the center of mass. Center of mass location for the thrower is different between the sexes due to differences in weight and mass distribution (Hay, 1993; Knudson, 2003; Kreighbaum, et. al., 1996). Smaller body mass and a lighter implement take women less energy to develop the counter against the forces acting upon them. (Hay, 1993; Knudson, 2003; Kreighbaum and Barthels, 1996). Men sit lower to counter the greater forces placed upon the system (Hay, 1993; Knudson, 2003; Kreighbaum and Barthels, 1996). The three determining factors of throw success are the velocity, height and angle at release (Hay, 1993; Knudson, 2003; Kreighbaum and Barthels, 1996). The most important factor is velocity at release (Hay, 1993). Men typically are capable of generating more force. This allows males to increase velocity to higher levels than females (Hunter and Killgore, 2003). In the hammer, the ability to maintain ground contact with both feet for as long as possible will enhance the acceleration of the ball (Bondarchuk, 1980;
Bondarchuk, 1982; Bosen, 1984). The ball will have a longer acceleration path which will allow for the increase in velocity to occur. Men have longer double support times in the first and third turns than women (Baronietz, Barclay and Gathercole, 1997; Baronietz and Borgstom, 1995; Romanov and Vrublevsky, 1998). Women are consistent with their time in double support (Baronietz, Barclay and Gathercole, 1997; Romanov and Vrublevsky, 1998). The added time in double support allows men to apply force for a longer period increasing velocity to higher rates than women.

Men being taller than most women will have an advantage. The extra height will allow the implement to travel further than the shorter female. (Hay, 1993; Knudson, 2003; Kreighbaum and Barthels, 1996).

Normally a person starts taking part in a game or event without proper guidance. It is thus a sheer chance that his choice of the sport may be suitable to his inherent capabilities. Therefore, the failure to become a champion in most of the cases is inevitable. Thus there is an urgent need to provide counseling to those endowed with such suitable characteristics that from the basis of performance in a game or event. This may be one of the most important factors that can help in raising the standard of sports in most of the countries. In Japan, however, the system
of selection keeping physique in view has been adopted in more than one thousand schools and was administered to some three thousand subjects from the Kindergartens to the universities. The consequent contribution made in awakening interest towards physical fitness and in the promotion of national programs of physical training has been indeed remarkable (Hirata, 1979).

The English translation of the motto of the Olympic Games is "faster, higher, and stronger". Perhaps we should add another comparative: "weirder". Because one of the guilty pleasures of watching elite athletes in competition is gawping at the extraordinary range of physiques on parade: the statuesque swimmers; the tiny gymnasts; the beanpole high jumpers; the rangy long-distance runners. The specific demands of any single-sport event tend to require of competitors a certain physique. But behind this seemingly obvious point lies an entire science dedicated to the shape and size of athletes.

1.1.2 Kinanthropometry

The term Kinanthropometry in its present connotation was first used in 1972 by Ross et. al., (1980). The term is derived from the word Morphometry that is measurement of shape and form of man. Now Kinanthropometry has taken a strong bonded relationship with physical education and sports
sciences. Kinanthropometry is a scientific specialization dealing with the measurement of persons 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 examines the link between anatomy (structure) and performance (function) (MacDougall et al., 1982). This science will help to understand an athlete's physical performance and normal growth and development. As a result, the measurements have relevant application to the development and monitoring of training programs and establishing and monitoring nutritional goals and practices. Kinanthropometry is closely allied to physical education, sports science, sports medicine, human biology and several medical disciplines.

If applied early enough in their careers, kinanthropometry can have a big impact on young talent. For instance, in a team sport such as rugby, it may not be apparent at 13 years old which position a gifted player will end up playing. It can determine fairly accurately the eventual height of a child by measuring his leg bones. If he's going to be a second-row [a
position requiring both height and strength], you need to be able to predict that he's going to be at least 6'4". Australia is leading the World in this sort of early talent evaluation, along with France and the US, but the UK isn't too far behind.

