INTRODUCTION

Athletics incorporates a range of sporting disciplines in which specific physique or morphological features play a major, arguably critical role in competition success. The body mass of winners in the Boston marathon, the World's oldest existing annual race has not varied over many decades suggesting this characteristic remains important. However, in the case of high jump, the move from a straddle to Fosbury flop technique in the late 1960's resulted in a substantial increase in the height of male competitors over two Olympiads. Despite a lack of empirical evidence for the influence of physiques on performance in some disciplines, coaches and athletes are often convinced of benefits based on personal experience, intuition and trained eye observation of successful competitors. In their pursuit to emulate champions, some athletes increase their risk for inadequate or inappropriate dietary intake and disordered eating, particularly when physique ideas are at the more extreme, low end for body weight and fat. Attaining ideals may be challenging, as genetic characteristics are largely responsible for phenotype.

More than one hundred scientists have attempted to describe the physique characteristics of elite athletes with the objective of relating their physique to athletic performance. Theoretically, the most successful athletes are

those with the appropriate structure to perform their event and Olympic or World championship athletes represent the optimum combination of genetic and environmental influences to produce maximum performance. Since the first studies on athletes at the winter and summer Olympic in 1928, major studies have been conducted on athletes at six different Olympic games.

Morphological Optimization

Many factors contribute to athletic success. Skill, the right affective and cognitive psychological characteristics, and powerful and capacious energy-production systems can all be important. One major success factor is body size and shape, or morphology. A guiding concept here is morphological optimization, the notion of an ideal body morphology, or narrow range of morphologies, most likely to be associated with success in various disciplines.

The importance of morphological optimization varies from sport to sport. Successful soccer players come in a wide range of size and shapes. Indeed the coefficients of variation in height and mass in elite male soccer players are not very different from those in the general population of young males. Successful sprinters on the other hand, tend to be more homogeneous.

The relative importance of morphological optimization can be quantified using three types of comparisons:

- Comparisons between the morphological characteristics of the athletic population and those of the source population from which they are drawn.
- Comparisons between the characteristics of athletes at different competitive levels (best vs. rest analyses; international vs. state level performers)
- Comparison across time, charting secular changes in morphological characteristics, against the backdrop of population changes.

Athletes vs. source populations

In many cases, athletes are clearly different from the source population. They are smaller (Hockey player), leaner (distance runner), more muscular (power lifters), fatter (sumo wrestlers), taller (basketball player), or have longer legs (high jumpers). The morphological characteristics of athletes can differ from the source population either by having different mean values, or different distributional characteristics or both.

Best vs. rest

Success as related to the critical morphological characteristics and the gradient of success among elite athletes is well established fact today. The mass of male 5000-10000 m runners, for example, varies with competitive level. For International level runners, the mean mass is 61.7 kg, for Australian state level it is 65.2 kg; and for club level runners, the mean is 67.1 kg. It is likely that a very low body

mass is important for distance running success. This is of course, is achieved in part by body fat content, but this is perhaps not only reason for low body mass.

Secular trends

Sport is Darwinian in nature. Over time, the morphology fittest are selected and the others disappear. Therefore it is expected to see time trend in success-critical morphological characteristics. It is observed from the throwers from the various Olympic Games between 1928 and 1992, the mass increased at a rate of 3-7 kg/decade or three to seven times the rate of increase in the source population (Norton & Olds, 2001). This disproportionate rate of increase suggested that mass is a major success-critical factor in throwing events. The existence of secular trends in athlete morphologies undergoes the importance of using up to date reference data.

Time trends do not always reveal open ended optimization where athletic characteristics become more and more extreme. Sometimes it can be an absolute optimization where athlete morphologies do not change in spite of background changes in the source population. Absolute optimization probably reflects a balance between differential effects of morphology on supply and demand factors in the event. In case of marathon, smaller body mass is probably associated with the better heat exchange and less

susceptibility to injury, but may reduce the benefit of elastic return when running.

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: 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, axiology, physical anthropology, gerontology, ergonomic and several medical disciplines.

"Athletes will tend to say they've had a body-fat assessment rather than a kin anthropometry session. The related definition of kinanthropometry is "the application of a series of measurements made on the body, including height, weight, thickness of adipose tissue [fat], limb and torso circumferences and skeletal proportions." It is a vehicle for individuals to contribute to basic research and applications in medicine, education and government. This requires a sense of responsibilities and willingness to engage in professional discourse and to become involved in public education. As the Olympics loom, kinanthropometry ensures that athletes have exactly the right balance of fat and muscle for their event. But this science can help athlete’s decades before they might contemplate competing in an Olympic final.

Kinanthropometry can also ensure that athletes don't over train and endanger their health. "Female endurance athletes and gymnasts will typically train hard and restrict their calorie intake to keep their weight down. This can lead to a disruption of the menstrual cycle and a decrease in estrogen production. This in turn leads to lower bone-mineral and osteopenia, a condition related to but not as serious as osteoporosis." So if some of those marathon runners' arms look as if they might snap like twigs, that's because it's not far from the truth; osteopenia manifests itself not in the load-

bearing limbs of the elite female endurance athletes but in their upper bodies. "By a process called dexa scanning, which measures bone-mineral density, and by body-fat assessment, we can ensure that the athlete remains healthy as well as fit.

Never heard an athlete thank their kinanthropometrist after a victory? However, it's safe to say that most of the British Olympic team will have used kinanthropometry throughout their careers.

If applied early enough in their careers, kinanthopometry 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 6ft 4in." 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.

Yet the process of talent evaluation also illustrates the limitations of the science: it can do little to effect change in skeletal structure. With the rest of the body, though, the kinanthropometrist can manipulate the health and performance of the athlete to a remarkable degree. "Athletes

in a certain track-and- field event may all look the same on the tally, but internally they'll be very different.

In disciplines with weight divisions - judo, boxing, lightweight rowing, power lifting - the kinanthropometrist assists the competitor in maximizing muscle mass while ensuring he or she can still make the weight limit without losing power. With boxers, for instance, train them at the weight they're going to compete at, which is heavier than at the weigh- in. Before the weigh-in, one strip off water from their bodies while preserving as far as possible their muscle mass.

Anthropometry is a series of systematized measuring techniques that express quantitatively the dimensions of the human body and skeleton. Anthropometry is often viewed as a traditional and perhaps the basic tool of biological anthropology, but it has a long tradition of use in forensic sciences and it is finding increased use in medical sciences especially in the discipline of forensic medicine. It is highly objective and reliable in the hands of trained anthropometrists. The significance and importance of somatometry, cephalometry, craniometry and osteometry in the identification of human remains have been described and a new term of 'forensic anthropometry' is coined. Some of the recent studies, which employ various techniques of anthropometry, are discussed. The ultimate aim of using anthropometry in forensic medicine/science is to help the law

enforcement agencies in achieving 'personal identity' in case of unknown human remains.

Anthropometry is the study of human body measurement for use in anthropological classification and comparison. In the 19th and early 20th centuries, anthropometry was a pseudoscience used mainly to classify potential criminals by facial characteristics. The most infamous use of anthropometry was by the Nazis, who's Bureau for Enlightenment on Population Policy and Racial Welfare recommended the classification of Aryans and non-Aryans on the basis of measurements of the skull and other physical features. The Nazis set up certification institutes to further their racial policies. Not measuring up meant denial of permission to marry or work, and for many it meant the death camps.

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. Many of the methods for physique assessment are laboratory-based techniques and are impractical or too expensive for the routine testing of athletes or for large-scale data collection. 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. While a variety of different sciences apply the principles of anthropometry, from nutritionists concerned with obesity to ergonomists concerned with low back pain, anthropometry has long been applied in a sporting setting due to the influence body morphology and somatotype has on sporting performance.

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 thick nesses and circumferences, and other linear dimensions to characterize a subject's fatness and nutritional status. Modern workers have calibrated various anthropometric dimensions against reference body composition estimates in order to develop specific component prediction models.

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 anthropometry 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.

Anthropometry and Body Image

The term 'body image' is a broad term describing an individual's internal and subjective representation of their physical appearance and bodily experience. Body image includes the perceptual, cognitive and affective elements where perceptual relates to visuospatial and sensory judgments; cognitive relates to thought processes and thinking styles; and affective refers to individual emotions and attitudes. The analysis of body image therefore considers both an individual's perceptions of his or her body, and the same individual's perceptions of the bodies of others.

Anthropometry is linked closely with body image as anthropometry provides a quantitative value to an individual's body size and shape, while body image provides the qualitative measure. Numerous studies have been done showing that age, gender, education, genetics and mass media can all influence an individual's body image both positively and negatively.

In a sporting setting, the desire to conform to a particular sports' perceived ideal body shape has been linked to eating disorders, unsafe training methods and the abuse of steroids. The uniforms, particularly of female athletes, and the portrayal of high profile individuals in the media, have also been linked to teenagers dropping out of sport due to the pressure to confirm to a particular image. As a result of these pressures, there is a great need to be sensitive and aware of the influence body image can have on an individual's motivation and goal setting.

The term body image refers to the view that a person has of his or her own body size and proportion. Body-image distortion occurs when a person's view of their body is significantly different from reality.

Physique is a factor in the success that may lead to inclusion in an Olympian team: or more negatively that lack of proper physique may make it almost impossible for an athlete to reach that degree of success. Hurdler for example,

has been found to have long leg short trunk. Hildreth (1958) observed that all high hurdlers, who recorded times less than 14 seconds, were over six feet tall, with the notable exception of one whom, though only 179.1 cm had the typically long legs of the Negro hurdlers. Longer legs are helpful to take the necessary long strides over the hurdlers without the loss of time that jumping entails.

Physique refers to the shape, the size and the form of an individual. Of course the three factors are intimately linked with each other and are manifestation of the internal structure and tissue components, which in turn, are influenced by the environment and genetic factors. The basic method of evaluating physique applied on athletes and sportsmen opened new dimensions for the development of the science of Kinanthropometry. The development of physique in particular sports seem to have a close link with the development of strength required in most sports activities. Further, the athletes while under training for a longer duration develops physiological adaptations resulting finally in some morphological adaptation too.

