Aerobic Training

Energy is derived aerobically when oxygen is utilized to metabolize substrates obtained from food, and deliver energy to the working muscles.

A sports event, or activity that will build cardiorespiratory endurance, is termed aerobic when the majority of the energy in the athlete is derived aerobically (aerobic training is without oxygen debt). Aerobic training should be activities that are performed continuously for a minimum of 15 to 20 minutes at a level of 70% to 90% of maximal heart rate; no less than three times a week (Andrews, 2008).

Athletes requiring a higher level of aerobic fitness (endurance) will get training for four to six days a week. Examples of large muscle group activities include; walking, jogging running non-sprint cycling, swimming, and cross-country skiing.

The critical feature of aerobic activity is continuous activity. And, specificity of training (SAID) dictates that the training should closely resemble the activity, or event: Runners
should run, and swimmers swim. Thus, to improve cardiovascular endurance, the athlete should be trained aerobically.

Athletes involved in activities with a low aerobic component, such as football, power events in track, sprint events in running, swimming, and cycling, may see a decrease in power and strength with excessive aerobic training. These athletes should limit their aerobic training to the early preparation of off-season training and then engage in a minimal amount of aerobic training to maintain good general fitness (Andrews, 2008).

**Anaerobic training**

Anaerobic training is shorter than aerobic training in duration (less than two minutes), in which oxygen is not a limiting factor in performance, and requires energy from anaerobic sources. These energy sources involve the utilization of phosphagen and lactic acid by the athlete’s body; and enables them to perform briefly, maximal muscular activity (<2 min). Events, or activity that lasts up to 30 seconds in length, rely almost exclusively on the phosphagen system (Andrews, 2008).
Activity that lasts from 30 seconds to 2 minutes, begin to rely on lactic acid (again, any activity beyond two minutes becomes aerobic training). These energy systems are effectively developed using an interval training system. It is important to note that although one energy system may be predominant for a given activity, all systems are in use to some degree during anaerobic, or interval training (Andrews, 2008).

Interval training uses, as named, intervals that can consist of running, swimming, calisthenic exercises, or resistance training. Work intervals, which also include rest intervals, vary depending on the athletes mode of training, or need (need analysis). For example; work intervals of less than 30 seconds (phosphagen system), are typically performed with rest intervals of approximately three times this duration (Andrews, 2008).

This type of training does not allow full recovery between bouts of work and is often done during the middle to later part of the athlete’s preseason training period.

As the competition phase approaches, preseason interval training consists of longer rest intervals to accommodate the near-maximal intensity. Exercising involving the lactic acid energy source generally has an exercise-to-rest ratio of 1:2 (one second of activity, to two seconds of rest) (Andrews, 2008).
Athletes perform more of this type of training, they will be able to tolerate and utilize increased concentrations of lactic acid. Most athletes are involved in strength and power activities, such as football, baseball, basketball, volleyball, running events under 800 m, and swimming events under 100 m. They utilize both aerobic and anaerobic energy sources to supply the majority of required energy.

Interval training should comprise the bulk of their metabolic training (Andrews, 2008). Each stage in an athlete’s training requires modification of the various modes and methods of training according to the goals set by the athlete, skill coach, and conditioning specialist. The basic programs design is to meet the critical needs of the athlete. Modification of the program, or some variation in these guidelines may be appropriate for different age groups and fitness levels.

The most important principle of conditioning (sequencing) may be listening to your body. The successful athlete has an optimal blend of training modes and methods. And just as with any other type of fitness, the intensity and duration of training must be increased gradually over time in a logical progression that allows the athlete to peak for the most important competitions.
To understand what constitutes an athlete’s program, a need of the athlete should be analysed on priority basis. To develop a need analysis, you may first analyze the physiological and biomechanical requirements of each sport.

