Chapter I

INTRODUCTION

Nations have passed away and left no traces
And history gives the naked cause of it—
One simple single reason in all cases
They fell because their people were not fit

Nothing on earth — no arts, no gifts no graces,
No fame, no wealth — outweigh the want of it
This is the law which every law embraces
Be fit — Be fit, in mind and body be fit

This is the lesson at all time and places
One changeless truth in all changing writ
For boys and girls, men, women, nations, races
Be fit — Be fit: and once again — Be fit.

—Rudyard Kipling.

Modern age is the age of science. The progress mankind
has achieved through the last quarter of a century excels that
of all the past centuries. It has been estimated that 90% of
the scientists who were ever born in this world are living
today. Present day has seen many things which were not even
dreamt of fifty years ago. Radio, supersonic flight, space
travel, computer, electronic equipments, television etc., are
all recent inventions unparalleled in human history.¹

Scientific research has contributed to the body of
knowledge in every field and that is true in case of Physical

¹David H. Clarke and H. Harrison Clarke, Research
Processed in Physical Education, Recreation and Health
Education and Sports also. Exercise physiology is an interdisciplinary area which has taken a prominent place in contributing scientific knowledge to physical education and sports.

Scientific studies on physiological adaptation resulting from human movement are becoming increasingly important with the growing realisation of the relationship of exercise to health and physical fitness. Physical movement itself is an activity in which every individual is involved, to some degree or other, throughout life. Movement is the very basis of 'life' and 'growth', besides contributing to physical fitness.

Fitness is based upon a solid foundation of good health. Healthful living implies freedom from disease, enough strength, endurance, skill, agility, capacity to meet the daily demands and sufficient reserves to meet extraordinary stresses without undue fatigue, besides mental development and emotional balance according to the maturity level of the individual.

Physiologically, fitness which may be termed 'training effect', is achieved through exercises or activities that promote the use of oxygen to burn fuel in the working muscles.

Aerobic exercises are considered to be more effective than anaerobic exercises in developing fitness, especially 'Cardio-respiratory endurance'. Aerobic exercises may also have more lasting effects on blood composition. Aerobic
exercises can be performed for long periods and they should leave the exerciser refreshed rather than exhausted. Aerobic activities include jogging or slow running, swimming, cycling, rope skipping, aerobic dance, brisk walking and the like, that significantly increase the heart and respiratory rates and which can be done continuously for longer periods.

Aerobic exercises are all done under submaximal speed, 130 to 150 heart beats per minute, whereby they may be carried on for considerable time, so that the heart may be engaged in pumping blood at a faster rate continuously over the period of exercise. For achieving benefits of aerobic exercises the heart rate has to be raised and retained much higher than the usual heart rate for a period of 15 to 20 minutes.

To effect this process the heart has to be strong and the stroke volume has to be more, to reduce the stress on the heart. Through systematic aerobic exercises the heart muscles become thicker and stronger and the stroke volume also increases. By and large a 'Trained heart' has an increased stroke volume and reduced pulse rate at rest.

However the heart is not a primary beneficiary of fitness promoting activities. Rather benefits accrue primarily to the muscles in the outer reaches of the body that are used during exercise. Hence physiologically, fitness refers to the amount of oxygen that the body is capable of extracting from
the inhaled air and transporting it to the muscles during all out physical effort.

Many men and women feel that their daily routine work provides them enough fitness. Going up and down the stairs or standing throughout the day at a job, appears to be physical exercise. These may cause exertion, but such limited activities do not use the lungs fully, nor provide adequate work or stimulation for the heart to produce any training effect and thus do not have any exercise value. Physiologically speaking, if normal day to day activities leave one fatigued at the end of the day, the need for increased energy and vitality is indicated. Regular stimulations of the total physique through vigorous exercises increase energy and vitality, besides promoting the numerous variables associated with good health and physical fitness. Physical fitness is not an end in itself but a means to an end. It provides the basic optimal physiological health and capacity to enjoy a full life.2

Every individual's life depends on the capacity of the heart, the blood vessels to deliver nutrients and the oxygen that is necessary for their recovery from fatigue. Oxygen is a continuous necessity for sustaining life. During vigorous activity, the exercising muscles utilise large amounts

of oxygen, resulting in corresponding amount of carbon dioxide as waste products.