The connection between physique and success in sport can be regarded today as a proven fact. Studies of physical endowments of athletes in relation to the events in which they excel in order to discover the optimal types for each event are performed all over the World. By Physique is meant the morphological constitution of an adult man, the

outcomes of his genetics endowment modified by adaptation, the effects of his environment and training. Athletes are a group of people who have been subjected to a selection process through various competitive tests resulting in their identity as those physically best fit. Therefore they provide a suitable group for the study of their morphological variations and other characteristics in the process of adaptation.

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 batter 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.

The value of being able to assess an individual competitive adult athlete's somatotype and therefore their morphology is that it allows a coach to ensure that not only are the athlete's strengths being optimized, but also, allowances (where possible) can be made for weaknesses.

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

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. As the ratings are made relative to the individual's stature, the somatotype rating is made independent of stature. The following image helps to illustrate the three categories of somatotype.

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 visual somatotype method generally involves taking standardized photographs of the athlete and rating their endomorphic, Mesomorphic and ectomorphic tendencies based on the visual descriptions. The athlete is normally viewed from standardized, side and rear views while dressed in minimal clothing.

It has long been known that an athlete's anthropometric characteristics can play a major role in their sporting success. This has brought about the idea of 'morphological optimization', which is the theory that only those athletes that have the ideal body type for their chosen sport will remain competitive at higher levels. While it is obvious that in some sports skill and physical fitness may also be key contributing factors this hasn't stopped anthropometric profiling being used in a number of sports. For example, an individual who scores low on mesomorphy and high on ectomorphy is unlikely, despite skill and fitness, to ever compete at a high level in rugby. An individual with high endomorphy rating and moderate mesomorphy ratings is unlikely to ever be highly competitive in ultra-endurance sport. This doesn't mean that only individuals with the optimal morphology will be competitive, it is just that the majority of successful athletes will be of that morphology. It

also doesn't mean that only individuals with the optimal morphology for a sport can participate in that sport.

While this may seem obvious at the elite sporting level, morphology and anthropometry still has applications to the amateur athlete, child sports participant or competitive adult. From an injury perspective some athletes may be more prone to injury if their morphology does not match the demands of their sport or their position within a team. For some athletes, learning complex tasks may be made difficult, as biomechanical they are disadvantaged due to their morphology. Within sporting teams, particular players may be better suited to certain positions based on the physical demands of that role and the athlete's physique. For the coach of children, ensuring that physical differences between athletes is considered during both training and games can help to not only reduce injuries, but also allow for success for those participants who may not be physically the best suited to that sport or at a different developmental stage to the other athletes.

In throwing events, greater weight is useful, because when the object is thrown forwards and upwards, an equal and opposite reactive force is exerted on the athlete, pushing him backwards and down. The effect of this is less, if the athletes are heavier, more if the athletes are lighter. The greater height in them will be of further advantage by making the flight of the implement longer before it touches the

ground. It is propounded that while throwing the discus, the speed of the discus at the moment of release is of prime importance in determining how far it will go, and for a given angular velocity (dependent on how fast the thrower does his turn) the speed is proportional to the length of lever throwing the discus, i.e. to the distance of the discus from the axis of the thrower; hence the desirability of having long and powerful arms.

For activities such as high jumps, pole vault, the size seems to play no role in the actual lifting of the center of gravity, but in the case of taller persons, the center of gravity is at a higher level, which is useful in crossing a greater height (Asmussen, 1971). Various other studies also suggest that different body sizes, shapes and proportions are beneficial in different physical activities.

The Japanese who are small had better concentrate on exercise which is best for small builds such as gymnastics, long distance running, and light class in boxing, weight lifting etc. Similarly Americans who are large and lean such sports as basketball, volleyball, swimming, long jumping and short and middle distance running are the best.

Dissatisfaction with body shape is one of the main reasons men vary their lifestyle. Usually this involves diet change and exercise but increasingly may involve cosmetic surgery. Pectoral implants, liposuction and jaw

enhancements are becoming more commonplace. For those more interested in lifestyle can change the activities they choose as it have some effect on their morphology (morph = shape). Aerobic exercises that involve all the muscle groups such as running, yoga and swimming are useful. Employing a steady rate of exercise and avoiding rapid bursts of activity are thought to be important. Isolating each muscle group in turn and operating on a principle of short explosive bursts of activity is a basic principle. Weight bearing exercises and repeated cycles within a given muscle group are necessary - as is relaxation after normally no more than seven repetitions. As men get older their metabolism slows down. Fat likes to gather around the belly of men and whilst it deposits easily it can be incredibly hard to shift. The middle age spread can be tackled with a sensible mix of exercise and healthy eating. Over a period of time most men will see fairly dramatic improvements particularly if they also concentrate on posture.

Natural body size is the size and shape that are inherited from his/her parents. It is determined almost entirely by genetics, just like height, eye colour and skin colour. One cannot change his natural body shape and size permanently. Some people do extreme things to change their body shape, but it doesn't usually last. Body has its own way of staying within a body weight range that is healthiest.

Applications in sports science

Describing 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 endomorph, part mesomorph and part 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.

These tables and graphs can be quite helpful for physical education teachers, coaches, scouts, etc. to ascertain where on the pitch someone should or could be playing, or which sport that particular individual may be good at. Obviously, there will always be the exception to the rule, but generally speaking certain somatotype is more suited to certain activities than others. For example, an extreme ectomorph will generally make a better long distance

runner than they will a prop in rugby, and a mesomorph will generally make a better wrestler than a ballet dancer.

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, 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.

Body Composition

The science of body composition is an important morphological characteristic. 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.

Understanding and being able to explain the difference between healthy leanness and undesirable thinness is one important concept the fitness instructor, personal trainer, and exercise leader must share with their athletes. In addition, there are some other reasons to become more informed about body composition:

1. To develop complete physical fitness profiles for athletes.
2. To monitor body fat loss and muscle growth resulting from exercise.
3. To provide baseline data for nutritional counseling and treatment of obesity

4. To describe changes due to growth, development, maturation, and aging.
5. To maximize the performance of athletes.

Lean body mass represents the weight of muscles, bones, ligaments, tendons, and internal organs. Lean body mass differs from fat-free mass. 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.

Our bodies require essential fat because it serves as an important metabolic fuel for energy production and other normal bodily functions. The essential fat requirements are

< 5% for men and < 8% for women. Normal body functions may be disrupted if body fat falls below the minimum level recommended for men (5%) and women (15%). The body fat ranges for optimal health (18%-30% for women and 10%-25% for men) are based on several epidemiological studies of the general population. Body fat percentages for optimal fitness and for athletes tend to be lower than optimal health values because excess fat may hinder physical performance and activity.

However, the degree of excess fat may play an advantageous role, if not a vital one in physical performance carried out under conditions of cold stress. It was observed that the middle distance runners and channel swimmers were endowed with a substantial amount of subcutaneous tissue and often were obese. Their ability to tolerate cold water for long periods was largely attributed to the insulation provided by the fat and to a reduced rate of heat loss.

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.

A large number of anthropometric body fat prediction models are reported in the literature based upon measured skinfolds and circumferences. These methods vary in the subject populations used to develop the prediction models, and the selected reference methods. Some models rely solely on measured skinfolds thickness while others rely primarily on circumference measurements. Geometric models allow estimation of limb fat areas using combined extremity skinfolds and circumference measurements.

An important feature of anthropometry is that selected skinfolds and circumference measurements provide estimates of adipose tissue distribution. In particular, anthropometry allows for the estimation of subcutaneous 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 94 cm for men and 80 cm for women should be taken as the cut points for limiting weight gain while a waist

circumference of 102 cm for men and 88 cm for women should be taken as the cut points for reducing weight.

While at one time the ratio of waist to hip circumference was applied as a measure of adipose tissue distribution, today only the waist circumference is usually measured. The saggital diameter, measured as the largest body thickness in supine subjects, is also used as a measure of visceral adipose tissue, but few studies have provided evidence that this anthropometric dimension is superior to the simpler waist circumference measurement. A major advantage of using anthropometry for assessing visceral adipose tissue is the relative ease with which measurements may be made, although well-trained technicians are essential requirement. Anthropometric measurements are less costly and easier than a comparable CT and MRI studies, but with these advantages come a loss of precision and repeatability.

There have been many validation studies of anthropometric prediction methods, and most published total-body fat and adipose tissue models tend to cross validate when compared to reference methods. Among the various measurement methods, anthropometric techniques usually demonstrate the largest standard error and lowest correlation coefficients when compared against other techniques for estimating total-body fat such as DXA, BIA, or in-vivo neutron activation analysis. Some technical concerns should also be considered, including the

requirement for technician training and the need for special calipers in very obese subjects. Thus, while anthropometric methods are useful in phenotype subjects for fatness, anthropometry is usually not applied for individual subject evaluations, for examining short-term changes in body fat. Anthropometric methods are important in field studies of nutrition and obesity where other methods either cannot be applied or are impractical in the selected setting.

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 calculation of percent body fat is the true definition of fitness and obesity. 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 methodology 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 over all 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 1.100 g/cm3 and contains a small amount of the essential lipid , in contrast, fat free body mass has no lipids.

Gender was found to be the single most important contributor to fat patterning: female athletes have a higher extremity/trunk fat ratio (Malina et al., 1982; Ross and Ward, 1984). However, there is also a sport effect. For instance, male and female short distance runners were found to have more centrally located fat, while swimmers had a lower extremity/trunk fat ratio (Malina et al., 1982).

The use of Anthropometric Measurement (girth and length) is a 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 tank.

Most elite athletes now have access to extensive facilities provided by their coaches and sports scientists, and 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.

Another well-known method is using the weight and circumference measurements. It uses only body weight in pounds, and waist in inches (at navel), to calculate body fat percentage using the formulas.

In general, 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).