A physiological analysis will allow you to devise a program that addresses the aspects of strength, muscular endurance, flexibility, cardiorespiratory endurance, power, and speed required for success in the sport. A biomechanical analysis will allow you to choose training activities that develop the athlete in the manner most specific to the sport and also to determine the areas of critical stress in the sport. Strength and weaknesses in each athlete need to be assessed by the chosen professional. As stated, different sports require various levels of fitness and all athletes should be tested, or analyzed for strength, flexibility, endurance, power and speed. An injury profile of an athlete is needed to determine specific needs with regard to injury prevention, or adaptation.

**Aerobic Exercise**

Aerobic exercise and fitness can be contrasted with anaerobic exercise, of which strength training and weight training are the most salient examples. These two types of exercises differ by the duration and intensity of muscular
contractions involved, as well as by how energy is generated within the muscle. Initially during aerobic exercise, glycogen is broken down to produce glucose, but in its absence, fat metabolism is initiated instead. The latter is a slow process, and is accompanied by a decline in performance level. The switch to fat as fuel is a major cause of what marathon runners call "hitting the wall". Anaerobic exercise, in contrast, refers to the initial phase of exercise, or any short burst of intense exertion, in which the glycogen or sugar is consumed without oxygen, and is a far less efficient process. Operating anaerobically, an untrained 400 meter sprinter may "hit the wall" short of the full distance. There are various types of aerobic exercise. In general, aerobic exercise is one performed at a low to moderate level of intensity over a long period of time. For example, running a long distance at a moderate pace is an aerobic exercise, but sprinting is not. Playing singles tennis, with near-continuous motion, is generally considered aerobic activity, while golf or doubles tennis, with their brief bursts of activity punctuated by more frequent breaks, may not be predominantly aerobic. Among the recognized benefits of doing regular aerobic exercise are (Bouchard et al 1999):
• Strengthening the muscles involved in respiration, will facilitate the flow of air in and out of the lungs

• Strengthening and enlarging the heart muscle, can improve its pumping efficiency and reduce the resting heart rate

• Toning muscles throughout the body, can improve overall circulation and reduce blood pressure

• Increasing the total number of red blood cells in the body, may facilitate transport of oxygen throughout the body (Bouchard et al. 1999)

As a result, aerobic exercise can reduce the risk of death due to cardiovascular problems. In addition, high-impact aerobic activities (such as jogging or jumping rope) can stimulate bone growth, as well as reducing the risk of osteoporosis for both men and women. In addition to the health benefits of aerobic exercise, there are numerous performance benefits (Bouchard et al. 1999).

• Increased storage of energy molecules such as fats and carbohydrates within the muscles, will allow increased endurance

• Neovascularization of the muscle sarcomeres will increase blood flow through the muscles
• Increasing speed at which aerobic metabolism is activated within muscles, allowing a greater portion of energy for intense exercise to be generated aerobically

• Improving the ability of muscles to use fats during exercise, preserving intramuscular glycogen

• Enhancing the speed at which muscles recover from high intensity exercise (Kolata, 2002).

"Aerobics" is a particular form of aerobic exercise. Aerobics classes generally involve rapid stepping patterns, performed to music with cues provided by an instructor. This type of aerobic activity became quite popular in the United States after the 1970 publication of *The New Aerobics* by Dr. Kenneth H. Cooper, and went through a brief period of intense popularity in the 1980s, when many celebrities (such as Jane Fonda and Richard Simmons) produced videos or created television shows promoting this type of aerobic exercise. Group exercise aerobics can be divided into two major types: freestyle aerobics and pre-choreographed aerobics (Kolata, 2002).

**Anaerobic Exercise**

**Anaerobic exercise** is used by athletes in non-endurance sports to build power and by body builders to build muscle
mass. Muscles trained under anaerobic conditions develop differently, leading to greater performance in short duration, high intensity activities, which last up to 2 minutes.

Aerobic exercise, on the other hand, includes lower intensity activities performed for longer periods of time. Such activities like walking, running, swimming, and cycling require a great deal of oxygen to generate the energy needed for prolonged exercise.

