Chapter 1

INTRODUCTION

The blood serves as the principal transport medium of the body, carrying oxygen, nutrients, and chemical messages to the tissues, and waste products and synthesized metabolites away. The circulatory system provides access to all cells of the body for materials ingested or prepared else where in the organism. Thus, blood plays many important roles in co-ordinating the individual cells into a whole complex organism. This is accomplished by the presence in the fluid of dispersed or dissolved nutrients, metabolites, electrolytes, hormones, substances to counteract infection and hemorrhage, and by equilibria between the cell and the blood stream so that homeostasis with respect to temperature, oxidation, reduction potential and ionic concentration is maintained throughout the organism.

The blood consists of two parts - a fluid part the plasma and a solid part the corpuscles. The plasma forms about 55 percent and carpuscles nearly 45 percent of the total blood volume. The blood corpuscles are of three kinds - the reds or the erythrocytes, the whites or the leukocytes, and the platelets. Plasma is a yellowish liquid containing very many substances in solution, some only in minutes treces, but nonetheless just as important. The chief of them are - glucose, amino acids, inorganic salts,
hormones, urea, uric acid, proteins, haemoglobin, cholesterol and dissolved gases - oxygen, carbon-di-oxide and nitrogen. The percentage composition of some of those constituents changes as a result of exercise.

The functions of the blood as a whole, are of course, the sum total of those of its components - corpuscles, salts, proteins and other substances. However, it is better physiologically to think of it in its entirety because there is much interplay and overlap. The main functions of blood may be summarised as follows.

1. By virtue of its haemoglobin contents, it takes in oxygen and distributes it to all the tissues and collect from them the excess of their carbon-di-oxide produced during the metabolic processes.

2. The blood maintains a constancy in the nature of the tissue environment (i.e. in respect of the water, inorganic salts, and temperature) under widely differing circumstances, without which no cell can survive and function properly.

3. The fluid components plasma, collects waste products, such as urea, urates, carbon-di-oxide (in part), excess salts, pigments and other

---


3 Ibid.

4 Ibid., p. 186
unwanted matters and conveys them to the appropriate organs for excretion (lungs, liver and kidneys).

4. The blood is concerned with the absorption of nutrient matter from the gut and transports it to the tissues for the purposes of growth, energy and repair.

5. It serves in a very efficient manner to distribute the heat generated by metabolic chemical processes (chiefly in the liver and muscles), throughout the whole body.

6. It acts as a defence against harmful substances, toxins, viruses, poisons and pathological organisms, by the production of antibodies and the mechanism of phagocytosis.

7. The blood prevents its own loss due to injury or haemorrhage, by the mechanism of clotting.

The major function of red blood cells is to transport haemoglobin, which in turn carries oxygen from the lungs to the tissues. In some lower animals haemoglobin circulates as free protein in the plasma, not enclosed in red blood cells. However, when it is free in the plasma of the human being, approximately 3 per cent of it leaks through the capillary membrane into the tissue spaces or through the glomerular membrane of the kidney into Bowman's capsule each time the blood passes through the capillaries. Therefore, for haemoglobin to remain in the blood stream, it must exist
inside red blood cells.\textsuperscript{5}

The leukocytes are the mobile units of the body's protective system. They are formed partially in the bone marrow (the granulocytes and monocytes, and a few lymphocytes) and partially in the lymph tissue (lymphocytes and plasma cells), but after formation they are transported in the blood to the different parts of the body where they are to be used. The real value of the white blood cells is that most of them are specifically transported to areas of serious inflammation, thereby providing a rapid and potent defense against any infectious agent that might be present.\textsuperscript{6}

Haemoglobin, the iron protein pigment in the red blood cell, increasing the oxygen carrying capacity of the whole blood about 65 times that carried in physical solution dissolved in plasma. The small amount of oxygen dissolved in plasma exerts molecular movement and establishes the partial pressure of oxygen in the blood. This determines the loading (oxygenation and unloading (deoxygenation) of the haemoglobin at the lungs and tissues respectively. The blood's oxygen transport capacity varies only slightly with normal variations in haemoglobin content. However, iron deficiency anaemia significantly decreases the blood's oxygen-carrying capacity and consequently reduces aerobic exercises performance.


\textsuperscript{6} Ibid., p. 67.
In skeletal and cardiac muscles, the iron protein pigment myoglobin acts as an "extra" oxygen store, it releases its oxygen at low oxygen pressure and probably facilitates oxygen transfer to the mitochondria, especially during strenuous exercise when cellular PO$_2$ decrease considerably\(^7\).

Cholesterol is present in the diet of all persons, and it can be absorbed slowly from the gastrointestinal tract into the intestinal lymph. It is highly fat soluble, but only slightly soluble in water, and it is capable of forming esters with fatty acids. Indeed, approximately 70 per cent of the cholesterol of the plasma is in the form of cholesterol esters.