The human physique differs in a thousand ways. It can be analyzed by studying the size, shape and form of an individual. For this purpose, a set of selected anthropometrical measurements is taken of an individual. The intergroup comparisons are made to understand the physical peculiarities of a population. From such body measurements, it is also possible to estimate the distribution of fat, bone and muscles in one's body. This seems to be more important in the case of athletes and sportsmen.

As Carter (1970) considered that the morphological characteristics of athletes were of interest of the human biologist for competitive sport demand the utmost from the body and it is therefore, responsible to expect to find in athletes a demonstration of the relationship of structure and function.

Today, Anthropometry has many practical uses, most of them benign. For example, it is used to assess nutritional status, to monitor the growth of children, and to assist in the design of office furniture. A major advantage of using anthropometry to study the physique of elite athletes is that large
amounts of data can be collected quickly. In addition most of these methods provide estimate of body fat or the fat free mass. For some sports or events however, structural characteristics, such as limb length, bone breadth may be more important than body fat.

Anthropometry is the most common used method of physique and body composition assessment in athletic population and is the only method that has been validated against a cadaver sample. Anthropometric measurements are among the oldest applied in the body composition field. Early workers applied body weight, height, various skinfolds thicknesses and circumferences and other linear dimensions to characterize a subject’s fatness and nutritional status.

Anthropometric measurements include body weight, height, skinfolds measurement, circumferences and various body diameters. The use of these measurements vary but either individually or combined they allow for reasonable predictions of body composition in non-obese subjects. For example, weight provides a simple measurement of body mass and thus total energy content. Skinfolds measurements reflect the relative amount of fat for a given body site and may be used to describe regional adiposity. Finally, weight combined with skinfolds
measurement and body diameters can accurately estimate the amount of fat-free mass and fat mass.

Precision in anthropometry is of utmost importance, as it requires lot of practice. Reliability of the measurement should be established and the best order for recording the measurements selected for a particular study or a particular problem should be determined. The most common errors in anthropology are positioning of the body or bones, reading measurements and recording. In other words, these errors are also termed as personal error and technical error of measurement respectively. In order to minimize these errors, standard procedures for recording these measurements should be used which are internationally recognized.

Where improved performance is the key, these weaknesses may have the potential to be altered with adapted training, or the athlete’s role changed so that the weakness may become strength. While somatotype and morphology are both sciences concerned with the structure of a person, the term somatotype is generally used, when rating an individual’s structure, while the term morphology is used when trying to describe an individual’s physique. Therefore somatotype ratings are more concerned with an individual’s current physique where
as morphology is more the adaptability of the various components of somatotype over time.

1.1.3 Somatotype

The idea of somatotyping is to describe body shape and composition that allows for both a quantitative and a qualitative summary of an individual physique. The outcome is a three number rating, which describes an individual’s endomorphic, mesomorphic and ectomorphic tendency. Endomorphy relates to the relative fatness, Mesomorphic the relative musculoskeletal (muscular and skeletal) robustness and ectomorphy the relative linearity or slenderness of the individuals physique. A score for the three-somatotype ratings are always reported endomorphy, mesomorphy then ectomorphy, with a rating usually on a scale of 1 – 12. While values in theory can be outside these ranges they are extremely rare, with most individuals falling between a rating of 1 ½ and 7 for each of the categories.

The greater height of an athlete will be advantage by making the flight of the implement longer before it touches the ground (Asmussen, 1971).

The length of the trunk is also of prime importance as the longer trunk has more potential to counter the centrifugal force, which is increased during the execution of the turns and
also helps to maintain the balance of whole body. Hirata (1966) suggested that the nation with people whose general physique was limited to the characteristics of champions in certain events should concentrate on exercises which are best for small builds such as gymnastic, long distance running, light class in boxing, weight lifting etc. Similarly for Americans who are large and lean, such sports as basketball, volleyball, long jump, sprints, throws are the best.

