CHAPTER I

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It is interesting to note that one-third of the world's population lives at an altitude above 2000 Metres. During the past decade a number of studies have been done to determine the physical performance of athletes living at high altitudes (Roy, 1967).

A large area of the globe is covered with high and rugged mountains, presenting conditions adverse to human, animal and plant life. In addition to the loneliness and cold climate of the high-altitude regions, the rarified atmosphere contributes greatly to the discomfort of man. At present these areas are populated up to an altitude of nearly 5000m. Despite the adverse environmental conditions, especially the relative lack of oxygen, these high-altitude dwellers meet the great physical demands of their daily life with adequate functional capacities.

During the 1955 Pan American Games, the 1962 World Pentathlon Championships, and the 1965 "Little Olympics" held in Mexico City at an elevation of 2250m (7,400 ft), athletes who lived and trained at high altitude performed better than those who had no previous altitude experience. Some post-competition episodes of unusual exhaustion, prolonged recovery times, and general illness occurred among the contestants. When Mexico City was awarded the 1968
Olympic Games, apprehension was expressed which centered around the adverse effects of hypoxia of maximal physical performance. Countries without training facilities at high altitudes were particularly concerned. For the optimum success of sports training at some particular altitudes, the factors of duration and intensity of training appear as important as the level of altitude at which it takes place. Success or failure of training becomes most evident in competitive events.

A high level of performance in sports not only requires certain physical qualities like speed, endurance, power, strength and agility but also a good physical structure. In modern times, especially in relation to training for sports and games with a focus on superior performance, adequate importance is given to the physique and body build of each athlete. Therefore, it is evident that 'body build', in scientific terminology known as "physiognomy" gets primary attention at the time of selection of players for games and sports where some superior competition is involved. In modern sports anthropometric measurements and their relationship with various motor traits are an important guide for coaches as well as athletes for making training schedules and for classification of students in different groups according to their age, abilities and so on. Scientists and physiologists have been of the view that anthropometric measurements and the physical components of an athlete have a lot to do with his performance. Along with technique or
the tactics of a player or a team, physical and physiological characteristics help him in achieving a better performance. Research findings show that a high level of technique performance alone has very little to do with competitive sports. Most of the games demand higher than normal level of speed, strength, endurance, flexibility, co-ordination and the optimum fitness of the organism.

The poor performance of Indian athletes and sportsmen in international competitions has been of great concern, especially to coaches, physical educationists and sports scientists. Efforts have been made to improve the standards of our sportsmen since long time now. However, little success has so far been achieved. There are numerous factors which are responsible for the performance of a sportsman. The performance of a sportsman in any game or event is not only dependent on his or her suppleness, skill, training motivation and on various other factors of physiological and biochemical nature but also on age, physical growth and geographical and ecological factors.

High-altitude natives are self-sustaining, some of them living in permanent settlements as high as 5486 metres in the Andes and Himalaya mountains. Prolonged exposure of an unacclimatised person to such an altitude may cause death from hypoxia. Even if the person remains inactive the physiological challenge of even a moderately high or medium
altitude becomes readily apparent during physical activity. The environment also influences the mode of doing work, which differs from place to place. It is seen that generally people living in hilly areas have to face more physical work as compared to people living in the plains. Work efficiency at a high altitude is much less. This everyday life work under difficult conditions itself acts as a load. Physiological changes are required for adaptation to such an environment. High and low altitudes have contributed not only in the field of minerals but have also played a vital role in developing human traits and features. It is a general observation, for example, that small and stout people are referred to as 'high altitude inhabitants'.

The longer we remain at some particular altitude, the better becomes our performance, but it never quite reaches the values that are obtained at sea level. The improved performance during a stay at particular altitude is brought through acclimatization. The number of weeks needed to acclimatize depends on altitude i.e. for 9000 feet about 7 to 10 days. These are only approximations; a great deal depend on the individual.

As we ascend above sea level the barometric pressure decreases and the weight of the atmosphere becomes less. The percentage in the air remains 20.9% but the number of oxygen molecules per unit volume decrease. This means that, when at an altitude, in order to receive the same number of
molecules in a breath of air that we receive at sea level, we must breath in more air (Shaver, 1982).

Prior to the 1968 Olympic Games in Mexico City (altitude of approximately 7,300 feet or 2,300 meters), scientific studies of work performance at high altitude had been concerned primarily with problems of military significance or mountaineering expeditions. In fact, every large country and several of the smaller ones have undertaken investigations both at home and abroad to determine the specific effect of high altitudes on sports performance. Several international symposia have recently been conducted to discuss problems related to work performance at high altitude.