Growth and Development

Children are not just version of adults. They have very particular needs and capabilities. One of the major issues in children's sports is a lack of knowledge on the part of coaches and parents about how children grow and develop. This ignorance places unrealistic expectations on the child and often causes them to give up the sport. Good coaches know and understand the many changes that take place from child to adult and structure their coaching to best suit the needs of the young athletes. There are clear stages that children pass through from birth to adults. Physical growth is obviously important to performance. There are important changes in body size and proportions. The changes affect the way children can perform different skills and activities. These changes in body proportions will have a great influence on how skill will be performed. For example, changes in the relative size of the head in childhood affects the balance of the body during movement and relative shortness of the legs in the very young limits running ability. At the beginning of puberty children have long arms and legs. They are better suited for running but the rapid growth may take them appear to be clumsy and to have difficulty in coordination. During growth spurts most of the

child's energy is used for growing. Children will be easily tired and may not be able to keep up their usual volume or intensity of training. Light training will stimulate bodily growth if the child has enough energy. The growth spurt and puberty occur at different ages for girls and boys. Girls usually start and finish the stages of puberty and adolescence earlier than boys. The characteristics differences between boys and girls occur at puberty in response to changes in hormones produced by the body. Typically, this results in shoulders and little changes in the hip width in boys and broader hips and little change in shoulder width in girls. These changes affect the way boys and girls move. Wider hips in the girl's results in the thigh being angled more inwards, which change their running action. This may be very frustrating and difficult for the athletes to understand. Knowledgeable coaches prepare their female athletes before the changes at puberty. There may be a period for the athletes when there is little or no improvement for running performance. Once the running action has been adapted to the new body shape progress can be made. This period of adjustment can take up to two years. Patience and encouragement from the coach during this time will be beneficial to the young women. The sexual development, which happens at puberty, can bring physical difficulties for adolescent athletes, as well as causing them mental and emotional preoccupation. Role of the coach starts here and continues till taking his athlete to the victory stand.

Statement of the Problem

"Morphological characteristics of Elite Indian Track and Field Athletes of 2010 Commonwealth Games".

Aims of the Present Study:-

1. To study in detail the event wise morphological characteristics of elite Indian men and women track and field athletes of 2010 Commonwealth games.
2. To compare the morphological characteristics of the present athletes of different events with their Olympic counterpart.
3. To high light the differences of morphological characteristics between the Indian and Olympic level athletes and to suggest the modalities of improvement.
4. To prepare the normative values of morphological characteristics of athletes of different events of Track Field.

Delimitations of the study:-

1. The study has been delimited to the athletes of Track and Field only.
2. Only those track and field athletes (men & women) have been examined who tend to participate in the forthcoming 2010 Commonwealth games.
3. Only selected Anthropometric measurements were taken on each athlete.

Limitations of the Study:-

1. As the study was planned to be conducted on the elite Indian track Field athletes preparing for 2010 Commonwealth game therefore, small number of the subjects was a limiting factor.
2. As athletes of the present study were from the different parts of the country so the present sample is not homogeneous in nature.

Significance of the study:-

The present study may be significant in the following ways:-

1. The study would provide the descriptive morphological characteristics of athletes in the different events of track and field.
2. The study would be helpful to improve the desirable level of morphological parameters such as height weight ratio, muscle mass, fat mass, lean body mass, mesomorphy component of Indian athletes so that they can perform better in 2010 Commonwealth games.
3. The study may be helpful to the coaches to identify the training related changes.
4. Results of the present study may serve as yard sticks for other athletes of Track & Field to have the same morphological characteristics.

REVIEW OF LITERARTURE

The first adequate data on the body size of Olympic athletes in different sports were reported by Kohlraush (1929), who measured athletes took part in 1928 Olympic Games. Although statistical treatment was limited that time but still the data indicated that there were differences in body dimensions between events. Earlier to this investigation for the first time in 1887 pointed out that athlete did run to types. He found that the sprint runners were typically light and relatively long bones with full chested bodies.

Krakower (1935) reported data on 16 high jumpers and found that the type of individual that succeeded in high jump had long legs, a short body and broad feet.

Cureton (1941) stated that in general people with long legs and long arms and relatively short trunks were physically work types in long sustained heavy work but might show great speed and endurance at high levels of athletic activity.

Parnell (1951) worked on university athletic club athletes and found all group of athletes taller than the controls. Among the athletes javelin throwers, discus thrower and shot putters were tallest, and the sprinters

shortest. While coming about the weight, middle and long distance runners were the lightest athletes though not lighter than the control groups. The reciprocal of Ponderal index was found to be lowest among heavy event athletes who also registered a small range. The conclusion was reached that an individual's choice of athletic event might be recognized, in greater degree, to be because of the characteristics probably inborn than those recognized previously.

Tanner (1964) examined physique and body composition of Olympic athlete at Rome during 1962, and inferred that the athletes were both born and made. Further he stated the basic structure must be present for the possibility of being an athlete to arise. There seemed to be a gradient decreasing Mesomorphy and increasing ectomorphy as we pass from the sprints through the 400m to the 800m and long races. The sprinters and the 100m hurdlers together stood out as being considerably more Mesomorphic than all other track athletes.

Hirata (1966) examined the physique of the 1964 Tokyo Olympic players of different sports. While comparing wrestlers, weight lifters, Judo and Boxers, he observed that the position of wrestlers can be placed between boxer and weightlifters as per the age. With regard to physique, he concluded that wrestlers had stoutest physique after weightlifters.

Westlake (1967) divided 61 female track and field athletes of San Diego County into four groups on the basis of their best event and somatotyped them using Heath-Carter (1967) anthropometric method. The mean somatotypes for each group were sprinters 3-3.5-4, jumpers 3-3-4.5, distance runners 3-4-3.5, and throwers 5-4.5-2. Thrower differed from the other groups in being heavier, more endomorphic, more mesomorphic and less ectomorphic. Distance runners were shortest and they were less linear than sprinters and jumpers. High endomorphy and Mesomorphy seemed to be assets to throwers, as with male throwers the body mass was important.

Jana et al (1968) has carried out the investigation on Body composition, changing characteristically not only according to age and sex but also according to the balance of energy input and output and functional state, has become one of the most interesting morphological features of human physique. Cross-sectional studies have revealed remarkable differences in the proportions of lean body mass and fat related to adaptation for intensive physical activity in both adults and children and also in the aged. These differences were significant even where body weight, absolute and relative, was the same. The dependence of the higher proportion of lean body mass to fat on the degree of physical activity has been further demonstrated by dynamic changes in these proportions during periods of changing intensity of physical activity, often even without marked

changes in total body weight. Body composition is very closely related to various functional characteristics-functional aerobic capacity (measured as maximal oxygen consumption during graded work loads), metabolic cost of work, heart volume, creatinine excretion, oxygen consumption at rest, etc.-better functional fitness being connected with a higher proportion of lean body mass. All these relationships can also be demonstrated dynamically; i.e., with changing ratios of lean body mass to fat, these functional indicators change accordingly, especially in subjects in which the changes are highly noticeable (e.g., obese subjects after reduction in weight due to increased physical activity). From a metabolic point of view, it has been shown that marked changes in total body fat during periods of varying intensity of physical activity are connected with more profound changes in fat metabolism: adaptation for increased muscular work probably leads to an increased ability to mobilize fat metabolites (and to utilize them in greater proportion as a fuel for work) and increased lipolytic activity in various tissues (e.g., heart muscle), the contrary being the case with decreased physical activity. In this respect, and in its greater fitness, an organism adapted for greater physical activity resembles a younger one, a finding which is interesting also from the point of view of the so-called civilization diseases-obesity, cardiovascular diseases, etc.

Carter (1970) reviewed 33 British Empire games and 34 USSR outstanding Wrestlers. He found them to be high in Mesomorphy and low in Endomorphy and Ectomorphy components. He observed that USSR wrestlers showed 167.1 cm as their mean height while British wrestlers were 173 cm in their mean height. He further stated that there were 21% ectomorphic among British wrestlers while none was ectomorphic in Russian sample.

The study done by Forbes et al. (1970) on measurement of K_4 and skinfolds of 293 boys aged 8.5 to 18 years and 179 girls aged 7.5 to 18 years has shown that at these ages males may have higher proportion of their body fat situated subcutaneously than do females.

Eiben (1972) studied 125 women athletes during the Europian athletic championship. He found that in each anthropological character the sprinters had small dimension than all other women athletes. Their small stature was due mainly to their short trunk. Their lower extremities, especially their thigh were long as compared to the trunk. The development of their widths was moderate, the upper extremities less muscular, the lower limbs specially the lower legs, were strong with well-developed muscles. The hurdlers were strong and muscular. The middle distance runners were the most linear and slanders. Between the two groups of jumpers, the women long jumpers were somewhat

smaller. The high jumpers were taller. The women throwers were tall, heavy and muscular.

Malhotra et al. (1972) studied the functional capacity and body composition of the throwers, jumpers, sprinters and the middle and long distance runners. The truck men and jumpers were found to have a higher lean body mass with less fat content than throwers who were tall and heavily built. The middle and long distance runners had highest and the throwers, the lowest maximum oxygen intake capacity values in term of body weight and lean body mass. Similarly trackman had lower maximum heart rate than the other groups of athletes. The jumpers and throwers had stronger muscle power; however, the latter were strong in arm and shoulder muscle strength too.

Tcheng et al (1973) made a comparative study among state finalists and average school wrestlers. The anthropometric study revealed that state finalists wrestlers were older, had wider diameters, small circumference and lower skinfold value than the average wrestler.

Muthiah and Venketswarlu (1973) studied the Indian track and field athletes and noticed the throwers to be heavier, taller and older than other athletes. Among the runners, the age increased and height and weight decreased with the increase in distance they run. The jumpers and hurdlers were taller and heavier than sprinters, but were

shorter and lighter than the throwers. The decathletes were the second heaviest as they are all rounder.