Body composition plays a vital role to improve the throwing distance. Studies in this regard indicate that the athlete who were very lean but heavy because of a well-developed musculature were in superior in certain sports i.e. football, weight-lifting and throwing (Bullen, 1971). On the other hand, athletes who have substantial amount of adipose tissue have increased energy demands owing to the inert weight of fat, thus rendering the work more difficult the work more difficult to perform in endurance activities where the body has to move longer with greater weight. (Tanner, 1964; Carter, 1970).

It is evident that physique and body composition have an important role to play in the performance of various activities. The selected physical activities reported here are athletics, cycling, weight lifting, wrestling, football, hockey, basketball and volleyball. In all these games and events, India
participates in international competitions. The physique in each group has been assessed with the help of Heath-Carter method (1967). The total body fat and the lean body mass have been estimated with the help of formula devised by Durnin and Womersley (1974).

In hammer throwing the lower body should more powerful than upper body because the arms play a passive role while turning. Parbhakar (1995) stated that unlike the shot putter the hammer thrower uses his legs & lower back more than his upper body and arms. You could ever say that the shoulder & arms play a comparative passive role. According to Felton (1970) hammer builds up about 650 pounds of centrifugal force of release if it is to travel 240 feet. Sweep the hammer through the widest possible radius while accelerating it strongly with your entire body, not just your arms (Parbhakar, 1995; Steben and Samball, 1978; Sagar, 1979; Bondarchuk, 1991; Bosen 1993). An optimal break performance in throwing events is the result of a carefully planned program integrating several components of training. Out of which components like specific and special strength are taken into consideration. The all-round specific strength training is very important as a connecting link between general and specific strength training (Khun, 1994; Pedemonate, 1986; Petrov 1980; Sagar 1979; Shea, 1979).
The speed is built up in progression to achieve it to the maximum degree towards the third turn to transmit release velocity of 26 to 27 m/sec. to the hammer (Jarver, 1977; Bondarchuk, 1980; Sagar, 1979; Tschiene, 1973). The need to develop a strong but flexible vertebral column and hip joint to enable a wide range of movements and body torque (Prabhakar 1995, Johnson 1969 & Sagar 1979).

The nature of hammer throwing is such that during competition its aerobic endurance requirement is virtually nil (Johnson, 1969 & Mahlotra et. al.1972)

1.1.4 Applications in sports science

The link between exercise performance and body shape, size, proportion and composition provides clues to the ideal physique for a sport or event. Collection of data on the elite athletes can therefore be used as a research tool to facilitate an understanding of the link between performance and physique and provide on going feedback to the coach of an athletes. It is important to remember that although an athletes may have the appropriate physical structure, factors such as physiological function, psychological make up and biomechanical constrains all contribute to athletic performance.

All athletes are made up of the three extreme body types-part I Endomorph, part-II Mesomorph and part-III
Ectomorph. By classifying our own body physiques using somatotyping, compare our body type with that of other athletes. Graphs and tables have been developed to decide which sports suit which somatotype better.

Obviously, somatotype is not the only factor determining how good athlete is at a particular sport. The specific skills, good hand-eye co-ordination, spatial awareness, timing, speed and concentration, etc. are many other associated factors which help to improve the performance.

Body size refers to the sports person’s height and weight. The ideal size for an athlete depends on their sport and sometimes on the position they play in their sport (consider the various body sizes in a rugby team). There are standard ideal weight charts based on an individual’s height, however, these tables do not help athletes because they do not allow for body composition, i.e. muscle is heavier than fat and therefore a person may seem overweight, when they are not. Athletes in a variety of sports seemingly have different objectives when it comes to weight control and proper body composition. For some gaining lean body weight (muscle) is the goal for others making weight is a goal.

1.1.5 Physique

Parnell (1951) in an anthropometrical study of athletes concluded that an individual’s choice of athletic events might
largely be due to characteristics, probably inborn. Tanner (1964) examined the physique and body composition of Olympic track and field athletes and inferred that the athletes were both born and made. “The basic structure”, he stated, “Must be present for the possibility of being an athlete to arise. Physique is a factor in the success that may lead to inclusion in an Olympic team: or more negatively that lack of proper physique may make it almost impossible for an athlete to reach that degree of success. But we do not suppose that winning the Olympic event has much to do with physique, except perhaps in some rare cases, where one single man is altogether outstanding.