There are some factors which effect the plasma cholesterol concentration. (1) An increase in the amount of cholesterol ingested each day increases the plasma concentration slightly. However, when cholesterol is ingested, an intrinsic feedback control system for control of the body cholesterol causes the liver to compensate to a great extent for this by synthesizing smaller quantities of endogenous cholesterol. As a result, plasma cholesterol concentration usually cannot be changed upward or downward more than $\pm$ 15 per cent by altering the diet, though extremes of the cholesterol in the diet can probably alter the level by as much as $\pm$ 30 per cent.

2. A saturated fat diet increases blood cholesterol concentration as much as 15 to 25 per cent. This presumably results from increased fat deposition in the liver, which then provides increased quantities of acetyl Co-A in the liver cells for production of cholesterol. Therefore, to decrease the blood cholesterol concentration, it is equally as important to maintain a diet low in saturated fat as to maintain a diet low in cholesterol concentration.

Ingestion of fat containing highly unsaturated fatty acids usually depresses the blood cholesterol concentration a slight to moderate amount.

4. The male sex hormones, the androgens, increase blood cholesterol.  

The plasma proteins represent a complex mixture containing a number of components which differ in properties and function. The major components proteins of plasma include (1) fibrinogen, (2) the various globulins, (3) albumins, (4) nucleoproteins, and (5) conjugated proteins such as seromucoid and lipoproteins.  

The liver is usually considered to be the site of formation of the plasma proteins, although other parts of the body may also have a function in this connection. Fibrinogen synthesis appears to be dependent entirely upon the liver. When the liver is damaged experimentally by poisons, the

---


9 Oser, Hawk's, *Physiological Chemistry*, p. 322.
fibrinogen content of the blood falls, returning to normal with liver regeneration and repair. If the blood of a normal animal is removed as much as possible and replaced by defibrinated blood, the fibrinogen level is restored to normal in a few hours; in the hepatectomized animal the restoration does not occur.\textsuperscript{10}

Body composition is defined as a relative percentage of fat and fat-free body mass. Excessive body fat is a health hazard and has been implicated as contributing to a variety of conditioning including hypertension, hyperlipoproteinemia and accident proneness. While all the mechanisms of how excess fat causes these problems have not been completely explained. Few health authorities would argue with the statement, "It is better to be lean than to be fat."

Body composition is a function of caloric balance, and although the emphasis has traditionally been on the caloric input side of the equation, we are now increasingly aware of the importance of energy output in regulating body weight. Short-term experimental trials and large scale community studies show that vigorous physical activity helps to reduce body fat.

The body composition is not only important to health and influence by exercise, but it is also a massive public health problem, and thus deserves

\textsuperscript{10} ibid, p. 330.
increased attention in fitness testing.\textsuperscript{11}

The first step of an exercise prescription is a complete evaluation, while it is advisable for any one who plans to participate in a regular physical exercise programme to have a medical examination. The best way to find-out any problem in the body by analysing the blood and urine. Through the blood test we can findout most of the diseases and problems in the body.

During muscular exercise, plasma level of poorly diffusible molecules increases about ten per cent as a result of fall in plasma water content.\textsuperscript{12} This effect must be taken into account in evaluating effects of exercise on lipoprotein levels as well as on molecules which are protein bound. Such as FFA. As a result of exercise, the levels of plasma triglycerides and very low density lipoproteins remain steady or fall only slightly in fasting subjects during exercise for two hours at load up to 400 kg.M/minute.\textsuperscript{13} With more prolonged and heavier exercise their levels fall consistently.\textsuperscript{14} Recent research has shown that exercise not only lowers total blood cholesterol, but also increases the fraction of cholesterol known


\textsuperscript{13} Ibid.

\textsuperscript{14} Ibid.
as high density lipoproteins (HDL) and decreases the low density lipoproteins (LDL) fractions. HDL cholesterol is thought to the protective against coronary heart disease whereas LDL is not.\textsuperscript{15}

The number of red blood corpuscles is definitely affected by exercise. Even after a short bout of exercise, such as 220 yard run, the number of red blood corpuscles increases. The increase depend on the load and duration of exercise. This increase in the number of red corpuscles for a given exertion is not constant, but seems to be modified by previous activity and stage of digestion among other factors. This increase is of short duration and within a few minutes after cessation of exercise the number of corpuscles begins to diminish, and within half an hour to two hours it will return to pre-exercise level.\textsuperscript{16}