Consequently, there is a likelihood of differences in somatotypes, anthropometric, motor fitness and physiological variables between different populations of different altitudes (Methews and Fox, 1976). Those who are interested in the "why" of various performances cannot omit body type information (Larson and Yocum, 1951).

**SOMATOTYPE**

Somatotype is name given to system of classifying physique introduced by William Sheldon and his associates and described in a book published in 1940 and an atlas of men's physique published in 1954. Various modifications of the system have been proposed. The somatotype classification considers shape and size.
Somatotypes are body types or physical classifications of the human body. The term somatotype has been used to describe the type of physique. The terms endomorphic, mesomorphic and ectomorphic are used to describe a person in terms of his or her somatotype. The first component of the somatotype or the rating of endomorphy is based upon three skinfolds (triceps, subscapular, and suprailiac); the second component or the rating of mesomorphy is estimated from the calf girth, bicep girth, humerus width, femur width, and height; the third component or the rating of ectomorphy is determined by $\text{Ht}/3/\text{wt}$.

Physical educators manifest an interest in "somatotyping" as means to relating body types to success in various sports. The somatotype of men and women athletes are gauged and related to the various sports in which they excel (Mathews and Fox, 1976). The method commonly used for somatotyping is the Sheldon technique (1954).

A more objective assessment of body build has been developed by Heath and Carter (1976), using height, weight and various skinfold and girth measurements to determine somatypes for the three components mesomorphic, endomorphic and ectomorphic.

Tanner (1964) derives the names of the three components from the three original embryonic layers of human cell. A brief description of three components follows:
As the most manifest external characteristic of an endomorph is the layer of fat, which indicates a predominance of the absorptive functions, it is named after the endoderm.

Similarly, the dominant characteristic of the mesomorph is the presence of massive muscles and large bones, their structures being derived from the mesoderm.

A relationship between the large surface area and sensory organs of the ectomorphs and the ectoderm layer is also indicated.

S.P. Singh, L.S. Sandhu, P. Malhotra and Abha Dhariwal (1987) stated that knowledge of somatotypes is valuable to quantify the overall morphological confirmation of the human body where several characteristics can be summarised in the form of rating of fitness, musculature and linearity. Its application has found its due place in the study of sportsmen. Olympic athletes have comprehensively been studied by various scientists for their somatotype classification (Fanner, 1964; Carter, et al., 1982; Hirata, 1979). In India, there has recently been an increasing trend to study the somatotypes of athletes. This is evident from some recent studies (Singh, 1973; Singh and Sidhu, 1975; Sodhi, 1976; Sodhi, 1980; Singh and Sidhu, 1982; Verma, et al., 1982; Sodhi and Sidhu, 1984).

The essential events which differentiate between
infancy, childhood and adulthood are the processes of growth and development, which are the manifestations of life. Their rate and quality indirectly reflect the general health of an individual. The health of an individual is gauged through a study of somatotype variables and body components. Many hereditary and environmental factors are also responsible for influencing the health of an individual. The socio-economic status of an individual also contributes to a great extent to his growth and development (Tanner, 1967; Lall, 1972; Kaul, 1975; Kaur, 1985).

Role of Physique in Sports

Studies on the physique of athletes have gained greater importance since the publication of the "The Physique of the Olympic Athletes" by J.M. Tanner (1964), a work based on the athletes at the Rome Olympics. Some aspects of physique of athletes have also been reported from time to time (Kohlrusch, 1929; Hirata, 1966, 1979; de Garay et al., 1974).

Carter (1970) considered the morphological characteristics of athletes to be of interest to biologists for competitive sport demands the utmost from the body. It is, therefore, reasonable to expect to find in athletes a demonstration of the relationship between structure and function. Parnell (1951), in an anthropometric study of athletes, concluded that an individual's choice of athletic events might largely be due to inborn characteristics. Tanner (1964) examined
the physique and body composition of Olympic track and field athletes and inferred that the athletes were both born and made. "The basic structure", he stated, "must be present for the possibility of being an athlete to arise". Physique is a factor in success that may lead to inclusion in an Olympic team, or more negatively, lack of proper physique may make it almost impossible for an athlete to reach that degree of success. The human physique differs in a thousand ways. It can be analysed by studying the size, shape and form of an individual.