De-Garay et al (1974) examined 1265 Olympic athletes at Mexico Olympics in 1968, from the total number of 6084 competitors and studied the apparent relationship between sports specially and physical structure of the individual. This study clearly supports the hypothesis: (a) there is a strong relationship between structure of athlete and the specific task in which he excels and (b) Clear physical prototypes exists for optional performance at the Olympic level games. de-Garay et al (1974) were perhaps the first to report comprehensive anthropometrical data to Olympic women players.

Sidhu and Wadhan (1974) worked on throwers who were found to be heavy and tall with relatively large limb circumferences and bicondylar diameters. They had better-developed lean tissue in the limbs associated with greater amount of fatty tissues.

Anthropometric study had been carried out extensively by Watson and Dako (1977) on African athletes to establish the anthropometric standard for those many countries of the developed world. Height, weight, skinfold thickness and mid upper arm circumference were measured in 540 males and 117 females aged 20 to 24 years who took part in the 1st African University Games, held at the University of

Ghana, Legon. Body fat content, Quetelet's index and mid upper muscle circumference were derived from the measurement taken. The physique or body build of the subjects as assessed by Quetelet's index showed that both male and female subjects from the various countries were of medium body build. The body fat content for male was between 10% to 12% with exception of the Egyptians (12.8%) while that of females was between 23% to 24%. Body measurements of the subjects compared favorably with that of international standards (WHO, 1966) with the exception of the triceps skinfold thickness which was only approximately 60% of standard value. The low value for triceps skinfold thickness are probably due to differences in the distribution of subcutaneous fat at the different sites in the body as found between Caucasian and non-Caucasian population groups. The results are discussed in relation to the findings of other workers on ethnic differences in skinfold thickness.

A group of top ranking hokey players has been studied by Sidhu & Sodhi (1979) to see the effect of training on subcutaneous tissue. The players were divided into three groups on the basis of estimated work load depending upon their field positions- group I being under maximum work load which is followed by group II and group III in a gradually descending order. Group I showed a substantial thinning of skin and subcutaneous tissue with training whereas group II also indicated this phenomena but of

lesser magnitude. But contrarily group III had shown thickening at most of sites. The sliming is relatively more in the limbs than that in the trunk.

According to Carter (1980) a relatively new and comprehensive approach for assessment of physique is through Kinanthropometry, which evaluates the physique structure of individuals. Kinanthropometry is one of the important and famous sports sciences of these days, which provides quantities interface between human structure and function. The term Kinanthropometry in its present connotation was used first time in 1972, (Ross et al, 1980). The use of the term Kinanthropometry was incorporated in a symposium on Kinanthropometry and egrometry at the International Congress of Physical Activity Sciences held in Quebec City in 1976, since then the knowledge of the science is increasingly being appreciated by the Sports Scientists, Physical educationists, Coaches and Sports administrators. The term Kinanthropometry is derived from Morphometry, which is measurement of shape and form of man.

Singal and Sidhu (1981) measured the stature, sitting height and subischial length in a cross-sectional sample of 502 Jat-Sikh and 510 Bania females of Punjab ranging in age from 20 to 80 years. It has been possible to separate out statural decrease due to ageing from secular effects by taking into consideration the subischial length, which is

least affected by ageing. The rate of loss in stature obtained due to ageing was 0.0997 +/- 0.012 cm/yr in Jat-Sikh females and 0.127 +/- 0.012 cm/yr in Bania females. After adjusting the stature for ageing, the secular estimate obtained was 0.051 +/- 0.022 cm/yr in Jat-Sikh and 0.047 +/- 0.021 cm/yr in Bania females. The ageing and secular estimates obtained per year in both the communities were significantly different from zero at 5% level. The ageing estimate obtained per year was more in Bania females, whereas the secular estimate per year was larger in Jat-Sikh females, although non-significant.

Body composition and somatotype were determined by Thorland et al (1981) in Junior Olympic competitors to evaluate the structural characteristics concomitant to high proficiency in various athletic activities. Underwater weighings and anthropometric determinations of somatotype were performed on 145 male and 133 female adolescent participants in national meet competition in the sports of track and field, gymnastics, diving, and wrestling. The most frequent differences within either the male or female Junior Olympic samples involved the performers in throwing events (shot put, discus, and javelin), who were taller, heavier, fatter, and of unique somatotype when compared to all or most other competitors. Additional structural differences, generally of a lesser magnitude, also existed between other groups of Junior Olympians. Differences in body composition characteristics were also

noted when Junior Olympians were compared with other adolescent athletes or non-athletes.

Roche et al. (1981) in one of their longitudinal study on white subjects of the Fels, found BMI to be the best indicator of percentage body fat in men and girls; subscapular skinfold as the best indicator in boys; and triceps skinfold, in children and women.

A cross-sectional study was done by Singal and Sidhu (1981) to see the morphological age changes with special reference to senescence has been conducted on the females of the Jat-Sikh and Bania communities of Punjab (India). These two communities are endogamous at caste level. The Jat-Sikh is traditionally an agriculturist community, mostly residing in the villages, whereas the Bania is traditionally a trading community and is living in cities. The data were collected during 1975-76 on 502 Jat-Sikh and 510 Bania females, ranging in age from 20 to 80 years. Weight, stature, sitting height and subischial length have been reported in the present paper. A peak in weight of 54.53 kg at age-group 40-44 in Jat-Sikhs and 58.01 kg at age-group 45-49 in Banias have been observed after which a decline sets in. The stature as been found to decrease continuously with advancing age from age group 20-24 in Bania and 30-34 in Jat-Sikhs up to age group 70+ giving a total decrement of 5.78 cm in Jat-Sikhs and 8.66 cm in Banias. Sitting height seems to play a major role in the shrinkage of stature

contributing about 4.50 cm in Jat-Sikhs and 6.71 cm in Banias, whereas subischial length has been found to decrease only by 1.65 cm in Jat-Sikhs and 1.95 cm in Bania females. The females of the present series have been compared with American, British and rural Colombian females.

Malina et al., (1982) analyzed Six skinfold measurements for male and female athletes (N=456) at the 1976 Montreal Olympic Games to identify principal components of fatness and anatomical distribution of fat, i.e., fat patterning. As in non-athletes, two principal components were evident among the athletes. All skinfolds were correlated positively with the first component, which was termed fatness, while extremity fat measurements were correlated positively and trunk measurements were correlated negatively with the second principal component, which was termed an extremity/trunk ratio component. The two principal components accounted for about 85% of the variance. The first component was related to control variables in order of descending contribution to its variance as follows: sex (21-31%), sport (19%), ethnicity (3%), and age (1-3%). Likewise, the second component (extremity/trunk ratio) was related to the control variables: sex (20-35%), age (4-7%), ethnicity (2%), and sport (2%). Fatness is more influenced by sport and by inference training than is the anatomical distribution or patterning of fat on the extremities relative to the trunk. The latter

characteristic may be more dependent on biological or environmental factors unrelated to sport and training.

Mueller et al (1982) conducted the study to analyze Six skinfold measurements of 92 White, Black and Mexican-American high school varsity female athletes to identify principal components of fatness and relative fat patterning. As in other athletic and non-athletic samples, two principal components were evident: a first component, accounting for 69% of the variation, was positively related to all skinfold sites, and a second principal component, accounting for 11% of the variation, was correlated positively with extremity sites (particularly lower limb sites) and negatively with trunk sites. The first component (fatness) was significantly related to sport (P less than 0.02) but not ethnicity. The second component (extremity/trunk) was significantly related to ethnicity (P less than 0.01) but not sport. These results, although tentative due to the limited sample size, support our earlier findings on Olympic athletes, i.e., fatness is more influenced by sport and by training than is fat patterning.

O'Connor et al., (1983) showed the evidence of the importance of physique in the athletics disciplines is supported by the persistence of certain characteristics over long periods, despite marked secular changes in the source population. These characteristics may also result in physiological benefits such as effective thermoregulation or

a greater power-to-weight ratio. Coaches and athletes are often convinced of weight or fat loss benefits based on personal or anecdotal experience, intuition, and "trained eye" observation of successful competitors. This may entice athletes into adopting unbalanced, erratic or highly restrictive eating patterns that increase the risk for nutrient deficiencies, and disordered eating. Despite heavy training loads and often-extreme diets, some athletes fall short of their physique goals as ultimately phenotype is under genetic control. Professionals assisting athletes with physique management need to be highly skilled in anthropometry and require a thorough understanding of sports-specific nutrition requirements. Careful assessment of the risks and benefits of various approaches to weight and fat loss is required before they are recommended to athletes.

In the study of 22 rural athletes of four different states of India have been studied by Bhatnagar and Grewal (1983) for 23 anthropometric parameters weight, height, sitting height, six diameters, six circumferences and eight skin and subcutaneous tissue folds. Rural athletes of Punjab and Haryana have been found to be comparable pertaining to all the anthropometric variables. Athletes of Madhya Pradesh show minimum values for most of the variables. The order of best anthropometry is athletes of Punjab and Haryana followed by Assam and Madhya Pradesh. Athletes of Madhya Pradesh are lacking behind in all the parameters

except skin and subcutaneous tissue folds as compared to athletes of Assam.

The paper reported by Singal and Sidhu (1983) showed the changes in body fat and lean body mass during 20 to 80 years. The data consisted of 502 Jat-Sikh and 510 Bania females. The body fat has been calculated by applying Durnin & Womersley's (1974) formulae. The body fat reaches a maximum value of 20.06 kg at age-group 60-64 in Jat-Sikh females and 22.15 kg at age-group 45-49 in Bania females followed by a decline, reaching a value of 15.28 kg in Jat-Sikhs and 14.93 kg in Banias in the 70+ age group. The redistribution of fat with ageing has also been observed from skinfold measurements and changing body contours. The lean body mass reaches a maximum value of 35.64 kg in Jat-Sikhs and 36.22 kg in Bania at age-group 35-39 followed by a steady decrease reaching a value of 30.47 kg in Jat-Sikhs and 28.27 kg in Banias at age-group 70+. The females of the present study possessed significantly lesser body fat and lean body mass as compared to American and British females. But in terms of percentages the Jat-Sikh females of the present study possessed the largest lean body mass and the least body fat.