Exercise improves the ability of muscles to extract oxygen. It also primes enzymes in these cells to produce more energy by combining oxygen with muscle fuel. In a trained person, muscles use more fat for fuel instead of glycogen, as the sugar based muscle cells are present only in limited amounts. Hence a conditioned person can sustain any activity for a longer period without developing fatigue.

Regular exercise, even of moderate intensity, would raise the amount of protective cholesterol, carrying proteins in the blood. These are high-density lipo proteins in the blood, which are believed to function like arterial Drano, removing cholesterol from blood vessels and helping to excrete it. Exercise may also lower total cholesterol levels and to an extent the amount of artery damaging low-density lipo protein cholesterol. Exercise can help to reduce the amount of triglycerides another artery damaging type of blood fat. Exercise helps people to loose pounds of heart-straining body fat, which in turn can reduce the risk of heart attack by countering high blood pressure and diabetes. Even without weight changes, exercise would help to reduce the risk of high blood pressure. In a study of nearly 17,000 Harvard alumni, those who did not engage in vigorous sports, it was found that 35 per cent were likely to develop high blood pressure than
those who participated in sports.³

In a study of more than 6000 men and women, examined at Cooper Clinic in Dallas it was found that those who were not physically fit were 50% more likely to develop high blood pressure. People who take to exercise, tend to make other changes that improve heart and lung function. For example they may stop smoking and decrease their consumption of fatty foods, while increasing their intake of starch.⁴

Exercise can forestal health problems other than that heart disease, among them the loss of bone mass with age, which has resulted in a virutual epidemic of osteoporosis and broken bones in elderly Americans. Vigorous physical activity has been shown to stem bone loss and to stimulate the formation of bone tissue in those parts of the body that are exercised against gravity.

According to Cooper⁵ 'endurance fitness' is the main 'training effect' of aerobic exercises, which increases the efficiency of the lungs to process more air with less effort,


⁴Ibid.

increases the efficiency of the heart to pump more blood with each stroke reducing the number of strokes, increases the number and size of the blood vessels which carry blood to the body tissues and increases the total blood volume for delivering more oxygen to the body tissues, besides toning up of the muscles, reducing blood pressure, and changing 'fat weight' to 'lean weight'.

It is important to understand the physiological mechanisms that sustain and set as the basis of every physiological system, respond to physical stimuli. There is a need for definite number of co-ordinated and compensatory adjustments to take place throughout the body which involves in metabolic functions in the nervous, muscular, circulatory and respiratory systems. Besides the environmental conditions, stress, training and fatigue play important roles in physiological mechanisms.

Hence the physiological systems of the body should interact to accomplish a variety of tasks and performance.

The initiator of the performance is the brain centre which co-ordinates and controls the organic systems that are involved in the individual's physical movement.

Berger\textsuperscript{6} has stated that the interaction and interdependence of the physiological system depends on the total

organic system. Their interdependence can be analogous to a symphony orchestra, whose different musical instruments represent various organic systems and whose conductor represents the higher brain centre. Some musical compositions and arrangements require all instruments to blend together; others require one or two instruments to pre-dominate before blending with others. At all times the precise and melodious interactions are regulated by the conductor.

The organic systems of primary concern are the skeletal muscles, the heart, the circulatory system, the nervous system and the respiratory system. The total interdependence or organic system is based upon the anatomy and physiology of an individual.

