Chapter 1

INTRODUCTION

During pre-historic times, hunger, thirst and danger were primary drives for human behaviour. The quest for food, water and safety was ever present. Man would often risk his life for food. In other words basic physiological needs took precedence over safety needs. In order to satisfy the needs at this, first two levels, the human body had to be prepared for action, to fight for food or run to safety, whatever the case happened to be. This made the cave man to run faster and or fight more vigorously, which led to the development of basic physiological response in the human body.

In the dawns of mans existence he developed certain patterns of movements which enabled him to survive the multiple hazards of his environment. Man had some kind of physical education from remotest antiquity, but in early days of the race no organized instruction was given. Much of the learning took place as the result of simple imitation and the influences that were brought to bear upon individuals were such, as to make him confirm to his environment and adjust himself to his fellows. Most of the activities of primitive man were directed towards securing the means of existence and were predominantly of physical in nature, hunting, fishing, preparing shelter and so on. The physical education that received attention was directed towards fitting each individual to secure the practical necessities of life.
Over a period of centuries man lived, grew, changed and developed under such primitive conditions. It is only recently with industrial revolution, however, that radical changes in the social group and mode of livings took place. Many people moved to towns and cities with different types of artificial situations created by the civilization and started living the sedentary life.¹

The human body is built for action not for rest. This was a historical necessity; the struggle for survival demanded good physical condition. But optimal function can only be achieved by regularly exposing the heart, circulation, the muscles, skeleton and nervous system to some loading i.e., training. In olden days the body got its exercise both in work and at leisure. In our modern society, however, machines have taken over an ever increasing share of the work elements which were formerly accomplished with muscular power alone. Our environment has come to be dominated by sitting, riding, and lying. Thus, the natural and vital stimulation that tissues and internal organs received through physical work has largely disappeared.²


Today, more than ever before, it is necessary for the physical educator and coach to recognize the vital part science plays in the successful conduct of physical education and athletic programmes. To contribute to the best of one's ability to all aspects of physical education and athletics will require good understanding of the available scientific knowledge. Not only will such understanding result in better teams and better programmes of activities but it will also enable to guard the health of pupils. Then too knowing the reasons why to select a particular training programme for accomplishing a scientific task, scientific knowledge is essential.\(^3\)

In today's world characterised by rapid change, the physical education and sports are experiencing new trends, shifts in programme emphasis, a greater knowledge and scientific evidence, and a rapidly expanding interest and participation in sports in large proportion of society.

As the system of sports training improves, its effect on the general level of sports achievements increase. It is indicative that Olympic records of the first modern Olympic game which in those times seemed to be outstanding today are within reach of thousands and thousands of rank and file athletes. This is

\(^3\)Fox and Mathews, *The Physiological Basis of Physical Education and Athletics*, pp. 1 and 2.
explained, in particular, by the development of new scientifically substantiated training methods, means of execution of sports exercise, improvement of sport gear and equipment as well as other components and conditions of the system of sports training, the types of organization, the conditioning of training and rehabilitation after sports injury and so on.\textsuperscript{4}

The history of modern sport is the story of athletes assaulting the records set by their predecessors. Each new mark becomes a target, and eventually determination wins out and new records are set. The major psychological and physiological barriers of the past have been challenged by skilled, determined young athletes.

World records reflects tremendous dedication, effort, conditioning, and natural ability on the part of the record setters. Not everyone is going to approach world record performances, but scientific approach towards training offers more opportunity for athletes to establish and attain realistic personal goals in any sports.\textsuperscript{5}


There is also progressive acceptance from individuals involved in competitive sports at all levels to be more aware and interested in a sound and balanced physical preparation. The days have disappeared when majority of athletes turned up year after year for lung bursting, heart rendering and muscle aching pre-season fitness session after a lengthy period of lay off and developed a superficial type of fitness. At present athletes seek sustained training programme which are based on sound physiological principles which can help them to reach an optimal level of fitness for their sport.\textsuperscript{6}

Sports training aims at the improvement of performance. It is formulated in such a way that sportsman is able to win or at least successfully participate in a competition. The competition aimed at can be few months or years in the future. The aim of winning a competition further makes it necessary to individualize the training process to make it more specific with passage of time.\textsuperscript{7}