In a study on Olympic athletes Carter (1984) reported that women runners and jumpers were proportionally lighter and the throwers heavier than their same sex sprinter prototype. Generally their proportional lengths were

not significantly different from the sprinter prototype except for shorter trunk for the high jumpers, shorter thighs for 400m runners and longer tibiale length for high jumpers and throwers. The breadths too were not significantly different from prototype except for larger billiocristale and femur breadth for throwers. Runners and jumpers were proportionally smaller in girths except for no significant difference in thigh and calf for long jumpers and calf for 400m and 800m runners.

The study was done by Bale (1985) to determine how female marathon runners of varying standards differed in body composition and physique and in their training regimes, and secondly to develop predictors of distance running performance from the anthropometric and training variables. Female marathon runners (n = 36), all participants in a national 10-mile (16 km) road racing championship, were divided into three groups according to their best time for the 26.2 mile race. They were assessed for body composition and somatotype using anthropometric techniques and completed a questionnaire about their current training for the marathon. No difference was found between the groups of distance runners when measured for height, bone widths and circumferences. The difference in body fat was particularly reflected in the triceps skinfold value. There was also a tendency for the elite runners to be more ectomorphic and less endomorphic than the others. The better runners were seen, on the whole, to have been

running longer, and to have more strenuous regimes, both in terms of intensity of training and distance run per week. Multiple regression and discriminant function analyses indicated that the number of training sessions per week and the number of years training were the best predictors of competitive performance at both 10 mile and marathon distances. They also indicated that a female long distance runner with a slim physique high in ectomorphy has the greatest potential for success.

Gilman and Mikelly (1985) reported an anthropometric investigation on 46 high school wrestlers. The study was conducted in pre season of training cycle. The mean age of wrestlers were reported to be 16.5 years and 65.1 kg in age and weight respectively. The fat percentage of wrestlers was recorded to be 13%.

Malina et al., (1986) studied the skeletal maturity relative to chronological age, and body size of national-level Belgian track and field athletes 15 to 18 years of age was considered. Among the 47 male athletes, 29 (62%) were skeletally mature, while 15 (52%) of the 29 female athletes were skeletally mature. There appeared to be a predominance of skeletally mature individuals among male sprinters and jumpers, while a majority of female sprinters were not skeletally mature. Both skeletally mature and immature individuals were rather evenly represented in the other track and field categories, with the exception of female

throwers, who were skeletally mature. Mean statures and weights of skeletally mature and immature 16-, 17- and 18-year-old male athletes did not differ significantly, though the skeletally mature tended to be heavier. In contrast, the skeletally mature female athletes, on the average, were taller and heavier than the skeletally immature, although the differences among the small groups were not statistically significant.

Beunen (1986) examined the association between the somatotype and age at peak velocity, in height, weight and static strength in Belgian boys and followed them longitudinally between 13 to 18 years of age. Data were based on 90 to 112 boys observed annually over five years, i.e. six observation points and include Sheldonian somatotypes at 18 years and age at peak velocity in height, weight and static strength (arm pulls). For the age at peak velocity respectively before the mean 1 sd on the mean 0.5 sd and after the mean 1 sd. A one way MANOVA was applied to test the statistical significance of the differences between the groups. Early matures in height or weight have higher Mesomorphy scores. For age at spurt in static strength, the differences between the somatotypes between tended to b significant.

Himes (1988) has been carried out an investigation about the racial variation in physique and body composition and also it is of interest to sport scientists because these

characteristics may be related to athletic performance, fitness, strength and injury. There is clearly variation among groups in mean somatotypes and the sitting height-stature relationship. Although differences are often emphasized, racial group distributions of variables describing physique often overlap to a considerable extent. Environment may be a factor in group differences in physique. Consistent Black-White differences are found in mean levels of variables related to bone mineralization, with Blacks exceeding Whites. It may be that the lean body mass of Blacks is of greater density than that of Whites. Gross morphological variation among groups is probably only a concomitant of variation in performance rather than a determinant of performance.

The Investigation made by Housh et al., (1988) to determine the yearly changes in the body composition as well as absolute and relative isokinetic forearm flexion and extension strength of high school wrestlers. The findings of this study indicated that the improved wrestling performance and the increased weight classification, which normally occurs during high school, are, in part, a function of yearly changes in body composition and muscular strength.

Singal and Sidhu (1983) studied the body measurements including height, weight, limb circumferences, skeletal diameters and skinfolds were taken

on 100 unrelated and healthy Jat-Sikh men of 17 to 25 years of age, belonging to different areas of Punjab, India. The average height and weight of Jat-Sikhs is 170.4 cm and 54.5 kg, respectively. The mean Heath-Carter somatotype is 3.22-3.40-4.11. The majority of somatotypes is concentrated in endo-ectomorph and meso-ectomorph sectors of the somatochart. Comparisons with recently described data on females of the same area and population show significant sex differences in various body measurements except for the bicristal diameter. The females possess significantly more subcutaneous fat. For the rest of the measurements, the males have higher values. The Jat-Sikh males are comparable in height and weight to the contemporary pooled Punjabi, but are distinctly taller than the neighbouring populations of Himachal Pradesh and pooled all India samples. However, they are comparatively smaller and lighter as compared to European and American populations.

Gaur and Singh (1998) showed the Changes in somatotype with age were investigated in a cross-sectional sample of 400 Garhwali men from northwest India. The subjects, 17-60 years of age, were somatotyped with the Heath-Carter anthropometric protocol. The overall mean somatotype was 3.0-3.7-3.1. A one-way MANOVA indicated significant differences among the nine age groups. Pairwise comparisons using Hotelling's T^2 showed significant differences between men up to 29 years and those over 30

years. Garhwali men 30+ years of age were more endomorphic and less ectomorphic than younger men. The mean somatotype for men 30+ years was 3.3-3.9-2.7 and for men <30 years was 2.8-3.3-3.9. Endomorphy and mesomorphy increased with age with a reciprocal decrease in ectomorphy up to 55 years; the trend was somewhat reversed thereafter. The somatotype categories mesomorphic ectomorph and mesomorph-ectomorph included the greatest proportion of Garhwali men <30 years; maximum percentages of men 30+ years belonged to the mesomorph-endomorph, endomorphic mesomorph and mesomorphic endomorph categories. Garhwali men were more ectomorphic and less endomorphic and mesomorphic than Canadians

Singh and Malhotra (1989) stated that Kinanthropometry equips us with the techniques of various body measurements e. g. height, body weight, transver diameter of various parts of the body, circumferences and length of various parts, skin and subcutaneous tissue folds thick nesses etc. According to them the body measurement can be utilized to study the gross size of an individual. How much tall and heavy is a person, an idea about his shape, size and proportion can be drawn.

Pollitzer and Anderson (1989) showed that the ethnic and genetic factors are significant determinants of bone mass, along with such environmental factors as diet and

exercise. Differences in bone density between blacks and whites remain even after adjustment for body mass. Black-white differences in bone mass appear to be related to ethnicity because blacks have not only greater skeletal calcium content, but also greater total body potassium and muscle mass. Genetic studies of twins and parent-offspring pairs reflect strong constitutional associations of both bone mineral content and bone density at commonly measured skeletal sites. At least for females, bone mass accumulation by age 20 years is highly associated with maternal bone mass; up to menopause it is enhanced by child-bearing and lactation; beyond menopause environmental factors seem to dominate. Dietary calcium and physical activity are significant in the control of bone mass. These findings are important for osteoporosis and fractures, especially in elderly people.

Anthropometric study was done by Sidhu (1990) on 105 runners specializing in long, middle and short distances, by applying standard techniques. The results indicated that long, middle and short distance runners have somatotype ratings of 1.5-3.5-3.91. 1.52-3.68-3.56 and 1.61-3.62-3.65 respectively. Percentage of body fat calculated by applying Brozek et al., (1963) formula is 7.51, 7.55 and 8.72 in long, middle and short distance runner. Long distance runners are less endomorphic than middle distance runners. Long distance runners are significantly leaner than short distance runners as indicated by

percentage of body fat, but do not differ significantly in somatotype components. Similarly middle distance runners have significantly less body fat than the short distance runners, but these two groups do not show significant differences in somatotype components.

Hebbelinck et al., (1973), studied the somatotypes in a Spanish school-aged population The study showed an evolution in the components of the somatotype with age, and a distribution of somatoplots in the somatochart which presented peculiar characteristics in both sexes.

Density and percentage of fat in the body were investigated by Petrasck et al., (1990) in 403 females and 356 males of Czech population. Fat values were found to increase with age, growing in females and males between the ages of 17 to 49 years from 27.1 to 35.4 and from 16.3% to26% respectively.

Sodhi et al., (1991). Suggested that the discus and hammer throwers and shot putters as well as the middle and heavy class wrestlers must reduce fat weight for better efficiency, in this connection it is also suggested that wrestlers be provided psychological counseling to avoid taking excessive amounts of animal ghee.

Leake and Carter (1991) studied the body composition and somatotype of 16 trained female athletes aged 18.8-

32.8 years was measured. All of the subjects were engaged in a competitive training programme and participated in the same triathlon. Anthropometric variables included height, mass, selected diameters, girths and skinfolds, and a Heath-Carter anthropometric somatotype. Body composition was determined by hydrostatic weighing procedures and skinfold pattern. Comparisons were made with Olympic swimmers and runners. This group of athletes was generally heavier, less lean, more mesomorphic and less ectomorphic than elite runners. Reported body densities from other studies indicated little difference between the athletes and other groups. Skinfold pattern was similar in shape for all groups, but the runners had smaller values, at all sites, than either swimmers or athletes. Because of lack of information on cyclists, adequate comparisons were not possible. Regression analysis indicated that training parameters were more important than anthropometric measures in the prediction of performance. It was concluded that this group of athletes were closer, with respect to both body composition and somatotype, to swimmers than to runners.