Studies on physique may be useful in choosing a suitable physical activity for an individual whose main objective is competition. Various other studies also suggest that different body sizes, shapes and proportions are beneficial in different physical activities (Kohlausch, 1929; Bharwells Ellis, Kralower, 1985; Curelor, 1933, 1947, 1951; Parnell, 1951, 1958; Kroll 1954; Tanner, 1964; Sodhi et al., 1974; Sidhu et al., 1975). They have suggested that a nation with people whose general physique was limited to the characteristics of champions in certain events should concentrate on those events. According to them, the Japanese who are small are best for events requiring small builds such as gymnastics, long distance running, light class boxing, weightlifting, etc. Similarly for North Americans, who are large and lean, such sports as basketball, volleyball, swimming, long-jumping and
short and middle-distance running were the best. Studies of body composition in certain sports indicated that the athletes who were very lean but heavy because of a well-developed muscle structure were superior in performance in certain competitive sports activities such as football, weightlifting and the shotput (Bhuller 1976).

On the other hand, athletes who have a 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, Sills, 1960). It may be for this reason that long-distance runners are found to be less endomorphic than other runners and their counterparts at a lower level of competition (Tanner, 1964; Carter, 1970).

Using Sheldon's as well as Heath and Carter's method of guaging somatotypes, numerous attempts have been made to study the relationship of somatotypes to the health and physical/motor fitness of individuals. A perusal of the relevant literature would seem to indicate that somatotype characteristics on one hand and fitness on the other are inter-related to serve as important factors in the health and fitness needs as well as the interests and abilities of individuals, and may be used for classification purposes (Tanner, 1964).
If differences in physical fitness, motor fitness and anthropometric and selected physiological and psychological variables are found to be common to body builds, then test interpretations and the development of norms must be done with a knowledge of individual physique (Willgoose and Rogers 1949). Due to geographical and climatic differences, depending on the altitude, there is a likelihood of differences in the motor fitness of the pupils of the two areas.

**MOTOR FITNESS**

The fitness of man has always been a concern of mankind. Physical fitness, from prehistoric times to the present day, has been equated with survival and power. Primitive people were fit or they perished. The earliest human beings were dependent mainly upon their individual strength, vigour and vitality for survival. For their very existence they had to acquire basic skills such as agility, balance, running, endurance and climbing. Primitive physical activity was related closely to survival activity. The people had to run in search of food, clothing, shelter and protection from a hostile environment. They had to prepare themselves to fight animals and other groups of human beings.

The poor performance of Indian sportsmen and women in international competitions has proved that they lack physical fitness. Therefore, it is felt that there is a dire need to improve the physical fitness levels of Indian youth.
Barrow (1983) stated that many earlier civilizations of the world such as Spartan Greeks, early Athenian Greeks and the early Romans laid great stress upon the physical fitness of their countrymen. Physical training was an important objective of their educational programmes. The countries which developed a strong nationalistic system of education in 19th and 20th centuries, such as the German Nazis, gave great importance to the physical fitness of their countrymen. The USA, during and after World War I and II, introduced an organized physical training programme for the physical fitness of the youth and this continues even today.

The term motor fitness became popular during World War II. Motor fitness may be defined as a limited phase of motor ability, emphasizing capacity for vigorous work. The aspects selected for emphasis are speed, endurance, power, strength and agility. More specifically, motor fitness might be referred to as efficient performance in such basic requirements as running, jumping, dodging, falling, climbing, swimming with sustained effort in a variety of situations.

The American Association for Health, Physical Education and Recreation (1976) defines fitness as: "That state which characterises the degree to which a person is able to function
efficiently. Fitness is an individual's matter. It implies the ability of each person to live most effectively within his or her potentialities. The ability to function depends upon the physical, mental, emotional, social, moral and spiritual components of fitness, all of which are related to each other and are mutually interdependent.

Too often people think only of physical fitness when the term "fitness" is used, but this encompasses only a part of a person's make-up. The above definition implies that one should view physical fitness as only a part of total fitness. This is backed up by Jones, et al. (1972), who state: "A totally fit individual has the strength, speed, agility, endurance and social and emotional adjustments appropriate to his age."

**Role of Motor Fitness in Sports**

Motor fitness is very essential for efficient living. No game or sport can be played well without motor fitness. It is the main factor which determines our sports performance. Motor fitness has an important role to play in competition. Countries which are sports conscious, have achieved a high ranking in international competition and want to maintain that high ranking have long since realised the importance of motor fitness. For a good performance in any sport or athletic event, the achievement of a high standard of fitness is a basic requirement. Mere participation in sports activity
is not enough to improve fitness. Fitness must be gained through conditioning programmes.