Performance sports aim at high sports performances and for that the physical and psychic capabilities of sportsmen are


developed to extreme limits. It is an aspect of complex human performance which has several aspects or dimensions. Hence several disciplines of sports science are required to work in a coordinated manner to explore the nature of sports performance and the process of improving sports performance.\(^8\)

The natural environment is a fundamental factor in the development of living being and influence the normal function of their body. Similarly, the environmental temperature is an important factor in which training and competition takes place. The human efficiency and working capacity mainly depends upon the environment of his surrounding when a person is suddenly exposed from cold to hot climate or vice versa, he is affected not only physically but also physiologically. Similarly when an athlete is exposed to a variety of climatic conditions during his participation, it will have considerable effect on his performance depending on the severity of the climate. Hence, it is very vital to consider the environmental aspect of competition in training and also its influence on various physiological responses.

It is important to consider the physical environment in which training or competition takes place. This is often the source

of various stresses whether thermal, barometrics, noise or pollution.9

Climates, seasons and weather exert such an influence on physical activities and sport that a sub area, bio-climatic, of sports appears justified within the field of sports medicine. The physical, physiological, and psychological reactions of man are very dependent on environmental conditions.

Temperature, atmospheric pressure, humidity, the composition and pollution of the air, solar radiation and other environmental factors may have a positive or negative influence on the human organism. As the general state of health can be affected so will the efficiency and capacity of physical performance and susceptibility to fatigue vary with extreme change in environmental conditions. The seasons of the year are characterised by typical meteorological and climatological phenomena that are directly related to physical performance, training, and sport.10

Environmental temperature is very important in propagation, practice and selection of sports specially when is combined with other factors such as humidity, wind velocity, solar radiation

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etc. At very high temperature performance is reduced, because probably large percentage of available energy is not used for muscular effort but for thermoregulating process which is generally disturbed.\textsuperscript{11}

The outdoor temperature is an important element in man's environment. It ranges from \(-70^\circ C\) in the arctic and sub-arctic part of the Northern hemisphere to some \(+50^\circ C\) in the tropical deserts.\textsuperscript{12}

The body temperature or, specifically, the temperature of the deeper tissues or core, is in dynamic equilibrium as a result of a balance between factors that add and subtract body heat. This balance is maintained by the integration of mechanisms that alter heat transfer to the periphery or shell, regulate heat evaporative cooling, and vary the body's rate of heat production. If heat gain outstrips heat loss, as can readily occur in vigorous exercise in a warm environment, core temperature rises; in the cold; on the other hand heat loss often exceeds heat production and core temperature falls.

\textsuperscript{11}M. Paparescos, "Environmental Factors Affecting the Athletic Activity and Career," The International Olympic Academy (July 1972) : 123.

\textsuperscript{12}Encyclopaedia of Sports Sciences and Medicine "Temperature" by Bodil Nielson, p. 867.
The requirement of thermoregulation can be considerable; price for failure is death. Only a drop in deep body temperature of 10°C and an increase of 5°C can be tolerated. This has been vividly illustrated by the relatively large number of unnecessary deaths of U.S. football players that were direct result of excessive heat stress practice. Such tragedies can be minimized if not totally avoided with the proper understanding of thermoregulation and the best way to support these mechanisms.\(^\text{13}\)

There is an increase of heart rate in all forms of submaximal effort, with a deterioration of maximum oxygen intake and endurance performance. Dehydration reduces cardiac stroke volume and, as the maximum minute volume of cardiac output falls, the blood flow to exercising muscles diminishes and an increasing proportion of energy needs are met anaerobically. Lactic acid accumulates in both blood and muscles, and the onset of fatigue is hastened. Initially an increased proportion of the total blood flow may be diverted to the cutaneous circulation, but as dehydration develops, the cutaneous circulation is also curtailed, further hampering the process of elimination. As activity is continued, sweat output also decreases due to maceration of the skin and a blockage of the exists from the sweat glands. The

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combined effect of all these reactions is to reduce the performance of athletes in the heat, particularly in endurance events. Therefore, a large part of responsibility also rests with the people who organize, guide and manage sport and physical activity programmes.\textsuperscript{14}