There are two types of anaerobic energy systems, the ATP-PCr energy system, which uses creatine phosphate as the main energy source, and the lactic acid (or anaerobic glycolysis) system that uses glucose (or glycogen) in the absence of oxygen. Events or activity that lasts up to thirty seconds relies almost exclusively on the former, phosphagen, system (Andrews, 2008). Beyond this first thirty seconds the lactic acid system begins to predominate. This provides an inefficient use of glucose, and produces by-products that are thought to be detrimental to muscle function. Continuing activity beyond two minutes becomes aerobic. The lactic acid system can still provide some of the required energy during aerobic exercise, as the body has the capacity to get rid of the anaerobic by-products. The efficiency of by-product removal by muscles can improve through training.
**Cholesterol**

**Cholesterol** is a lipid found in the cell membranes of all animal tissues, and it is transported in the blood plasma of all animals. Cholesterol is also considered a sterol (a combination steroid and alcohol). Because cholesterol is synthesized by all eukaryotes, trace amounts of cholesterol are also found in membranes of plants and fungi.

The name originates from the Greek *chole-* (bile) and *stereos* (solid), and the chemical suffix *-ol* for an alcohol, as researchers first identified cholesterol in solid form in gallstones by François Poulletier de la Salle in 1769. However, it is only in 1815 that chemist Eugène Chevreul named the compound "cholesterine".

Most of the cholesterol in the body is synthesized by the body and some has dietary origin. Cholesterol is more abundant in tissues which either synthesize more or have more abundant densely-packed membranes, for example, the liver, spinal cord and brain. It plays a central role in many biochemical processes, such as the composition of cell membranes and the synthesis of steroid hormones.
Since cholesterol is insoluble in blood, it is transported in the circulatory system within lipoproteins, complex spherical particles which have an exterior composed mainly of water-soluble proteins; fats and cholesterol are carried internally (Tushar, 2009). There is a large range of lipoproteins within blood, generally called, from larger to smaller size: chylomicrons, very low density lipoprotein (VLDL), intermediate density lipoprotein (IDL), low density lipoprotein (LDL) and high density lipoprotein (HDL). The cholesterol within all the various lipoproteins is identical.

According to the lipid hypothesis, abnormally high cholesterol levels (hypercholesterolemia), or, more correctly, higher concentrations of LDL and lower concentrations functional HDL are strongly associated with cardiovascular disease because these promote atheroma development in arteries (atherosclerosis). This disease process leads to myocardial infarction (heart attack), stroke and peripheral vascular disease. Since higher blood concentrations of LDL, especially the smaller and denser LDL particles, contribute to this process, they are often termed "bad cholesterol" because they have been linked to atheroma formation, while high concentrations of functional HDL, which can remove cholesterol from cells and atheroma,
offer protection. These balances are mostly genetically determined but can be changed by body build, medications, food choices and other factors (Tushar, 2009).

**Lactic Acid**

**Lactic acid** (IUPAC systematic name: **2-hydroxypropanoic acid**), also known as **milk acid**, is a chemical compound that plays a role in several biochemical processes. It was first isolated in 1780 by a Swedish chemist, Carl Wilhelm Scheele, and is a carboxylic acid with a chemical formula of $\text{C}_3\text{H}_6\text{O}_3$. It has a hydroxyl group adjacent to the carboxyl group, making it an alpha hydroxy acid (AHA). In solution, it can lose a proton from the acidic group, producing the **lactate** ion $\text{CH}_3\text{CH(OH)}\text{COO}^-$. It is miscible with water or ethanol, and is hygroscopic (Robergs et al, 2004).

Lactic acid is chiral and has two optical isomers. One is known as $\text{L-}(+)$-lactic acid or $(\text{S})$-lactic acid and the other, its mirror image, is $\text{D-}(-)$-lactic acid or $(\text{R})$-lactic acid. $\text{L-}(+)$-Lactic acid is the biologically important isomer (Robergs et al, 2004).