Exercise of any type increases the leukocyte count: even random activity causes a significant rise above the basel level. Following brief period of strenuous exertions the increase in white blood cells count is caused primarily by an increased number of lymphocytes, but if the exercise prolonged, the further rise in cell count is caused almost entirely by an increase in the neutrophils. The greater the degree of stress associated with exercise, the greater is the rise in the white cells' count, and as such the less fit persons show a greater rise than do the athletes.


when same exercise is performed by both.\textsuperscript{17}

All kinds of cholesterol are not considered to be risk factors. In fact, the high density lipoprotein cholesterol (HDL) fraction is thought to be protective against coronary heart disease. Regular exercise programmes have been shown to increase the HDL fraction. One of the reasons why HDLs are not harmful is that they do not collect or adhere to the inner linings of arteries. In fact, they actually help to break down the fatty deposits already present. The fatty atherosclerotic deposits are composed of low density (LDL) and very low density (VLDL) lipoprotein cholesterol fractions. Therefore, an overall low cholesterol level, with low LDL and VLDL fractions plus a high HDL fraction, appears to be a healthy balance with respect to blood cholesterol.\textsuperscript{18}

Regular aerobic exercise causes many changes in body and mind, the sum of which is known as the training effect.\textsuperscript{17} Understanding the change that result from exercise such as running, cycling, and swimming will help you to evaluate your training programme.

The primary adoption to aerobic exercise is improved delivery of oxygen to the muscles. This is accomplished because of change in the blood and heart. Training increases blood volume and raises the level of


\textsuperscript{18}Fox and Mathews, The Physiological Basis of Physical Education and Athletics, pp. 400-401.
oxygen carrying haemoglobin in red blood cells. The heart becomes capable to rejecting greater amount of blood with each beat or stroke. This increase in stroke volume results in fewer heart beats being needed to circulate the given amount of blood. Highly trained endurance athletes typically have resting heart rates as low as 30 to 40 beats/min. But their maximal heart rate does not change and therefore, the increase stroke volume provide more oxygen during exhaustive exercise.

Changes also occur in the cells of the skeletal muscles that are involved in the exercise, giving them a greater capacity to use oxygen. These cellular changes occur mostly in the mitochondria which are known as the powerhouse of the cell because energy production occur at these sites in the presence of oxygen.

The improved delivery and use of oxygen results, increased energy production, which in turn support muscular contractions for better endurance performance. Endurance is also aided by an enhanced ability of the muscle cells to use fat as fuel, preserving the limited supply of muscle glycogen, the store form of carbo-hydrate that serve as the primary source of fuel during heavy exercise.

Increased lung volume, enhanced movement of oxygen from the lungs into the blood, and the ability to breathe more air per minute all occur with training.

Training also results in several changes that help in the prevention of heart disease, such as reduction of body fat due to the large
number of calories burned lower blood concentrations of cholesterol and triglycerides, increase levels of high density lipoprotein cholesterol, and reduction of high blood pressure.

Orthopedic changes that occur with the exercise include stronger ligaments, which bind bones together at joints, stronger tendons, which attach muscles to bone, and thickened cartilage, which helps bones fit together at joint. These changes occur mostly in exercise such as running, in which there is great orthopedic stress, rather than bicycling or swimming, in which the body is supported.

Although the psychological effects of aerobic training have not been well established, evidence does suggest that training can improve mental outlook and self image, reduce tension and anxiety; and increase self discipline, motivation and self determination.

Once the overall training effect is established, continued regular exercise is necessary to sustain it. Loss of the training effect is proportional to the extent and length of inactivity. As little as one week of total inactivity such as bed rest can result in significant loss. Hippocrates said it best, "that which is used develops and that which is not used waste away."19

The effect of training can be studied most easily by classifying the changes as follows:

1.) Those occurring at the tissue level, that is, bio-chemical changes; (2) those occurring systematically, that is, those effecting in circulatory and respiratory systems, including the oxygen transport system; and (3) other changes such as those concerned with the body composition, blood cholesterol and triglyceride levels, blood pressure changes, and changes with respect to heat acclimatization.

Much new information concerning the effects of physical training at the cellular or biochemical level has made available only recently.

Aerobic changes - there are three major aerobic adaptations that occur in skeletal muscle, mainly as a result of endurance training programmes:

1. Increased myoglobin content: Myoglobin is an oxygen binding pigment similar to haemoglobin. In the respect, it acts as a store of oxygen. However, this is considered a minor function in contributing to the improvement of the aerobic system. Its main function is in aiding the delivery of oxygen from the cell membrane to the mitochondria where it is consumed.

2. Increased oxidation of carbohydrate (Glycogen). Training increases the capacity of skeletal muscle to break down glycogen in the presence of oxygen (Oxidize) to \( \text{CO}_2 + \text{H}_2\text{O} \) with ATP production. In other words, the capacity of the muscle to generate aerobically is improved.
The anaerobic changes in skeletal muscle resulting from training involve increased capacities of (1) The phosphagen (ATP-PC) system, and (2) Anaerobic glycolysis i.e. the lactic acid system.