Cold injuries are most likely to occur if there is a combination of cold plus high winds. Cold by itself is not nearly as dangerous. For instance -1\textdegree C (30\textdegree F) is not particularly cold, but if the wind is blowing at 35 miles per hour, the chill factor is such that it will reduce the actual temperature to -5\textdegree C (20\textdegree F). The effect of both cold and high wind are intensified if the athlete is also wet and exhausted. In addition an athlete who has previously suffered from frostbite is more likely to be injured by the cold.\textsuperscript{15}

The physiology of each athlete varies, and so does each athletes ability to adapt to handle heat stress. Big athletes with large muscle mass seen particularly at risk. So are those with a thick layer of sub-cutaneous fat. Any athlete with a previous heat injury should take special precautions and should be carefully


observed for early signs of a heat problem.\textsuperscript{16}

When exercise is performed, physical and chemical changes in the body are suddenly speeded up, the circulatory, respiratory and thermoregulating systems automatically shift into high gear. These changes can be described in terms of nervous and endocrine message to various effector organs of the body. Moreover, these changes can be expressed in terms of quantitative relations between demand and supply. After exercise is over the recovery occurs so that initial state is reached again. The kinetics of recovery is not same all through. This pattern of recovery is affected by various factors like, physiological condition of the subject, rate and intensity of work, type and mode of work and on top of that the physiological ability of the subject to face and adjust to particular work stress.\textsuperscript{17}

Any form of exercise represents an acute disturbance in homeostasis of the resting athlete. Recovery from exercise, then, represents the sum of total of the processes that return the athlete to resting state. As we all know that during recovery

\textsuperscript{16}Ibid., p. 479.

from exercise our energy demand is considerably less since we are no longer exercising. However, our oxygen consumption continues at a relatively high level for a period of time, the length of which is dependent on the intensity of the preceding exercise and the type of environment.\textsuperscript{18}

Monitoring of atmospheric conditions is very vital, so that athlete can judge the amount of work that can safely be handled during a particular workout session. Guess work should be eliminated. It is necessary to know not only the temperature, but also humidity and relative humidity.

Cases of severe heat injuries have occurred at moderate temperature but high humidity. It is therefore, vitally important that the relative humidity be established so that true picture of the situation can be obtained.

Therefore, it has great momentus consequence to study the environmental stresses on cardiorespiratory endurance and other associated physiological responses.

Statement of the Problem

The purpose of this study was to investigate the environmental stress on cardiorespiratory endurance and associated physiological responses under cold, under hot-dry, and under hot-humid environmental conditions.

Delimitations

1. The study was delimited to thirty Inter I.I.T level hockey playing (National Sports Organization) male students who were in the age group of 18 to 21 years, belonging to Indian Institute of Technology, Bombay.

2. The study was confined to the cold (12°C with 20% Rh), the hot-dry (40°C with 30% Rh) and the hot-humid (37°C with 80% Rh) environmental stress simulated artificially in an environmental chamber.

3. The study was confined to submaximal work performed on a bicycle ergometer to establish cardiorespiratory endurance.

4. The study was further confined to testing of the following physiological variables.
   a) Heart rate
   b) Blood pressure (Systolic and Diastolic)
   c) Respiratory rate
   d) Sweat loss and
e) Recovery: After the submaximal work (on a bicycle ergometer) the kinetics of recovery of heart rate, blood pressure (systolic and diastolic) and respiratory rate were observed for 21 minutes duration at an interval of three minutes.

**Limitations**

1. The effect of uncontrollable factors, which might have influenced the endurance test was recognized as a limitation of this study.

2. Non availability of sophisticated environmental chamber to simulate the environmental conditions was treated as limitation for this study.