Motor fitness is a basic requirement for good programmes in various sports activities. It should not be forgotten that man is an individual unity, where in all parts act and react in an integrated whole. We cannot possibly divide him into discrete components. Numerous researchers in this connection have related physical traits to the total effectiveness of the individual—physically, mentally and psychologically. Medical authorities have universally emphasised that in order to maintain basic organic soundness throughout one's life, physical activity is a must. Nutritionists advise exercise for weight control. Youth fitness is a topic of great national interest today as the motor fitness of the youth is considered the national wealth of a country.

Today, we live in a civilisation where the genius of man has created an easy way of living which has removed much physical activity from our daily tasks. Children from birth are adapted to a mechanical life. The lack of physical education in our elementary schools and recreational facilities in our communities makes it practically impossible for many except the few who make to a variety of teams to participate in vigorous
athletics and sports. The decline in physical strength and vigour is self-evident, and this is a product of our mechanical age, particularly the automobile. The lack of physical activities in our elementary and secondary schools is a contributing factor in the decline of motor fitness.

Indian society displays marked differences in socio-economic divisions in society. To what extent influence the physical powers and skills of an individual has been the subject of speculation and debate among sports scientists. On the one hand, it can be said that a high nutrition level, medical facilities and educational opportunities which are available to members of the socially and economically higher classes give them a considerable advantage over the less-privileged sections and makes way for greater and better use of muscular capacities, leading to high standards of physical fitness. Similarly there may be significant differences in the attitudes of the higher and lower classes regarding the need for developing motor fitness and the type of physical activities engaged in for developing high standards of motor fitness in accordance with their respective social aspirations and ideals.

Whatever a person's life style, he can maintain
a required level of fitness provided he is keen to be fit. What he needs to know is what aspects of being fit are missing from his life. Why is it essential to develop and maintain good motor fitness. The effective functioning of these bodily activities will enable a person to maintain a healthy, strong and fit body throughout his life. Malfunctioning of these activities may well result in physical deterioration and even death. To check this deterioration, people ought to be fit. Jokl (1959) suggests that regular exercise will fulfil these requirements by acting as preventing medicine. He further emphasises that those who maintain physical activity have better performance records, less degenerative disease, and probably a longer life expectancy than the general population. There is no doubt that proper physical activity, as part of a way of life, can significantly delay the aging process.

**PHYSIOLOGICAL VARIABLES**

Physique and motor fitness are not exclusive factors in selection. Other factors which determine performance also need due consideration. Consequently there is an awakening interest in physiological variables. The physiological changes that take place during acclimatization are:
1) Increased pulmonary ventilation.
2) Increased number of red cells and haemoglobin concentration.
3) Elimination of bicarbonates \((\text{HCO}_3^-)\) in the urine.
4) Tissue levels change.

Thus apart from physical appearance, physiologists have shown sample differences in various physiological functions pertaining to natural acclimatisation. According to Meardle Natch and Katch (1981), the following are the gains of living at a high altitude:

a) Hyperventilation.
b) Excretion of base via kidney and a concomitant reduction in alkaline reserve.
c) Sub-maximal heart rate remains elevated.
d) Sub-maximal cardiac output falls to below sea level values.
e) Stroke volume lowered.
f) Maximum cardiac output lowered.
g) Decreases in plasma volume.
h) Increase in total number of red blood cell.
i) Increased haemoglobin concentration.
j) Possible increase in capillarisation of skeletal muscle.
k) Increased red blood cells.
l) Increased mitochondria.
m) Increased aerobic enzymes.
Anderson (1968) has pointed out that the systolic pressure increases during exercise. The initial period of an increasing systolic pressure during the performance of rhythmic exercises lasts for one to two minutes, after which a fairly constant value is reached and maintained, the level of which depending upon the intensity of the exercise. The diastolic pressure remains practically unchanged by light and moderately heavy exercise, but may increase slightly during heavy exercise. As a consequence of the differential rise in systolic and diastolic pressures, the pulse pressure increases greatly.

According to Karpovich and Sinning (1971), the systolic pressure shows an increase in both athletes and non-athletes; but the diastolic pressure changes slightly because of less peripheral resistance and the elasticity of the walls of the arterioles. Non-athletes do not show any large increase for a given heart-rate. The pulse pressure tends to increase and decrease with systolic pressure.