The tendency to move rhythmically is inborn. Movement improves muscle tone and creates a sense of well being. Besides creating pleasure, movement of a specific type of activity helps to sustain agility and alertness, besides exerting a deep social and psychological influence. The lack of it can cause obesity and degenerative metabolic diseases. Any exercise or activity in the long run would produce some physiological adaptations to the body. Moreover exercise increases the capacity for more exercise by stimulating morphological, physiological and behavioural changes in the organism.

Continuous muscular work depends upon the adequate supply of oxygen. Although fuels for energy may be present,
muscular work can not be prolonged without oxygen. Without sufficient oxygen, energy production fails to support physical activity after a limited time.

It is essential to recognise the major source of energy utilised to perform a given task and then through specific training to develop that particular energy source, so that, the performance capacity of an individual can be improved.

Normally energy supply for performing a task comes either from aerobic or anerobic metabolism. In aerobic metabolism glycogen is oxidised and converted into carbon dioxide, water and adenosine triphosphate, through various chemical reactions. On the other hand, anaerobic metabolism occurs without the help of oxygen and in that lactic acid and adenosine triphosphate and creatine phosphate only react.

The basic difference in these two energy sources is that aerobic metabolism is pre-dominant in activities which are of low intensity and longer duration whereas anaerobic metabolism is pre-dominant in activities which are of high intensity and short duration. Therefore on the basis of such classification the primary source of energy for an activity may be indicated, depending upon its intensity and duration.  

Ibid., pp. 55-57.
An effective programme of physical education and sports have been gradually gaining great importance from the pre-school stage to the college level. It is important for an individual to know about the physiological system primarily involved in work and how they can be modified by training.

Cooper\textsuperscript{8} has expressed that anaerobic exercises have very little value and what matters is the aerobic capacity developed through aerobic exercises only.

\textbf{Statement of the Problem}

Any exercise or activity in the long run would produce some physiological adaptation to the body. This adaptive changes are subjected to the specific type of activity. e.g. aerobic or anaerobic activity. Moreover the question as to whether enduring physiological benefits could be achieved through aerobic or anaerobic activities is still under debate.

The purpose of the study was to make a comparative analysis of the physiological adaptations resulting from aerobic and anaerobic training on girls of Higher Secondary Schools in selected physiological variables.

Delimitations

The study was confined to 105 girls of Sri Sarada Vidyalaya Girls Higher Secondary School, Salem.

The study was restricted to the following physiological variables:

a. Basal Blood Pressure (Systolic and Diastolic).
b. Basal Heart Rate.
c. Haemoglobin percentage.
e. Recovery Heart Rate.

The Training Programme was confined to sprinting, running, jogging, jumping, jacks and rope skipping.

Limitations

1. The subjects selected for the study were both residential and non-residential and as such their living conditions, life style, diet, etc., varied considerably from subject to subject and the heterogeneous nature of the subjects was considered as a limitation.

2. The quantum of physical activities involved outside their training programme could not be assessed or restricted and this was also recognised as a limitation of the study.

3. The meteorological variations in air temperature, relative humidity, atmospheric pressure, etc., during the
training and testing seasons could not be assessed or controlled and this was accepted as a limitation.

4. The nullifying effect of the various factors that might have impinged on the results of the study could not be assumed or accepted, which was also recognised as a limitation.

Hypothesis

It has been scientifically established that effective training over a continuous period of time is bound to produce some physiological adaptations in the body. The adaptive changes may be subject to the specific type of activity like aerobic or anaerobic. Studies and literature on the subject indicate that aerobics produce more enduring physiological changes, when compared to anaerobics.

Hence it was hypothesised that there will be significant differences in the selected physiological variables resulting from aerobic training, when compared with anaerobic training.

Definitions and Explanations of the Terms

Aerobic Activity

"Aerobic activities are those in which there is a continual supply of oxygen and the activity can be continued for a prolonged period of time". 9

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Aerobic exercises demand oxygen without producing an intolerable oxygen debt so that they can be continued for long periods.\(^\text{10}\)

The above definitions were considered suitable for this study.