In animals, $\text{L}$-lactate is constantly produced from pyruvate via the enzyme lactate dehydrogenase (LDH) in a process of fermentation during normal metabolism and exercise. It does not
increase in concentration until the rate of lactate production exceeds the rate of lactate removal which is governed by a number of factors including: monocarboxylate transporters, concentration and isoform of LDH and oxidative capacity of tissues. The concentration of blood lactate is usually 1-2 mmol/L at rest, but can rise to over 20 mmol/L during intense exertion (Robergs et al, 2004).

Industrially, lactic acid fermentation is performed by *Lactobacillus* bacteria, among others. These bacteria can operate in the mouth; the acid they produce is responsible for the tooth decay known as caries (Robergs et al, 2004).

In medicine, lactate is one of the main components of Ringer’s lactate or lactated Ringer’s solution (Compound Sodium Lactate or Hartmann’s Solution in the UK). This intravenous fluid consists of sodium and potassium cations, with lactate and chloride anions, in solution with distilled water in concentration so as to be isotonic compared to human blood. It is commonly used for fluid resuscitation after blood loss due to trauma, surgery, or a burn injury (Robergs et al, 2004).

During power-intensive exercises such as sprinting, when the rate of demand for energy is high, lactate is produced faster than the ability of the tissues to remove it and lactate
concentration begins to rise. This is a beneficial process since the regeneration of NAD\(^+\) ensures that energy production is maintained and exercise can continue. The increased lactate produced can be removed in a number of ways including oxidation to pyruvate by well-oxygenated muscle cells which is then directly used to fuel the citric acid cycle and conversion to glucose via the Cori cycle in the liver through the process of gluconeogenesis (Robergs et al, 2004).

Contrary to popular belief, this increased concentration of lactate does not directly cause acidosis, nor is it responsible for delayed onset muscle soreness. This is because lactate itself is not capable of releasing a proton, and secondly, the acidic form of lactate, lactic acid, cannot be formed under normal circumstances in human tissues. Analysis of the glycolytic pathway in humans indicates that there are not enough hydrogen ions present in the glycolytic intermediates to produce lactic or any other acid (Robergs et al, 2004).

The acidosis that is associated with an increase in lactate concentration during heavy exercise arises from a separate reaction. When ATP is hydrolysed, a hydrogen ion is released. ATP-derived hydrogen ions are primarily responsible for the decrease in pH. During intense exercise, aerobic metabolism
cannot produce ATP quickly enough to supply the demands of the muscle. As a result, anaerobic metabolism becomes the dominant energy producing pathway as it can form ATP at high rates. Due to the large amounts of ATP being produced and hydrolysed in a short period of time, the buffering systems of the tissues are overcome, causing pH to fall and creating a state of acidosis. This may be a factor, among many, that contributes to the acute muscular discomfort experienced shortly after intense exercise (Robergs et al, 2004).

The effect of lactate on acidosis has been the topic of many recent conferences in the field of exercise physiology. Robergs et al (2004) have accurately chased the proton movement that occurs during glycolysis. However, in doing so, they have suggested that \([H^+]\) is an independent variable that determines its own concentration. A recent review by Lindinger et al (2005) has been written to rebut the stoichiometric approach used by Robergs et al (2004). In using this stoichiometric process, Robergs et al (2004) have ignored the causative factors (independent variables) of the concentration of hydrogen ions (denoted \([H^+]\)). These factors are strong ion difference \([\text{SID}]\), PCO\(_2\), and weak acid buffers. Lactate is a strong anion, and causes a reduction in \([\text{SID}]\) which causes an increase in \([H^+]\) to
maintain electroneutrality. PCO$_2$ also causes an increase in [H$^+$]. During exercise, the intramuscular lactate concentration and PCO$_2$ increase, causing an increase in [H$^+$], and thus a decrease in pH (Siggaard-Andersen, 1995).