The haematological variables such as R.B.C., W.B.C. haemoglobin serum cholesterol and serum protein, beside this body composition, are likely to be effected by training. In case of some of the haematological variables, the effect of training are known but a clear-cut information is still not available regarding the comparative and combined effect of aerobic and anaerobic workout as well as hematological responses to that, which have motivated the investigator to under-take the present study.

Statement of the Problem

The purpose of the study was to find out the comparative effect of aerobic and anaerobic workout on selected haematological and body composition variables.

Delimitations

1. The study was delimited to the eighth, ninth, and tenth grade male students of Rabbani School, Gwalior.

2. The study was confined to the following haematological and body composition variables.

---

20 Fox and Mathew, The Physiological basis of Physical Education and Athletic, pp. 294-298.
I - Haematological Variables:

1. Formed Elements:
   a) Red Blood Corpuscles (total count)
   b) White Blood Corpuscles (total count)
   c) Haemoglobin.

2. Plasma Constituents.
   a) Serum Cholesterol
   b) Serum Protein.

II - Body Composition Variables:

   a) Total Body Weight
   b) Body Fat
   c) Lean Body Weight.

3. The workout chosen for the study were, purely aerobics, purely anaerobics and combination of aerobic and anaerobic.

Limitation

The present study is comparative in nature in which the aerobic and anaerobic workout on selected haematological and body composition variables were investigated. The instruments which were available in L.N.C.P.E. Laboratory were used which were considered as limitation for the study.

Hypotheses

It was hypothesised that:

1. The blood variables will respond significantly to aerobic and anaerobic workout.
2. The haematological responses as a result of training will be different in subjects belonging to aerobic and anaerobic and combination of aerobic and anaerobic groups.

3. The body composition variables will respond differently to aerobic, anaerobic, and combined workout of aerobics and anaerobics.

**Definition and Explanation of Terms**

**Blood**

Blood may be described as a specialised connective tissue in which there is liquid intercelluler substance known as plasma and formed elements, the red blood cells, the white blood cells, and the platelets suspended in the plasma.

**Plasma**

Plasma is the liquid part of blood in which the blood cells are suspended.

**Haematological Response**

It refers to variations taking place in selected blood variables as a result of aerobics and anaerobics and combination of aerobic and anaerobic workout.

---


22 Morehouse and Miller, *Physiology of Exercise*, p. 310.
Aerobic Work

Physical activities in which metabolic demands can be met by the oxygen transport system, i.e. oxygen supplied by respiration during activity provide sufficient energy for executing the activities.\textsuperscript{23}

Anaerobic Work

The activity which exceeds the ability of oxygen transport system to supply the necessary energy. Energy liberated by break-down of substances not involving consumption of oxygen is necessary for the completion of the activity.\textsuperscript{24}

Body Composition

Body composition is the proportion of the lean, fat free body mass and depot fat, it is one of the most important morphological features characterizing human organism.\textsuperscript{25}


\textsuperscript{24}Ibid.

Body Fat

Fat is the most variable tissue in the body and is distributed throughout the body primarily under the skin and in the abdominal cavity. 26

Skinfold thickness gives an estimation of the total body fat, in as much as fifty per cent of total fat lies immediately under the skin. 27

Lean Body Weight

The total body weight minus the weight of the body's fat is called lean body weight. 28

\[ \text{LBW} = \text{Total Body Weight} - \text{Weight of Fat.} \]

Significance of the Study

It is established that a training of adequate intensity and volume of stimulus leads to noticeable changes in the physiological and bio-chemical system of the body. These changes are affected by a number of factors including age, sex, environment and fitness level. Though the effect of the training is supported by circulatory system, respiratory system, nervous system, endocrine system and many other relative systems, yet the actual


work is done at tissue level especially in the active muscles. To assess objectively, the effect of training, and study the changes which take place in specially haematological and body composition variables, investigator tried his best to gather adequate information regarding changes taking place in the above mentioned variables.

The present study, therefore, will be significant in the following ways:

1. The study will reveal the comparative and combined effect of aerobics and anaerobics workout on selected haematological variables namely - R.B.C., W.B.C., Haemoglobin, Serum Cholesterol, Serum Protein.

2. The study, in addition to discovering new facts in the area of exercise physiology and bio-chemistry, will help physical educators and coaches in evaluating the comparative and combined effects of aerobics, anaerobics worked out on body composition variables namely total body weight, body fat and lean body weight.

3. This study will have some applied value in correcting various haematological problems with the help of activity.

4. This study will also help physical education teachers, coaches and even physicians in body weight problems by using appropriate methods of training for solving weight related problems.