In aerobic training method the oxygen is made available easily to the musculature and in adequate quantity so as to sustain muscular work under stress.\(^\text{11}\)

The ability to perform in aerobic activity depends first on the availability of oxygen to the working muscles. Oxygen consumption is an index of aerobic power and is also the best measure of fitness of continuous exercise.\(^\text{12}\)

The term 'aerobic' literally means 'with Oxygen'. Aerobic capacity is that quality which allows us to carry on as long as possible, a relatively generalised muscular effort in aerobic conditions.\(^\text{13}\)

\(^{10}\)Copper, *Aerobics*, p. 22.


According to Getchell\textsuperscript{14} the largest volume of oxygen that is consumed per minute is called maximal oxygen uptake. This maximal volume, often referred to as the aerobic capacity, is a functional measure of the physical fitness. The maximum effort you can exert over a prolonged period of time is limited by the ability to deliver oxygen to the active tissues used. Theoretically a higher oxygen uptake indicates an increased ability of heart to pump blood to the lungs to ventilate a larger volume of air and of muscle cells to take up oxygen and remove carbon dioxide.

Effects of exercise on respiratory system have caused improvement in neuromuscular functions which make oxygen consumption and carbon dioxide production decrease progressively for the same work to a minimum level as training progresses. As a result the pulmonary ventilation becomes more efficient and respiratory rate decreases. Thus the amount of oxygen needed by the respiratory muscle becomes less. These muscles improve their efficiency during training. Changes in pulmonary ventilation are associated with a decrease in rate and an increase in depth of respiration. For the trained subjects, even at rest the depth of breathing is greater and the respiratory rate gets reduced. So also the heart rate is considerably reduced.

Zohman and Kattus have stated that the well-conditioned heart beats slower, both during exercise and at rest. The heart of a well-conditioned person beating just 45 to 50 times a minute can pump the same amount of blood as the heart of an unconditioned person beating 70 to 75 times a minute. Over the course of a day this can mean 36,000 beats and in a year over 13 million more beats for the unconditioned heart. The slower the heart rate, the longer the heart muscle can rest between the beats. The muscle of the heart's main pumping chamber enlarges and it pumps more forcefully so that more blood is forced out with each heart beat. In other words, the heart becomes a more efficient pump. The blood pressure rises less during exercise than it would otherwise.

Aerobic exercise has even been shown to be useful in lowering resting blood pressure among those with hypertension. The lungs of well-conditioned individual can hold more air and such people need fewer breaths to sustain a given level of activity. Thus the conditioned heart can get more oxygen-rich blood to work with less effort. Vigorous exercise thus enables people to sustain intense activity for longer periods. They get less fatigued from such activity and they recover more quickly from extreme exertion.

15Lenora R. Zohman and Albert A. Kattus, 'Cardiologists Guide to Fitness Health Through Exercise - Taxing the Heart to Stay Fit', The Hindu (Madras: August 10, 1985), Magazine Section, p. 11, Col. 3.
Anaerobic Activity

Anaerobic activities are those for which there is no continual supply of oxygen and which are carried out to the extent of the person's anaerobic capacity.

Anaerobic capacity is that quality which allows one to carry on for as long as possible a relatively generalised muscular effort in anaerobic conditions.\textsuperscript{16}

For the purpose of this study anaerobic activities have been defined as activities which are done in short durations without the use of oxygen and where the intensity of work is very high. The concept of anaerobic capacity is thus related to the capacity of the individual to accumulate and sustain a greater oxygen debt, in case of work carried out in anaerobic conditions and thus greater the ability to withstand oxygen debt, greater the anaerobic capacity.

Anaerobic activities are important for brief activities of high intensity or for activities that require more energy than is available from the oxygen transporting system.\textsuperscript{17}

Anaerobic activities have ability of moving large muscle groups repeatedly for at least one minute, but not

\textsuperscript{16}\textit{Ibid.}, p. 17.