Studies on physique may be useful in choosing a suitable physical activity for an individual, whose main objective is competition. The throwers, for example, have been found heavier and taller, with long muscular arms and wide shoulders. (Cureton, 1951; Parnell, 1951; Pere et al.,1954; Tanner,1964; Hitata, 1966; Muthiah and Venketswarlu, 1973). In throwing events, greater weight is useful, because when the object is thrown forward and upwards, an equal and opposite reaction force is exerted on the athlete, pushing him backward and down. The effect is less if the athlete is heavier; more, if he is lighter (Tanner 1964).
The shaping of athletes seems to be very complex phenomena. Yet, in recent past attempts have been made to understand if there was specific body constitution, which helps them to attain better performance. On the other hand certain body types may be hindrance in the development of athletes. It is now an established fact that champions of different athletic and sporting events differ significantly in their physique and physiological characteristics that correspond to some extent with the particular requirements of their respective events.

**1.1.6 Body Composition**

The body is composed of water, protein, minerals, and fat. A two-component model of body composition divides the body into a fat component and fat-free component. Body fat is the most variable constituent of the body. The total amount of body fat consists of essential fat and storage fat. Fat in the marrow of bones, in the heart, lungs, liver, spleen, kidneys, intestines, muscles and lipid-rich tissues throughout the central nervous system is called essential fat, whereas fat that accumulates in adipose tissue is called storage fat. Essential fat is necessary for normal bodily functioning. The essential fat of women is higher than that of men because it includes sex-characteristic fat related to childbearing. Storage fat is located around internal organs (internal storage fat) and directly beneath the skin (subcutaneous
storage fat). It provides bodily protection and serves as an insulator to conserve body heat. The relationship between subcutaneous fat and internal fat may not be the same for all individuals and may fluctuate during the life cycle.

Body Composition is the technical term used to describe the different components that, when taken together, make up a person's body weight. Now must keep in mind that body composition and body weight are two entirely different concepts and they are not interchangeable. Evaluation of body composition is a common and important component of overall physical fitness assessment. It is well established that excess body fat is harmful to health but many misconceptions exist regarding the assessment and interpretation of such data.

Studies on body composition in certain sports indicated that the athletes who were very lean but heavy because of a well-developed musculature were superior in performance in certain competitive sports activities, such as football, weight lifting and the shot put (Bullen, 1971). On the other hand, athletes who have substantial amount of adipose tissue have increased energy demands owing to the inert weight of fat, thus rendering the work more difficult to perform in endurance activities where the body has to move longer with greater weight (Buskirk and Taylor, 1957). It may be for the reasons that the long distance runner are
found to be less endomorphic than other runners and their counterparts at a lower level of competition.

Lean body mass differs from fat-free mass. Lean body mass represents the weight of muscles, bones, ligaments, tendons and internal organs. Since there is some essential fat in the marrow of bones and internal organs, the lean body mass includes a small percentage of essential fat. However, with the two-component model of body composition, these sources of essential fat are estimated and subtracted from total body weight to obtain the fat-free mass. Practical methods of assessing body composition such as skinfolds, bioelectrical impedance analysis (BIA), and hydrostatic weighing are based on the two-component (fat and fat-free mass) model of body composition. The field of body composition assessment is developing rapidly on several fronts. Some of the major areas are the estimation of fat and fat free body composition of the body and sources of variation in that composition associated with growth and senescence, physical activity and specific exercise training programs along with ethnic and gender patterns of fat distribution and differential development of musculoskeletal system.

Health practitioners universally agree that too much body fat is a serious health risk. Problems such as hypertension, elevated blood lipids (fats and cholesterol), diabetes mellitus,
cardiovascular disease, respiratory dysfunction, gall bladder
disease and some joint diseases are all related to obesity. Also,
some research suggests that excessive accumulation of fat at
specific body sites may be an important health risk factor. For
instance, it appears that extra fat around the abdomen and
waist is associated with higher risk of diabetes, heart disease
and hyperlipidemia. Individuals who accumulate a lot of fat
around the waist (apple-shaped) are worse off than those who
tend to accumulate fat in the thighs and buttocks (pear-shaped).
The apple-shaped pattern of fat deposition is more commonly
seen in men; whereas women tend to be pear-shaped.