The heart rate and blood pressure are influenced by several factors such as age, sex, body size, body position (posture), the time of recording, smoking, alcoholic intake, ingestion of food, emotions, body and environmental temperature, the physical condition of the individual and so on.

Most observations have shown that the pulse rate is definitely affected by body position. The rate is lowest
in lying and highest in standing. Digestion of food accelerates
the heart rate for two or three hours. A high environmental
temperature may greatly increase the frequency of the heart
beat. Variations in the emotional state effect the pulse
rate much more than postural changes. Among anemic subjects,
the pulse rate will be higher. It is, therefore, difficult to
find out the exact and true resting values (Best and Taylor,

Vital capacity is defined as the maximal volume of air
which a person can expel from his or her lungs by forcible
expiration after the deepest possible inspiration. Vital
capacity is related to age, body weight, height and the skin-
surface area. The lung capacity of a normal, healthy female
is approximately 10 per cent less than that of her male
counterpart of similar age and size. This difference may be
due, in part, to the females' lower metabolic rate, which
demands less oxygen. The difference may be explained through
the male's more developed respiratory muscles. It should be
pointed out that although vital capacity can be increased with
training, it is not related in a very high degree to one's
ability to perform work.

Another adjustment which the body makes towards accli-
matization is an increase in the number of red blood cells, for
hypoxia causes rapid production of these cells by the bone
marrow. Usually, in full acclimatization to low oxygen, the
hematocrit (the percentage, by volume, of the red cells in
the blood) increases from a normal value of 40 per cent (women)
and 45 per cent (men) to an average of about 59 per cent
which, in turn, increases the blood viscosity. At the same time,
the hemoglobin concentration increases from the normal 15 grams per cent to an average of approximately 20 grams per cent. The increases in the hematocrit and hemoglobin concentrations are probably due to the overall decrease in plasma volume. In addition, the blood volume generally increases by as much as 20 to 30 per cent. This results in a 50 to 90 per cent total increase in the circulating hemoglobin. It has been found that an increase in blood hematocrit above the normal level of 40 to 45 per cent reduces the cardiac output because of the increased blood viscosity. As a result, at an altitude, this means that the heart must do more work in order to compensate for the increased blood viscosity.

Prolonged residence at an altitude as low as 12000 feet often develops red blood cell counts as high as 7 to 8 million per cu.mm as compared with the normal count of 5 million.

Hemoglobin is the compound found in red blood cells that carries most of the oxygen from the lungs to the skeletal muscles. The greater the blood volume the greater the hemoglobin. Thus both hemoglobin and blood volume are directly related to the amount of oxygen transferred and hence to the functional size of aerobic or oxygen systems i.e. (to the v0max). The blood volume and hemoglobin also play an important role during exercise at high altitudes. The increase in haemoglobin concentration is rapid during the first few weeks at high altitudes, the increase becoming more gradual thereafter.
The function of this response is to increase the oxygen content of arterial blood.

Vogal and Hansen (1977) have stated that the heart and circulation are quite capable of meeting the demands of oxygen delivery during work at altitudes up to 4300 meters. In addition, more information is needed about nutritional requirements during rapid translocation to high altitudes. Hypoxia, voluntary hypohydration and alkalosis are factors contributing to losses in body weight and plasma volume and probably to symptoms of acute altitude sickness. The effect of hypoxia on work performance received renewed attention during the period 1962-1968, largely as a result of planning for the 1968 Summer Olympics, the conflict between the Indians and Chinese in the Himalayas and the reduced physical capacity for work observed during the United States' troop movements and maneuvers at high altitudes.

Role of Physiology in Sports

Apart from the study of somatotype measurements and motor fitness variables, physiological variables play an equally important role in improving the sports performance of athletes. This investigator, along with somatotype and motor fitness variables, has also included certain physiological variables to find out the differences between high and low altitude sports girls and non-sports girls.
The development of the science of physiology in the 20th century provided sound bases for establishing the mechanisms of the beneficial effects which exercise produces in the human body. For specific physiological systems of the body to be fit, they must function well enough to support the particular game that the player is playing. Since different games make different demands upon the organism with respect to neurological, respiratory, circulatory, metabolic and temperature-regulating functions, physiological fitness is specific to the activity at hand. Physiological systems are highly adaptable to exercise. Each task has its own major physiological components, and fitness for that task requires the effective functioning of appropriate systems. The functional ability of the muscle is dependent upon the efficiency of the circulatory system. The circulatory system gives nutrition to the working muscles. Inefficient circulation decrease the power to do a work. All this we can know only with the help of physiology. Knowledge in physiology is a must for coaches and physical education teachers. This will be an effort to study the magnitude of the differences in populations caused by climatic and altitude factors.