3. The daily routine and work of the subjects were considered as the third limitation for this study.

**Hypothesis**

On the basis of literature reviewed and from the scholar's own experience in physical education it is hypothesised that there will be significant differences among chosen parameters during the submaximal work at peak condition and the post exercise recovery period under the cold, hot-dry and the hot-humid environmental conditions respectively.
Definition and Explanation of Terms

Cardiorespiratory Endurance

Cardiorespiratory endurance is the ability of the lungs and heart to take in and transport adequate amounts of oxygen to the working muscles, allowing activities that involve large muscle masses to be performed over long periods of time.\(^{19}\)

Heart Rate

The distension of the arterial wall at the beginning of systolic ejection of blood is not confined to aorta but travels down the arteries as a wave followed by a wave of recoil in the arteries that lie close to the body such as radial artery of the wrist, the arrival of the wave of distension and subsequent recoil may be felt as a distant throb, the pulse, which affords a convenient method of counting the heart rate.\(^{20}\)

Blood Pressure

Blood pressure has been defined as the force with which the blood exerts on the walls of the blood vessels in which it

\(^{19}\)Ibid., p. 692.

is obtained. When left ventricular contracts and pushes the blood into aorta, the pressure produced is known as systolic blood pressure. When the complete cardiac diastole occurs and the heart is resting with no ejection of blood, the pressure within the blood vessel, is termed as diastolic blood pressure.\(^{21}\)

**Respiratory Rate**

Respiratory is the sum of total of the processes involved in the exchange of gases (\(O_2\) and \(CO_2\)) between an organism and its environment.

Respiratory rate can be defined as number of inspiration in a minute or number of expiration in a minute.\(^{22}\)

**Recovery**

The act of regaining or returning towards a normal or usual state.\(^{23}\)

**Work Load**

The intensity of work, usually expressed in terms of foot

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\(^{22}\) Fox and Mathews, *The Physiological Basis of Physical Education and Athletics*, p. 184.

pounds or kilogram - meters (kilopond meters) of work per minute; sometimes the work load is also expressed in terms of the oxygen requirement per minute.\textsuperscript{24}

**Environmental Stress**

According to the investigator the environmental stress may be defined as a physical stress (namely cold, hot-dry and hot-humid) on the functioning status of selected physiological parameters (namely heart rate, systolic and diastolic blood pressure, respiratory rate and sweating pattern) of the experimental subject before during and after their submaximal work load under above mentioned environmental conditions.

**Relative Humidity**

The ratio of the amount of moisture in the air to the amount that would be present if the air were completely saturated with moisture at a certain temperature usually expressed in percent of complete saturation.\textsuperscript{25}

\textsuperscript{24} Morehouse and Miller, *Physiology of Exercise*, p. 312.

\textsuperscript{25} Ibid., p. 310.
Dry Bulb Temperature

The temperature recorded by a thermometer exposed to the air in the usual manner. This value is unaffected by humidity.\textsuperscript{26}

Wet Bulb Temperature

The temperature recorded by a thermometer whose bulb is kept moist (usually by wrapping it with moist cotton) and moved rapidly through the air to be tested by a sling device. The lower the humidity, the greater is the evaporation of moisture from the bulb wrapping, and hence the greater the cooling of the bulb and lower will be wet bulb temperature. If both the wet bulb and dry bulb temperatures are known, the relative humidity may be read from a table.\textsuperscript{27}

Bicycle Ergometer

The bicycle ergometer is a stationary bicycle in which the front wheel is replaced by a heavy fly wheel against which the subject performs work, and, it is an apparatus for measuring the amount of work performed (kilopond meter/minute) by a subject.

\textsuperscript{26} Ibid., p. 307.
\textsuperscript{27} Ibid., p. 312.
and to determine the effect of exercise on various physiological responses.\textsuperscript{28}

**Significance of the Study**

The result of the study may be significance in the following ways:

1. The study will indicate the influence of sub-maximal work load under different types of stress caused by the environmental conditions on selected physiological parameters.

2. The study will also indicate the kinetics of recovery of selected physiological responses under different environmental conditions.

3. The study will also indicate the quanta of sweating as a result of submaximal work under different environmental conditions.

4. The findings of this study may also help the physical education professionals and coaches to formulate some strategies to face and overcome some of the hazards (if and when) resulted from performance while working in some extreme/adverse environmental conditions.

\textsuperscript{28}\textit{Ibid.}, p. 307.
5. The findings of the study may also contribute for preparing and planning of various training programme to acclimatize the subjects while they train/perform under different environmental conditions.

6. The findings of this study may also help physical educators and coaches to determine the amount of work that can safely be carried out during a particular work out session in a particular environmental condition.