In anthropometry, selected skinfolds and
circumference measurements provide estimates of adipose tissue
distribution. For example, the waist circumference measurement
provides a well-validated measure of visceral adipose tissue.
According to National Institutes of Health Guidelines a waist
circumference of 94cm. for men and 80cm. for women should be
taken as the cut points for limiting weight gain while a waist
circumference of 102cm. for men and 88cm. for women should
be taken as the cut points for reducing weight.

After age 20, should expect at least 1-3% fat gain per
decade up to the age of 60; thereafter fatness declines gradually.
In addition, there is approximately a 2% loss of bone mass per decade in older populations. As a result of these changes, men and women who weight the same at age 60 as they did at age 20 may actually have double the amount of body fat unless they have been physically active throughout their life.

The accurate measurement of Lean Body Mass is now the most rational basis for nutritional and exercise prescriptions. The importance of clinical body composition is now being recognized. There is evidence that research and interest in body composition was explored centuries ago by Archimedes, though most of the research data that is available on human body composition has been completed in the last forty years. With the recent interest in personal health, nutritional status and fitness, several methods of estimating body fat have been developed and used in clinical settings.

The test for body fat estimation with skin fold measurements requires the use of a "caliper device" to measure the thickness of substantial fat stores. The assumption is that substantial fat is proportional to overall body fat and thus by measuring several sites total body fat may be calculated. Many body composition studies estimate fat free body mass from densitometry using Siri (1961) or Brozek et al., (1963) equation.
As originally defined by Behnke (1959), lean body mass has a density less than $1.100g/cm^2$ and contains a small amount of the essential lipid but fat free body mass has no lipids.

Anthropometric Measurements (girth and length) are quick, easy and inexpensive method to estimate body composition. Using a standard calibrated cloth tape, girth and length measurements are taken from specific points on the body. The methodology is based on the assumption that body fat is distributed at various sites on the body such as the waist, neck and thigh. Muscle tissue on the other hand is usually located at anatomical locations such as the biceps, forearm and calf. The subject’s weight, height, girth size and ratios of various site comparisons are utilized in the calculations of percent body fat. Although the use of anthropometric measurements provides a reasonably reproducible value and gives a topographical assessment of an individual, the established accuracy for the prediction of body fat is at least ±5% compared to the hydrostatic method.

Most elite athletes now have access to extensive facilities provided by their coaches and scientists, having funding for such facilities; it would therefore be more
economically viable for the elite athlete to use the more accurate methods of measuring body fat composition.

The skinfold estimation methods are based on a skinfolds, whereby a pinch of skin is precisely measured by caliper at several standardized points on the body to determine the subcutaneous fat layer thickness. These measurements are converted to an estimated body fat percentage by an equation. Some formulas require as few as three measurements others as many as seven. The accuracy of these estimates is more dependent on a person's unique body fat distribution than on the number of sites measured. As well, it is of utmost importance to test in a precise location with a fixed pressure. Although it may not give an accurate reading of real body fat percentage, it is a reliable measure of body composition change over a period of time, provided the test is carried out by the same person with the same technique.

Skinfolds-based body fat estimation is sensitive to the type of caliper used, and technique. This method also only measures one type of fat: subcutaneous adipose tissue (fat under the skin). Two individuals might have nearly identical measurements at all of the skin fold sites, yet differ greatly in their body fat levels due to differences in other body fat deposits
such as visceral adipose tissue: fat in the abdominal cavity. Some models partially address this problem by including age as a variable in the statistics and the resulting formula. Older individuals are found to have a lower body density for the same skinfolds measurements, which is assumed to signify a higher body fat percentage. However, older, highly athletic individuals might not fit this assumption, causing the formulas to underestimate their body density.