Sports and Non-sports

"Sports", in the view of Vanderzwag and Sheehan (1973) is a higher order of playful games. The spirit of play never completely disappears from sports. Sports retains a play-like quality as one of its characteristics. Sports in its purest and most complete form occurs in game situations. As games become more organised or formal, rules become more codified and consequently more binding. Sports as we know
today fall more on the structure side of the game-rule continuum. By its very nature, sports is generic, referring to a type of activity rather than a specific activity. In the generic sense, sports compares to music, art, literature, science and religion. One outstanding feature of sports is its playlike nature, owing its origins to playful attitudes". Similar views on the nature of sports have been expressed by Schmitz (1972) and Alderman (1974).

Sports and competition have been analysed from the training and performance points of view in various research studies. Researchers in education are constantly devising and verifying methods of instruction. The research designs in such studies seem to have ignored the role of sports and games in our set-up.

Because of fast changes in society, the concept of sports has undergone a great change. Competitive sports is one of the outgrowths of modern society. It is a challenge which stimulates, inspires and motivates men and women to run faster, jump higher, throw farther and exhibit greater strength, endurance and skills to establish supremacy over others. Every individual or team which participates in any sport or game wants to win as society attaches a great significance to "winning". According to Renewar (1972), "performance is the keynote of all sports—its basic principle."
Since sports have become a prestigious aspect to prove one's superiority, the philosophy of participation in games and sports has undergone a great change.

It has been observed that an individual becomes progressively different from his fellows with every maturational change and accompanying environmental experience. As in other spheres, the activity of an individual influences his personality and other characteristics. Hence it is logical to expect that the varied experiences of athletes will produce some physiological, anthropological, sociological and psychological changes in them. It is also possible that the characteristics that differentiate athletes from non-athletes, or different group of athletes, could be due to selectivity in the sense that certain types of persons are attracted to athletics.

Recognising the value of physical education and sports in the education of an all-round developed individual, students in educational institutions are provided with a host of opportunities to participate in these activities. Physical education teacher usually assume this responsibility and disseminate the knowledge and skills associated with sports. The also assume responsibility for such other educational objectives as health and hygiene, physical fitness, posture, movement skills, recreational skills and dance skills which necessitate systematic research efforts on the part of physical education teachers and researchers so that these educational objectives are realised adequately and the physical education
programme in the educational institution is carried out on more systematic and scientific lines. The introduction of physical education as a compulsory subject in the educational curricula of schools and colleges in some of the States in India is a testimony to this fact. The new education policy has also stressed the need for introducing physical education at the primary level. Commenting on the utility and purposefulness of physical education and sports, Bucher (1975) remarked: "It is not merely a 'frill' or an 'ornament' that has a means of keeping the children busy. It is instead a very important and an integral part of the total educational process. Through well-directed programmes children develop skills for the worthy use of leisure time, engage in activities that are conducive to healthful living and all these endeavours lead to their physical, social, mental and emotional health".

Coakley (1973), summing up the importance of sports, said: "It is popularly believed that sports builds character and provides outlets for aggressive energy. Hence one may expect different characteristics among participants in different sports groups as well as non-participants".

It is within this framework that the effects of
of physical activity on a growing child must be understood, as exercise-induced responses are likely to become permanent features. The physical activity puts the organism to various stresses which affect the biochemical and physiological responses and, finally, several responses get reflected in the morphological state. The magnitude and degree of a response varies with the duration and intensity of and perhaps training with the activity stimulus. The responses generated via regular physical activity initiated during childhood are believed by many to result in favourable influences on the organism during growth and into adulthood.

The discussion on the proceeding pages leads to the emergence of the design of the present study of the sports and non-sports girls of varying altitudes with a focus on the anthropometric, motor fitness and physiological variables.

**STATEMENT OF THE PROBLEM**

The focus of this study was on comparing somatotype measurements, motor fitness and selected physiological variables of sports girls and non-sports girls at varying altitudes in the case of schoolgirls. The problem
was thus stated:

"COMPARATIVE STUDY OF SOMATOTYPE, MOTOR FITNESS AND SELECTED PHYSIOLOGICAL VARIABLES OF SPORTS AND NON-SPORTS SCHOOL GIRLS AT DIFFERENT ALTITUDES".

OBJECTIVES OF THE STUDY:

The objectives of the present study were:

1) To study the level of the differences in somatotypes between sports girls and non-sports girls living at varying altitudes.