Body composition of North Italian athletes was studied by Gualdi et al., (1992) in relation to sex, age, sports and level performance. About thickness and anatomical distribution of subcutaneous fat females showed skinfolds thicker than males. Significant differences were observed in skinfold thickness means of different sports groups. Sub

scapular and forearm skinfolds were the best discriminate variables for male and females respectively. With aging body density decreased whereas fat percentage and fat free mass increased.

Claessens (1994) investigated in order to determine the role of body build characteristics in modern athletes, 65 female participants at the IXth World Modern Pentathlon Championships, 1989 were investigated. Anthropometric characteristics (body mass, lengths, breadths, girths and skinfolds), somatotype and body composition estimates were determined. Compared with other female athletes (e.g. swimmers, runners, fencers), the elite modern athletes were rather tall and, as indicated by the body mass index they had a high mass relative to their stature. Based on skinfolds, body fat was estimated as 16%, and anthropometrically determined somatotype was on average 2.5-3.9-2.8. The relationship between the athletes' anthropometric characteristics and modern pentathlon performance was investigated by means of Pearson zero-order correlations between the physical traits and the competitive performance scores. Significant correlations were found mainly for the 'fat' variables, such as skinfolds, percent fat and the endomorphy component, which indicated an inverse relationship between the amount of fatness and modern pentathlon performance. To investigate this relationship further, Pearson zero-order correlations were calculated between the respective factors scores,

derived from a rotated factor pattern were carried out on selected somatic variables, and the performance scores. The results demonstrated that, in relation to anthropometric characteristics, modern pentathlon performance in females is mainly associated with the 'fat development' factor, and to a lesser degree with the 'bone-muscle development' factor. Variables representing linearity of physique seem to be unrelated to modern pentathlon performance. Stepwise regression analysis revealed that 42.4% of the variance in modern pentathlon performance can be explained by the following anthropometric variables: sum of 10 skinfolds, biacromial breadth and humerus diameter. To obtain a high level of modern pentathlon performance, it would seem that a female athlete must above all have a low level of body fatness and, to a lesser degree, a relatively high level of lean body mass.

Hawes et al., (1994) showed that the concept of a morphological prototype in relation to the development of athletes is examined from the standpoint of the Kinanthropometric techniques available to the sport scientist. Examples of the utility of the morphological prototype in the context of modern-day sport are provided in a variety of winter and summer sports. Somatotypes drawn from competitors at the 1988 Olympic and 1991 World Junior Speed Skating Championships are presented representing the somatotypic prototype. Statement of the prototype in variables that are both discrete and sensitive to

change over the short term is considered to be more appropriate for evaluating the progress of young athletes. Examples drawn from speed skating, figure skating, swimming and synchronized swimming are used to illustrate changes and differences in muscle mass, skinfold corrected muscle diameters, bone mass and sum of skinfolds. The concept of establishing an individual ideal prototype through optimizing morphological variables is introduced.

Sodhi and Rajni (1994) investigated the physical structure of elite Indian boxers by dividing them into three broad weight categories Viz light, medium and heavy. The boxers showed a gradient of increasing body measurements with the advancement of weight categories. And Indian boxers were found to possess significantly more body fat with less development mesomorphic component. But ectomorphy does not much differ from Olympic counterparts.

A total sample of 304 athletes of Bahrain was collected to study the body composition by Musaiger (1994). The findings revealed that there were differences in body composition among athletes (football, handball, volleyball and basketball) according to the type of sports. Basketball and volleyball were the tallest athletes while the handball players were the heaviest one. Skin fold thickness

measurements showed that basketball and handball players have more subcutaneous fat than other athletic group.

The investigation has been done by Rajni (1994) on twenty three top ranking Indian weightlifters belonging to three broad categories such as light class (N=8), medium class (N=10) and heavy class (N=5). Results reveal that the majority of weightlifters are overweight by 0.5 to 4.5 kg and the Indian weightlifters are found to be younger in age and heavier because of excessive fat than those Olympic level weightlifters.

Khanna et al., (1994) found that the Cuban boxers are taller and this gives them advantage over the opponent during competition. The optimum requirement of developing the mesomorphic components beyond that it may not play significant role in improving the performance. Body fat should not exceed 10%, 12%, and 15% in lower, middle and heavy weight categories respectively. The aerobic and anaerobic development of the boxers should be optimum. The most important aspect that is, recovery should be faster and the boxers should have better cardio-respiratory adaptation with technical superiority can determine the success in the competition.

Eston and Reilly (1996) studied with the purpose to cross validate conventional equations on a group of 56 Chinese adults. Body density was assessed by underwater

weighing and also predicted by equations which use a combination of selected skinfolds-biceps, triceps, pectoral, sub scapular, abdominal, suprailiac, thigh and calf. There were significant correlations ($P < 0.01$) between the various methods of predicting percentage fat. However, analysis of variance revealed significant differences ($P < 0.01$) between mean values. In the men, the Jackson and Pollock equation underestimated, and the Durnin and Womersley equation overestimated, the percentage fat predicted by underwater weighing. The best predictor site in this group was the medial calf skinfold ($r = 0.81$), which is not included in either equation. In the women, the best predictor sites were the triceps, suprailiac and thigh. As these sites are also used in the Jackson et al. equation, it is not surprising that there was no difference between the prediction of percentage fat by this equation and underwent weight. It is concluded that the Durnin and Womersley and Jackson and Pollock equations tend to overestimate and underestimate, respectively, the percentage fat in Chinese men. Alternative equations, which use the calf skinfold, may be more appropriate for this ethnic group. In Chinese women, there appears to be good agreement between Jackson and Pollock and hydro densitometry estimations of percentage fat.

Davy et al,. (1996). Studied thirty endurance athletes of similar competitive ranking ranging in age from 23-56 years to test the hypothesis that age does not directly influence body composition or regional body fat distribution

throughout middle age in women. Body composition (hydro densitometry and skinfolds) and regional body fat distribution (waist and hip circumference and triceps, subscapular, suprailiac, abdomen and thigh skinfolds); maximal oxygen uptake were taken following standard protocol.

Balla & Walia (1996) studied 154 infants (86 males and 68 females) born to normal healthy Punjabi parents residing in the Chandigarh and outskirts comprised the sample for the longitudinal study. The two measure of muscle mass, mid upper arm muscle circumference and corrected upper arm diameter were estimated at monthly interval from 1 month to 12 month of age. Monthly distance and velocity means for two measures of muscle mass along with their SD(s) are presented growth velocities for the two indicators of muscle mass in general depicted rapid declaration during about first half of infancy rather than the latter one where trends becomes more consistent. Male infants in general possessed higher means for muscle mass than the females. Sex differences for distance data were found to be significant from 4 to 6 months; however, gender differences remained statistically no significant for monthly growth velocities throughout the age-range considered.

Talwar and Kaur (1997) examined the age changes in somatotype during adolescence among Bania girls of Punjab. A cross sectional sample 284 healthy girls, ranging

in ages from 9 to 16years, were somatotyped using the Heath and Carter Anthropmetric Method. The endomorphic and mesomorphic ratings showed an increase of 0.9 to 0.6 unites respectively while a decrease of 0.9 units; is witnessed in the ectomorphic component during this eight years span. The somatotype of the sample girls at 9 years was 1.84-1.36-3.43 and at 16 years 2.74-1.98-2.48. Results indicate a shift in component dominance with age. Which eventually leads to variability of somatotype during adolescence?

Nelson and Barondess (1997) measured whole body bone, fat and lean mass, by dual-energy x-ray absorptiometry, of third-grade children in a suburban public school district adjacent to Detroit. Of 1,340 eligible children, 773 participated. Using U.S. Census categories, parents identified their children as black/African-American (57%), white (38%), or one of several other categories (5%). Some of the participants also identified with a relatively large Middle Eastern subgroup (Chaldeans). Of the 773 participants, 734 are included in this report (71 Chaldeans, 226 whites, and 437 black/African-Americans; other categories are omitted). We describe body size, body composition, and physical activity levels in the three groups. The Chaldean and black children have significantly higher average whole body bone mineral content (BMC) than whites ($P > 0.05$), but are not different from each other. Lean mass and height are significantly greater for Chaldeans and

blacks than for whites. The ratio of BMC to height was also significantly greater in Chaldeans and blacks compared with whites. Chaldeans have a significantly higher weight and fat mass than either the black or white children, and report significantly less physical activity than either the white or the black children. The higher bone mass among the Chaldean children may be partially explained by their greater body mass, but there is no readily apparent explanation for the observed ethnic differences in body size. We cannot exclude genetic or environmental factors not evaluated in this observational study. Our unexpected finding that Chaldean children, when analyzed as a separate group, are more similar in body composition to black/African-American than to white children contributes to a growing body of literature indicating that the uncritical use of "race" categories may obscure rather than facilitate the identification of population differences.

Trippo and klipstein (1998) investigated a comprehensive analysis of body build, body composition and nutritional status. The study sample consists of 498 men and women aged from 35 to 65 years. Subjects underwent a detailed anthropometric examination encompassing thirty-one body measurements, eleven skin fold thickness measurements and bioelectrical impedance analysis for determination of body composition. Dietary intake was assessed by a semi quantities food frequency questionnaire. The body composition was clearly associated

with age and body build. Somatometric differentiation by use of the metric index showed that percentage of body fat was significantly higher in pycnomorphic compared to leptomorphic subjects, whereas reported dietary energy intake was lower. Comparison of estimates of body fat showed considerably deviating results for skinfold thickness measurements and bioelectrical impedance analysis depending on the equations used. This was especially pronounced in obese subjects where on an average bioelectrical impedance analysis resulted in higher values for percentage of body fat compared to skinfold thickness measurements. It was concluded that for assessment of nutritional status, body composition should be investigated taking into account body build in addition to age and sex.