Elite athletes may be characterized by optimal endurance and strength as well as a physique conductive to high performance. For instance, long distance runners will have an excellent cardio respiratory endurance, and shot putters will show a well-developed strength profile. Artistic gymnasts are generally shorter than swimmers or basketball players. Regardless of the sport discipline and on average, athletes are less fat and more muscular than non-athletes (McDougall et al., 1982).

1.2 Need of the Study

Hammer throwing is an exciting, challenging and fitness demanding event in the athletics. The performance standard of Indian men hammer throwers stayed around $65 \pm 5$ meter from last fifty years, while the international performance
standard is around 84m. So to fill this gap there is a need of diagnosis of the conditions under. But unfortunately in India no study has been done in this regard. Therefore, the investigator has planned to conduct the present investigation. In view of this the investigator aims to find out through this study to know morphological characteristics and physical fitness level of men and women hammer throwers in India. Hence the present study has been taken.

1.3 Statement of the problem:

The present study was designed to know morphological characteristics and physical fitness level of India hammer throwers.

So the problem is stated as:

PHYSICAL FITNESS AND MORPHOLOGICAL CHARACTERISTICS OF HAMMER THROWERS IN INDIA.
1.4 Hypotheses:

The study has been conducted with the following hypothesis:

1. There will be significant differences in Physical Fitness profile of men and women Hammer throwers at different level of performance.

2. There will be significant differences in body morphology of men and women hammer throwers.

3. There will be significant differences in body Morphology of men Hammer throwers with the standards given by De Garay et al. (1974) study based on 19th Olympic game athletes.

4. There will be differences in Physical Fitness profile at different levels of performance of Indian men and women hammer throwers with norms given by Didier Poppe - 2001.

1.5 Objectives of the study:

Present study has been conducted with the following objectives:

1. To find out the significant differences in Physical Fitness profile of men and women Hammer throwers at different level of performance.
2. To access the significant differences in body morphology of men and women hammer throwers.

3. To explore the significant differences in body Morphology of men Hammer throwers with the standards given by De Garay et al. (1974) study based on 19th Olympic game athletes.

4. To find out the differences in Physical Fitness profile at different levels of performance of Indian men and women hammer throwers with norms given by Didier Poppe - 2001.
1.6 Delimitations:

1. The study has been done at performance levels of Indian men and women Hammer Throwers on Physical fitness parameters.

2. The study has been delimited to various parameters of general (Maximum strength, Power, Speed, Explosive power and specific fitness (Special strength) given by Poppe Didier (2001).

3. The study has been delimited to Indian Hammer throwers on Morphological characteristics (Age, Height, Weight, Sitting height, Height weight Ratio, Ponder Index, Three skinfolds, Full arm length, Body fat %, Muscle mass, Bone mass and Somatotype).

4. Morphological characteristics of Indian men Hammer Throwers will be compared with the standards given by de Garay et. al. (1974).

5. Morphological characteristics of Indian women Hammer Throwers has been compared with other weight throw (Shot put, Discus and Javelin throw) because literature on female has been limited to anthropometric data.

6. In this study 60 male and 30 female hammer throwers has been taken as a sample.
7. The study has been based on different levels of performance of five groups, which starts from 40 meters for male and 30 meters for female hammer throwers with 5-meter differences each.

8. The tests has been conducted from various national competitions, domestic meets, SAI and state sports department centers that are running in India e.g. Alahabad, Mastuana Sahib, NIS Patiala, PAP and BSF Jalander etc.

9. The data has been collected during competition period of 2007 with the help of coaches and senior players.

1.7 Limitations:

1. The tests can’t be carried out on all subjects together because of non availability all of them at one place at a time.

2. The present study can’t include the Biomechanical aspects for technical analysis.

3. The Morphological characteristics for women can’t be compared with norms, It compared with throwers of other weight i.e. Shot put, Discus and Javelin, as this event has introduced first time for women in 2004 Olympics games and no study has been done in this regard.
4. As athletes of the present study were from the different parts of the country so the present sample is not homogenous in nature.