2) To find out if any difference exists in the level of the motor fitness amongst sports girls and non-sports girls living at varying altitudes.

3) To compare the level of the physiological fitness of sports girls and non-sports girls at two different altitudes.

4) To find out the differences with regard to the somatotype measurements, motor fitness and physiological variables of sports girls and non-sports girls living in the same climate and at the same altitude.
To find out independent and interactive effects of sports and non-sports girls of high and low altitudes on somatotype, motor fitness and selected physiological variables.

HYPOTHESES:

1) There will be significant differences in the somatotype measurements between sports girls and non-sports girls of different altitudes.

2) There will be significant differences in the motor fitness of sports girls and non-sports girls due to altitude differences.

3) There will be significant differences in the physiological variables between sports girls and non-sports girls of different altitudes.

4) There will be significant differences in the somatotype measurements, motor fitness and the physiological variables of sports girls and non-sports school girls living under the same climate and at the same altitude.
6) **The interactive effects of sports participation and altitude will account for significant variations in the studied variables.**

**DELIMITATION:**

1) **This study was delimited to the assessment of the somatotype components through the Heath-Garter Anthropometric Somatotype Method.**

2) **It further delimited to the assessment of motor fitness as measured by the AAHPER Youth Fitness Test (1976).**

3) **It was also delimited to the assessment of selected physiological variables.**

4) **The study was restricted to female students ranging in age from 13 to 15 years.**

5) **Girls belonging to selected regions (Chandigarh and Shimla) were studied.**

6) **Only the native schoolgirls of the selected regions were studied.**

**LIMITATIONS:**

The following are the limitations of the study:

1) **The study has been conducted on schoolgirls who were natives of Shimla and Chandigarh. These girls, however, do not belong to the same economic class or caste. The conditions under which these**
2) Further, the tests could not be given to the sample subjects on the same days, and during same hours. That the diurnal variations might have had some effect on performance was identified as yet another limitation of the study.

3) The unavailability of sophisticated instruments and up-to-date techniques for collecting data was seen as another limitation.

4) Variations in playground surfaces and the physical education programmes offered by different schools could also be treated as a limitation for the study.

DEFINITION AND EXPLANATION OF THE TERMS:

The three somatotype components, viz. endomorphy, mesomorphy and ectomorphy, have been described as follows (Sheldon and Tucker, 1940):

Endomorphy: Endomorphy is characterised by roundness and softness of the body. The anterior, posterior as well as lateral diameters tend toward equality in the head, neck, trunk and limbs. Features of this type are: predominance of the abdomen over the thorax, high, square shoulders and a short neck. There is smoothness of contours throughout, with no muscle relief. The breasts are always well-developed, usually as a result of fatty deposits.
Mesomorphy: Mesomorphy is characterised by a square body with hard, rugged and prominent muscle formation. The bones are large and covered with thick muscles. The outstanding characteristics of this type are forearm thickness and heavy wrists, hands and fingers. The thorax is large and the wrist is relatively slender. The shoulders are broad, the trunk is usually upright and the trapezius and deltoid muscles are quite massive.

Ectomorphy: Ectomorphy includes, as predominant characteristics, linearity, fragility and delicacy of the body. The bones are small and the muscle thin. The limbs are relatively long and the trunk short. However, this does not necessarily mean that the individual is tall. The abdomen and the lumber curve are flat, while the thoracic curve is relatively sharp and elevated.

Motor Fitness: This may be defined as a limited phase of motor ability, emphasizing the capacity for vigorous work. The aspects selected for emphasis are speed, endurance, power, strength and agility. More specifically, motor fitness might be referred to as efficient performance in such basic requirements as running, jumping, dodging, falling, climbing, swimming, or displaying a sustained effort in a variety of situations.

Speed: According to Johnson and Nelson (1982), speed of movement could be defined as "the rate at which a person can propel his body, or parts of his body, through space".
**Agility:** Agility is the physical ability which enables an individual to rapidly change body position and direction in a precise manner (Johnson and Nelson, 1982).

**Muscular Power:** Power may be identified as the ability to release maximum force in the fastest possible time.

**Muscular Strength:** Johnson and Nelson (1982) defined strength as "the muscular force exerted against movable and immovable objects".

**Muscular Endurance:** Muscular endurance may either be dynamic or static in nature and concerns the ability of a muscle to repeat identical movements or pressures, or to maintain a certain degree of tension over a period of time (Johnson and Nelson, 1982).