During the Sixth All Africa Games held in Harare, Zimbabwe in September 1995, when an international team of researchers undertook anthropometric investigations on elite African athletes by Ridder (1998). The project was named *HAAGKP* (the Harare All Africa Games Kinanthropometric Project). There are few studies on the morphology of world-ranking female African athletes. Data were collected on 178 female athletes with a mean age of 21.7 years. The athletes were from 18 countries with Zimbabwe (n=45), South Africa (n=38), Namibia (n=25), Botswana (n=24) and Zaire (n=10) having the most subjects. The majority of the subjects were Black (65.7%) with Caucasians (29.8%) the second largest group. Females from

11 different sports were measured with track and field (n=52), netball (n=48), swimming (n=15) and handball (n=14) the sports with the most competitors. The anthropometric variables and techniques selected were primarily those described in Carter and Ackland (1994). Data analyses were performed using Statistical 5.0 (StatSoft, Inc. 1984-1996). Heath-Carter somatotypes were calculated using equations of Carter and Heath (1990). Endomorphy was calculated with a height correction. Results indicated that the average somatotype for the female athletes (N=178) was 3.3-3.6-2.8, that is, a central somatotype with slightly more mesomorphy and endomorphy than ectomorphy. The four-somatotype categories to the left of center on the somatochart (in which endomorphy and mesomorphy combinations are high and ectomorphy was low) account for 40.5% of all female athletes. Another 33.1% are in the central and balanced mesomorphy categories, and 26.4% are to the right of the center in ecto-mesomorphy through balanced mesomorphy categories. Finally, none of the female athletes are in the lower sector of the somatochart where mesomorphy is lower than both endomorphy and ectomorphy. Somatotype comparisons were made of female athletes in each of the 11 sports by event or by playing position and performance level. Differences in somatotypes were found between events or positions within sport categories. There were for example significant differences between track and field athletes in the 9 different events in the endomorphic ($F=7.19$; $p<.05$),

the mesomorphic ($F=5.42$; $p<.05$) as well as the ectomorphic ($F=4.10$; $p<.05$) components.

Murakani (1999) studied the changes in body shape among Japanese women aged in their 20's by measuring the subcutaneous fat over whole body and its circumference at certain points. The longitudinal research clarified the changes in body shape among Japanese women aged in their 20's, by measuring the subcutaneous fat distribution over the whole body and its circumference at certain points. The subjects, 13 healthy women, were measured twice, once in their early 20's and 5 years later in their late 20's. Subcutaneous fat thickness was measured at 14 points on the body using the B-mode ultrasound method and the body size was measured directly at 8 points on the body using a steel measure. Subcutaneous fat thickness tends to increase with age, except at the cheek, neck, bust and leg. Significant increases were detected especially at lower parts of the trunk such as the waist and infragluteal region. Meanwhile, despite the significant change in subcutaneous fat thickness, the circumferences measured did not change, and also weight tended to decrease with age. Based on this finding, except for fat, body mass, such as muscle and bone, decreases with age due to decreased exercise and changes in calorie intake. Cluster analysis of the accumulation patterns of subcutaneous fat indicated that there were the following 3 patterns of subcutaneous fat accumulation from the early 20's to the late 20's. I.

Accumulation on the whole trunk (bust, abdomen, waist and back) and upper arm - trunk/upper arm accumulation pattern II. Significant accumulation around waist - waist accumulation pattern III. Accumulation at abdomen, side abdomen, hip and lower hip-abdomen/hip accumulation pattern.

Ruff (2000) estimated Body mass from measures of skeletal frame size (stature and bi-iliac (maximum pelvic) breadth) fairly accurately in modern human populations. Here the stature/bi-iliac method is tested, using data available for modern Olympic and Olympic-caliber athletes, with the rationale that these individuals may be more representative of the general physique and degree of physical conditioning characteristic of earlier populations. The average percent prediction error of body mass among both male and female athletes is less than 3%, with males slightly underestimated and females slightly overestimated. Among males, the ratio of shoulder to hip (biacromial/bi-iliac) breadth is correlated with prediction error, while lower limb/trunk length has only a weak inconsistent effect. In both sexes, athletes in weight events (e.g., shot put, weight-lifting), which emphasize strength, are underestimated, while those in more endurance-related events (e.g., long distance running) are overestimated. The events most closely approximating these requirements in Olympic athletes are the decathlon, pentathlon, and wrestling, all of which have average percent prediction errors of body mass

of 5% or less. Thus, morph metric estimation of body mass from skeletal frame size appears to work reasonably well in both normal and highly athletic modern humans, increasing confidence that the technique will also be applicable to earlier hominines.

Moreno et al., (2001) examined adolescent children of Zaragoza (Spain) were becoming centrally obese to a greater extent than predicted by their relative body weights. Two cross sectional studies were conducted in 1980 and 1985 among selected subjects and four skinfolds thicknesses (biceps, Triceps, subscapular, suprailiac) were measured and some indices of fat patterning were calculated: triceps/subscapular skinfolds (T/SS), Biceps + triceps/ subscpular + Suprailiac skinfolds (B+T/SS+SI). As a result, a trend to a central pattern of adipose tissue distribution, especially in males and that too at the young ages (6-11 yr in males and 6-7 yr in females) was found.

Tetsuya et al., (2001) in competitive sports, the body composition of athletes has a significant influence on the athlete's performance. In this study we analyzed the body composition of women Judo athletes. In the righter weight categories, body fat % and LBM were lower than in the heavier weight categories, and this tendency was more marked in the higher-level athletes. The fat volume % increment was most marked in the trunk and tended to be higher in the heavier weight categories. However, the fat

volume % in the legs and head decreased at and over 78kg weight categories. The fat volume% in the arms did not change in any of the weight categories. There was no significant correlation between right or left hand grips in regard to body fat composition.

The investigation of body composition was done by Ibnaziaten et al., (2002). Monitoring of several anthropometric parameters in young handball players of various ages indicated that the physical activities was beneficial to health, promoting a decrease in fat mass and an increase in muscle mass. The findings also revealed that from the ages 10 to 14 years, percentage of fat mass decreases, and a changes in the distribution of subcutaneous fat is observed.

Eisenmann and Malina (2002) stated that age- and sex-associated variation in subcutaneous adipose tissue of adolescents engaged in regular endurance training is similar to trends observed in the general population of youths, although sum of six skinfolds (biceps, triceps, subscapular, suprailiac, abdomen, calf) is less. An increase in SUM6, rather than the ratio of the sum of three trunk skinfolds to the sum of three extremity skinfolds (TER), is significantly associated with an increase in low density lipoprotein cholesterol (LDL-C), triglycerides (TG) and TC: HDL in adolescent males, and a decline in high density lipoprotein cholesterol (HDL-C) and an increase in TG in females. This

study demonstrates the differential effects of gender on the pubertal development of SAT and blood lipoproteins in young distance runners and highlights the need to explore the interactions among sexual maturation, fatness, fat distribution, exercise training, and blood lipoproteins during adolescence.

The study has been conducted by Singh et al., (2003) on 121 junior boxers ranging in age from 16 to 18 yrs. Body proportions were calculated according to formula of Ross and Wilson. The result indicated that height increases from lower weight categories to higher weight categories. The heavy and super heavy weight players possess positive *z*-values due to more body weight than those of phantom. The higher weight categories possess more *z*- values of upper arm, forearm and thigh circumference than those of phantom.

The anthropometric evaluation of Indian boxers who participated in eight different weight categories in Busan Asian games had been carried out by Singh et al., (2003). A Comparison also had been made so as to evaluate possible structural discrepancies of the Indian boxers. The study thrown light exclusively on the on the limitations to the boxers performances due to morphological characteristics like absolute and proportional body size, body composition and somatotype.

Watts et al., (2003) studied to describe the general anthropometric characteristics of junior US competitive rock climbers. Ninety subjects volunteered to participate. All competed at the Junior Competition Climbers Association US National Championship. Anthropometric variables, including height, mass, body mass index (BMI), arm span, biiliocristal and biacromial breadths, skinfold thickness at nine anatomical sites, forearm and hand volumes, and handgrip strength, were measured. Selected variables were expressed as ratio values and as normative age and sex matched centile scores where appropriate. A control group (n=45) of non-climbing children and youths who participated in a variety of sports activities, including basketball, cross country running, cross country skiing, soccer, and swimming, underwent the same testing procedures in the Exercise Science Laboratory of Northern Michigan University. Despite significantly lower skinfold sums and estimated body fat percentage, no differences were found between climbers and controls for absolute BMI or BMI expressed as a centile score. Young competitive climbers have similar general anthropometric characteristics to elite adult climbers. These include relatively small stature, low body mass, low sums of skinfolds, and high handgrip to mass ratio. Relative to age matched athletic non-climbers; climbers appear to be more linear in body type with narrow shoulders relative to hips. Differences in body composition exist between climbers and non-climbing athletes despite similar BMI values. Warner

(2004) investigated that despite widespread use of skinfolds to estimate body fatness, few prediction models have been validated on females athletes to develop a skinfold model that predict fat free mass in female collegiate athletes. In these athletes fat free mass can be predicted accurately from body mass and abdominal and thigh skinfold. In conclusion, it was found that a body composition model using body weight and two skinfolds showed excellent validity for predicting fat free mass in collegiate level female athletes.

Kapoor et al., (2005) showed that the high altitude adult females to be leaner and to store more fat on the trunk region as compared to females from plains, thereby pointing towards the fact that not only the quantity of fat but also the way it is distributed over the body's surface differs among females inhabiting two contrasting environmental situations.. The present study however points towards the limitation of BMI as an index of obesity and the BMI with the skinfold thickness would provide a better insight into the body composition of an individual. Although a clear age related redistribution of fat in favors of trunk has been found among the highlanders who have yet not reached the mid age their pattern may provide some adaptive advantage to the delicate organs situated in the upper trunk region against the climatic status of high altitude.

Eight skinfolds were measured on males (n=130) and females (n=56) of top class runners by Arrese et al., (2005). It was to determine skinfold value among both sexes in order to identify the association of sex and event with fatness and distribution of subcutaneous fat. The study concluded that the lower skinfold value, found in all groups of runners, may be due to their high performance. This analysis also showed that a slight excess of fat is not beneficial in order to obtain a high performance.