1.8 Definition and Technical Terms:

1.8.1 PHYSICAL FITNESS PROFILE:

It refers to the athlete’s status on those components which are essential for efficient functioning in the psycho-motor domain. These components are performance oriented and are dependent upon functioning of different system of the body in an integrated manner.

MOTOR ABILITY:

Motor ability indicates the present athletic ability and is denoted as the immediate state of the individual to perform a wide range of motor skill (Singer, 1975).

ANGLE OF THE HAMMER AT RELEASE:

The angle of trajectory the hammer head is following at the time of release relative to horizontal.

HEIGHT OF THE HAMMER AT RELEASE.

The height the hammer head is from the ground at the time of release.
SPEED:

Speed is the capacity of moving a limb or part of the body’s system or the whole body with the greatest possible velocity.

MAXIMUM STRENGTH:

It is the ability to overcome or act against maximum resistance. It is measured by finding out maximum resistance which can be overcome or maximum force which can be applied by the muscles. (Singh Hardial, 1984).

EXPLOSIVE POWER:

Explosive power is an action where maximum muscular force is released at maximum speed. It is also said to an Elastic strength.

REACTIVE POWER:

It is the ability to release maximum force with the body weight in the fastest possible time. It is also known as all body power.

LOW LOAD SPEED STRENGTH:

It is defined as the ability to overcome the resistance in minimum possible time with low load.

HEAVY LOAD SPEED STRENGTH:

It is defined as the ability to overcome the resistance in minimum possible time with heavy/high load.
ALL BODY POWER:

It is defined as the capacity of the all body muscle to bring in to play maximum muscular contraction in minimum possible time. It is the combination of speed and strength.

SPECIAL STRENGTH:

It is the ability to tackle resistance in a particular sport. It can be any strength ability (Maximum strength or Explosive strength or strength endurance) required for specific sports.

AGILITY:

It is the physical ability that enables an individual to change his body position, direction rapidly and precisely.

MOTOR SKILL:

It is muscular movement of motion of the body required for the successful execution of a desired act.

1.8.2 Kinanthropometric variables:

MORPHOLOGY:

Morphology is a scientific study of forms of living the branch of biology that deals with the form and structure of organism without considering of function. (Oxford Dictionary)

ANTHROPOMETRY:

It means the measurements of man, whether living or dead, and consists primarily in the measurement of the dimension of the body. Anthropometry is the measurements of
man-provides scientific methods and observation on the living man and the Skelton. Anthropometry represents the typical and traditional tools of Human biology physical anthropometry and anemology. Recently, it has taken a strong bonded relationship with physical education and sports sciences.

**KINANTHROPOMETRY:**

The measurement of structure and proportion of the body is called kinanthropometry.

**SOMATOTYPE:**

It is one of the methods of describing morphology. It is a convenient description of overall physique in terms of body shape and composition, independent of body size.

**FAT PERCENTAGE:**

Percentage of fat was estimated based on technique described by Durnin and Rehaman employing skinfold measurements namely biceps, triceps, sub-scapular and supra regions. where the estimated fat percent values are provided based on age and sum of mentioned four skinfolds.

**FULL ARM LENGTH:**

The length between the highest point on the lateral border of the Acromion process and lowest point of the middle finger of same hand is known as full arm length. To increase the radius in hammer throw full arm length is very important.
1.9 **Significance of the study:**

This study will lead to important training guidelines for improving the performance of Indian Hammer Throwers. It will be helpful for selecting Hammer Throwers at early ages. The results study will be helpful for guideline and counseling about the body Morphology and physical fitness of hammer throwers. The study will be helpful for talent identification of novice throwers. Conclusions may be helpful to the coaches to identify the training selected changes. Results of present study may serve as yard sticks for other hammer throwers to have to same morphological characteristics of physical fitness tests.
Fig. 1: Long handled hammer – Scottish Games

Fig. 2: Hammer Throw ring dimensions
Fig. 3: Hammer

Fig. 4: Complete Hammer Throw Sequence.