**Cardiovascular Endurance:** Cardiovascular endurance is defined as the "ability of the circulatory and respiratory systems to adjust to and recover from the effects of exercise or work" (Johnson and Nelson, 1982).

**SELECTED PHYSIOLOGICAL VARIABLES**

**Systolic blood pressure:** The maximal level of arterial blood pressure is called systolic pressure. When the ventricle contracts, the blood is ejected into the aorta due to the arterial resistance. The pressure in the arteries rises rapidly, distending the elastic arterial walls.
**Diastolic blood pressure:** The lowest level reached by the arterial pressure in this decline is referred to as the diastolic pressure. The diastolic pressure is recorded when the ventricle is relaxed.

**Haemoglobin:** Haemoglobin is a complex molecule found in red blood cells, which contains iron and protein and is capable of combining with oxygen (Mathews & Fox, 1976).

**Vital capacity:** Vital capacity is the maximum volume of air that can be exhaled after forceful inhalation, without any discomfort and changes in the alveolar lining of the alveoli normal (predicted) value.

**Pulse rate:** The heart beat per minute is known as the pulse rate. The heart beat is governed by two sets of nerves—the sympathetic and the vagus. The heart rate is accelerated by the sympathetic set of nerves, while it is slowed down by the vagus set of nerves.

**Sportsmen:** Several experts and investigators have used the terms athlete or player for a sportsman and the term non-sportsmen has been referred to by many as non-athletes (Aldermen, 1974; Singer, 1972; Tutko and Tosi, 1976; Weiss & Knoppers, 1983; Wascott, 1981; Wooden, 1980).

A comprehensive definition of "athlete" by Alderman (1974) has been adopted as an operational definition of sportsmen for the present study. This can be put as follows: An athlete
is any person who executes and completes an identifiable, short or long term, skilled motor performance while competing against an objective, external standard, or against oneself.

Here it would be pertinent to state that in the present investigation there is an inter-changeable use of the terms athlete, player and sportsman.

Non-sportsmen: According to Singer (1972), "a non-athlete might be a person who never participated in interscholastic or inter-collegiate sport, or a person who never played on an organised team".

According to Wescott (1981), non-athletes are students who have had no participation in any formal athletics competition while in school or college.

The following is the operational definition of the term non-sportsmen as adopted in the present study: A non-sportsman is an individual who has never participated in any organised and structured competition at any of the levels, i.e. inter-school, district, inter-district, university, inter-university, inter-state and so on.

Data: Facts or figures from which conclusions can be drawn.

Hypothesis: A guiding idea, a temporary explanation or a statement of probability, used to begin and guide an investigation for relevant data and to predict certain results and consequences.
SIGNIFICANCE OF THE STUDY

The study is based on the hypothesis that altitude differences play a major role in the sports performance of the athlete. If the findings of the study support the hypothesis, these could be of great use for all those who are interested in improving sports performance and health. Such research may have potential significance in the field of sports and physical education, for example, in decision-making guidance and the placement of girls in specific sports.

In the setting of Indian sports, scarcity of research has been noticed in the field of somatotypes and related components. While height and fitness levels of world class teams in all games and sports has undergone a significant change, Indian players are far removed from them in such parameters. This work will study the basis for mode of selection of sportsmen for various disciplines, besides investigating how the altitude factor influences an athlete's performance.

Normally a person starts taking part in a game or event without proper guidance. It is by sheer chance that his choice of a particular sport is suitable to his inherent capabilities. In most cases, however, failure to become a champion is inevitable. Thus there is urgent need for research in this field to provide counselling to those
endowed with such suitable characteristics as form the basis of good performance in a game or event. With this in view, it is desirable to focus the attention of those who are connected with sports in one way or another on improving selection procedures, particularly in the case of females. The findings of this study may be used as screening tools for aiding coaches in assessing and classifying players and planning suitable activities or programmers according to their abilities.

From the performance point of view, the study of somatotypes, motor fitness and selected physiological variables seems to be very important. Perhaps successful athletic performance in sports depends upon the physique and motor fitness qualities of athletes, which are determined by heredity, environment and climatic conditions. This study may reveal the present status of sports and non-sports schoolgirls with regard to the above discussed variables, keeping in view the factor of altitude. Very few, or rather negligible number of studies were found to be related to sportsgirls and non-sportsgirls. No study on school sports and non-sports girls of different altitudes has been conducted by taking into consideration the different variables included in the present study. Hence there is all the more need for this investigation.