Investigation conducted by Kang et al., (2005) showed the changes in fat patterns during adolescence (10-17 yrs.) among schedule cast males of Naraingarh (Haryana). Various anthropometric indices have also been calculated to assess the fat patterning in these adolescents subjects. Percent body fat was calculated by using skinfolds measurements as well as BMI. It was seen that body fat% calculated by skinfold measurements is a better measure of adiposity than that by BMI.

Legaz and Eston (2005) studied thirty top class runners to determine if the changes in specific skinfold sites induced by intense athletic conditioning over a three year period were associated with changes in running performances in high level athletes. On the basis of the findings it may conclude that the anthropometric assessment of top class athletes should include an

evaluation of all skinfolds. The lower limb skinfold may be particularly useful predictor of running performance.

Kang et al., (2005) investigated the national female hokey players (Senior, N=19 and Junior N=40). Fifteen anthropometric measurements were taken on each subject using standard technique of Weiner and Louire (1969), to demonstrate subcutaneous fat patterns and somatotypes, and compared with in and also with other countries of the world. From this study, we found that height, weight and mesomorphic component of international players showed significant dominance over Indian national players and also showed significant difference of t- test values. The senior players are heavier in weight, less in height, having high % of body fat, low lean body mass and having lesser musculo-skeletal development when compared to the international players.

The additional adiposity has shown a negative effect on performance in homogeneous groups of elite runners. The purpose of this study was to determine weather the sum of skinfolds thickness and a specific single skin fold site were related to competitive running performance in homogeneous groups of male and female elite athletes. Biceps, triceps, sub scapular, pectoral, iliac crest, abdominal, front thigh and medial calf were taken among 184 top class runners (130 males and 54 females). The results of the study indicated that skin fold thickness in lower limb were

positively associated with running time over several distances and may be a useful predictor of athletic performance.

Roy et al., (2006) studied the body composition of one hundred and twenty two sportspersons, including sixty-two females, belonging to five disciplines of weight categories sports in Imphal, Manipur. This study highlighted that the male and female sportspersons are yet to develop optimal body composition, specific for their particular discipline, for success both in the national and international sports arena.

Willy, et al., (2006) conducted a study and purpose of this study was to assess relative total body fat and skin fold patterning in Filipino national karate athletes. Participants were members of the Philippine men's and women's national teams in karate (12 males, 5 females) In addition to age, the following anthropometric measurements were taken: height, body mass, triceps, sub scapular, supraspinale, umbilical, anterior thigh and medial calf skinfolds. Relative total body fat was expressed as sum of six skinfolds. Sum of skinfolds and each individual skin fold were also expressed relative to Phantom height. The men had a lower proportional triceps skinfolds (-1.72 ± 0.71 versus - 0.35 ± 0.75, $p < 0.001$). Collapsed over gender, the karate athletes (-2.18 ± 0.66) had a lower proportional anterior thigh skin fold than their pancake slat colleagues (-1.71 ± 0.74, $p = 0.001$).

Debnath and Debnath (2006) conducted the study to differentiate the body composition and somatotype characteristics of elite sports women, in individual sports disciplines. Fat percentage, lean body mass and somatotype of each athlete were obtained by applying appropriate methods. So from the findings of the study it has been concluded that there are significant differences in fat percentage, lean body mass, somatotype characters among Indian elite female gymnasts track sprinter, long distance runner, swimmer sprinters and long distance swimmers. Indian elite female gymnasts and track sprinters have been found as balanced mesomorphic; the long distance runners as mesomorph-ectomorph; the swimming sprinters as balanced mesomorph; and the long distance swimmers have been found to possess central somatotype.

Freedman et al., (2007) examined the additional information provided by skin fold thicknesses on body fatness, beyond that conveyed by BMI-for-age, among healthy 5- to 18-years old (n = 1196). Although the body mass index (BMI, kg m (-2)) is widely used as a measure of adiposity, it is a measure of excess weight, rather than excess body fat. It has been suggested that skin fold thicknesses be measured among overweight children to confirm the presence of excess adiposity. Skin fold thicknesses, when used in addition to BMI-for-age, can substantially improve the estimation of body fatness, the improvement among overweight children is small.

Fruth et al., (2007) has showed the primary purpose of this investigation was to compare percent body fat (%BF) determined using skinfold regression equations for female athletes to %BF measured using the BOD POD criterion measure. Valid skinfold equation for female collegiate athletes allows individuals to accurately and easily determine players' %BF in a field setting. Participants in this study were 75 female collegiate athletes at a Division III University between the ages of 18-24 years. Each participant was tested in the BOD POD and had four skinfold sites measured. Criterion-related concurrent validity and intra class reliability were tested before testing began to ensure the investigator was valid and reliable at taking skinfold measurement. Three previously developed skinfold equation for females were used to calculate %BF: The first equation (SF-UWW) utilized UWW as the criterion, the second equation (SF-DEXA) was developed using DEXA as the criterion, while the third equation (SF-Gen) was a general skinfold equation that has been recommended for women ages 18-55 years using UWW as the criterion. A one–way analysis of variance (ANOVA) was performed with repeated measures on the four body composition techniques. Tukey's HSD post hoc analysis was used to compare the means for each technique. Cohen's d was used to calculate effect size for mean differences. No significant differences were found between the BOD POD and any of the skinfold measurement. However, significant differences were found with SF-DEXA having a lower %BF than SF-

UWW and SF-Gen. In conclusion, it was found that the three skinfold equation used in this study compared with the criterion measure, BOD POD.

The study of Franchini et al., (2007) had as objectives (1) to compare the morphological and functional characteristics of the male judo players of the Brazilian Team. According to these results the main conclusions are: (1) the physical variables measured do not discriminate performance when analysis is directed to the best athletes; (2) a higher percent body fat is negatively correlated with performance in activities with body mass locomotion (Cooper test and the SJFT); (3) judo players with higher aerobic power performed better in high-intensity intermittent exercise; (4) judo players with bigger circumferences present bigger absolute maximal strength.

Talwar et al., (2007) conducted a study (unpublished) to determine the specific morphological characteristics of young male athletes compared with non-athlete students. Anthropometric measurements of 19 badminton players, 96 soccer players, 74 volleyball players, and 51 non-athlete undergraduate students, aged 16 to 28, were obtained in 1994 and 1995. Stature, body weight, bicondylar breadths of the humerus and femur, calf and upper arm circumferences, and skinfolds (at triceps, subscapula, calf, and supraspine) were measured for each subject. Heath-Carter somatotypes were determined in all the subjects. The

results of the ANOVA of the body measurements showed that the three groups of athletes and the non-athlete students were heterogeneous: the badminton players were shorter and lighter with greater skinfold values among the athlete groups; the soccer players were relatively shorter and with smaller skinfold values and greater arm and leg girths; and the volleyball players were taller and heavier with smaller elbow and knee breadths and very small skinfold values. Greater arm girth, elbow breadths, knee breadths, and backs and leg skinfolds characterized the non-athlete students. In mean somatotype category, the badminton players were 'central' (3.3-3.7-3.7), the soccer players were 'balanced mesomorph' (2.7-4.9-3.0), the volleyball players were 'mesomorph-ectomorph' (2.4-3.5-3.7), and the non-athlete students were 'ectomorphic mesomorph' (2.7-5.2-3.8). Comparisons of international data with each of the different sports showed that the Indian players were extremely short and light.

Malousaris et al., (2008) studied the morphological characteristics of competitive female Volleyball players. Volleyball athletes of this study were mainly balanced endomorphs. Significant differences were found among athletes of different playing positions, which are interpreted, by their varying role and physical demands during a volleyball game.

Investigation made by Hagmar et al., (2008) to characterize various parameters related to weight control in Olympic competitors. It shows optimization of body weight and composition is a key priority for elite athletes striving for a competitive advantage. The weight control practices employed by Olympic athletes participating disciplines that emphasize leanness appear to be sub optimal. Counseling concerning weight control could be used as a tool to prevent illness and enhance performance.

Nevill et al., (2008) stated cast serious doubts on the validity of BMI to represent adiposity accurately and its ability to differentiate between populations. These findings suggest a more valid (less biased) assessment of fatness will be obtained using surface anthropometry such as skinfolds taken by experienced practitioners following established procedures.

Singh et al., (2008) showed a significant difference among 16 yrs, 17 yrs and 18 yrs age group in height and weight in Basketball boys. And there is no significant difference among selected groups in fitness variables. In case of a drastic change in body height or body weight, more weight age in training should be given to performance factors, the technique and coordination.

Vucetic et al., (2008) studied to present the morphological characteristics of 54 Croatian national level

track-and-field athletes. 21 anthropometric body measures were taken on a sample of 15 sprinters (S), 16 endurance sprinters (S4), 10 middle-distance runners (MD) and 13 long-distance runners (LD). Body fat percentage, body mass index and somatotype were also calculated. Canonical discriminative analysis showed significant difference between the athletes of various running events, in the measures of body volume and body fat, while no significant difference was found in the variables of longitudinal and transversal dimensions of the skeleton. ANOVA and Student t-test for independent samples showed statistically significantly higher thigh and lower leg circumference in sprinters, as well as greater upper arm skin fold in middle-distance runners. The mesomorphic component is a dominant characteristic of somatotype of the runners in all events, whereas the ectomorphic component is the least marked.

The study has been conducted by Singh et al., (2008) to find out the differences among the somatotypes of various groups of inter university male throwers and long distance runners, age ranging from 18 to 25 yrs. Height, weight and somatotype of each subject were obtained by applying appropriate methods. The throwers were found heavier and taller as compared to long distance runners. The endomorphy and mesomorphy components have been noticed maximum in throwers (shot putter followed by discus and javelin throwers) followed by runners (5000m

followed by 10000m and cross country runners). The inter university athletes were found more endomorphic and less mesomorphic, as compare to the elite Indian athletes and Olympic level athletes.