\textsuperscript{17}Berger, \textit{Applied Exercise Physiology}, p. 57.
for more than two minutes. The limitation in the performance lies within the muscle's short term energy supply and the oxygen delivery system. 18

Blood Pressure

According to Chatterjee 19 "Blood pressure is the lateral pressure exerted by the blood on the vessel walls while flowing through it".

Resting blood pressure would indicate the pressure during basal condition.

Systolic Pressure

Webster 20 has defined systolic pressure as the highest arterial blood pressure of the cardiac cycle occurring immediately after systole of the left ventricle of the heart.

Diastolic Pressure

Diastolic pressure is the lowest arterial blood pressure of the cardiac cycle occurring during diastole of the heart. 21

18 Ibid., pp. 58-59.


21 Ibid., p. 232.
Resting Heart Rate

Best and Taylor\textsuperscript{22} have stated that the resting heart rate is pressure change transmitted as a wave through the arterial wall and blood column to the periphery while the person is at rest.

The number of ventricular beats per minute is heart rate. Heart rate is usually determined from pulse rate which is the number of pressure waves per minute along the carotid artery at the neck or the radial artery at the wrist. In normal individual's heart rate equals pulse rate. The time period from one heart beat to the next is the interval between cardiac cycles. Control of heart rate at rest and during work is maintained by the blood entering the heart and by the autonomous nervous system. Stimulation of the vagus nerves to the heart slows down heart rate whereas stimulation of the sympathetic nerves speed up heart rate.\textsuperscript{23}

Haemoglobin

Haemoglobin is a red coloured protein located in erythrocytes which transports most of the oxygen in the blood. Anologeneric protein composed of four polypeptide chains each of which contains a heme group having a single atom of iron with which oxygen reversible combines.\textsuperscript{24}


\textsuperscript{23}Berger, \textit{Applied Exercise Physiology}, p. 143.

\textsuperscript{24}Best and Taylor, \textit{The Body}, p. 156.
Blood Corpuscles

Blood contains three groups of formed elements viz. red blood corpuscles, white blood corpuscles and platelets.

**Red Blood Corpuscles**

The red blood corpuscles (erthrocytes) form the greater proportion of the blood cells (90% of the total numbers) which lacks nuclei and are pale red by transmitted light with paler centers because of their biconcavity.25

**White Blood Corpuscles**

White blood corpuscles (Leucocytes) are the mobile units of the body's protective systems. They are formed partially in the bone marrow and partially in the lymph tissue. But after formation, they are transported in the blood to the different parts of the body, where they are to be used.26

**Recovery Heart Rate**

Recovery Heart Rate may be defined as the time required for the heart rate to return to normal after the cessation of exercise.27

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Recovery Heart Rate is an indicator of the cardiovascular efficiency as the heart recovery to normal rate after strenuous exercise will be quicker for a trained person when compared to an untrained person.

Cardiovascular Endurance

Cardiovascular endurance reflects ability of large muscle groups to function for relatively long periods of time under submaximal work load, as in the case of sustained running swimming and bicycling etc., without undue fatigue.

According to Shaver\textsuperscript{26} Cardio respiratory endurance is the ability of the body to take in and distribute adequate amount of oxygen to working muscles during physical activities.

**Significance of the Study**

Any exercise or activity in the long run is bound to produce specific physiological adaptations to the body. This investigation may help in determining whether aerobic training or anaerobic training show marked significance in physiological adaptation to the body, after a course of training programme.

This study would help the physical education teachers and coaches to select specific aerobic or anaerobic activities according to the specific physiological adaptations desired.

This study may also help in evaluating specific training schedules prescribed for sports training. Since the same activities, running, skipping and jumping jacks have been chosen to be administered with different intensities, duration and pause, this study may be of great value to ascertain which of the two systems of training would be more effective to bring about the desired physiological modifications.

The findings of this study would add to the body of knowledge in the area of exercise physiology.