**Pyruvate**

Pyruvate is an important chemical compound in biochemistry. It is the output of the aerobic metabolism of glucose known as glycolysis. One molecule of glucose breaks down into two molecules of pyruvate, which are then used to provide further energy, in one of two ways. Pyruvate is converted into acetyl-coenzyme A, which is the main input for a series of reactions known as the Krebs cycle. Pyruvate is also converted to oxaloacetate by an anaplerotic reaction which replenishes Krebs cycle intermediates; alternatively, the oxaloacetate is used for gluconeogenesis. These reactions are named after Hans Adolf Krebs, the biochemist awarded the 1953 Nobel Prize for physiology, jointly with Fritz Lipmann, for research into metabolic processes. The cycle is also called the citric acid cycle, because citric acid is one of the intermediate compounds formed during the reactions (Cody, 2000).

If insufficient oxygen is available, the acid is broken down anaerobically, creating lactic acid in animals and ethanol in
plants. Pyruvate from glycolysis is converted by anaerobic respiration to lactate using the enzyme lactate dehydrogenase and the coenzyme NADH in lactate fermentation, or to acetaldehyde and then to ethanol in alcoholic fermentation (Cody, 2000).

Pyruvate is a key intersection in the network of metabolic pathways. Pyruvate can be converted to carbohydrates via gluconeogenesis, to fatty acids or energy through acetyl-CoA, to the amino acid alanine and to ethanol. Therefore it unites several key metabolic processes (Cody, 2000).

The pyruvic acid derivative bromopyruvic acid is being studied for potential cancer treatment applications, by Young Hee Ko at Johns Hopkins University and others in ways that would support the Warburg hypothesis on the cause(s) of cancer (Cody, 2000).
Statement of the Problem

The present study was undertaken to find out the relative effect of aerobic training and anaerobic training on selected biochemical variables such as cholesterol, proteins, hemoglobin, pyruvic acid, lactic acid, blood urea and blood sugar of athletes and non-athletes.

Delimitations

The study was delimited in the following factors.

1. To achieve the purpose of the study, 90 students from Ayya Nadar Janaki Ammal College, Sivakasi, Tamilnadu, India were selected randomly as subjects.

2. Only male students were selected as subjects for this study.

3. The age of the subjects ranged from 18 to 21 years.

4. The selected subjects were mainly divided into two categories such as athletes and non-athletes based on their participation in the sports and games at school or college or university level and their average training age was 4 yrs.

5. Subjects were randomly assigned in to six groups of fifteen each such as four experimental groups and two control groups.
6. The aerobic training and anaerobic training were given for six days per week for 12 weeks.

7. The following variables were selected for this study such as cholesterol, proteins, hemoglobin, pyruvic acid, lactic acid, blood urea and blood sugar.

**Limitations**

1. The external factors like diet, climate conditions and other environmental factors, which may have the effect on the study, were not taken into considerations.

2. The participation of the subjects in other activities as a part of curriculum was not considered.

3. No motivational techniques were applied to motivate the Athletes and Non-Athletes.

4. Psychological and sociological aspects of their day-to-day life interactions to their environment could not be controlled.

5. The hereditary aspects and the life styles of the subject were not ascertained and there might have influenced the study.

**Hypotheses**

It is generally accepted that any systematic and regular conditioning programme causes modifications in the
physiological functions of the different systems of the body. Hence it is considered worthwhile to study the relative effect of aerobic and anaerobic training on selected Biochemical variables.

The following hypotheses are framed for this study:

1. There would be a significant improvement on the selected variables due to aerobic and anaerobic training of athletes.

2. There would be a significant improvement on the selected variables due to aerobic and anaerobic training of non-athletes.

3. There would be a significant difference among the experimental groups on selected variables of athletes and non-athletes.

**Significance of the Study**

Any training programme should be progressive in intensity, frequency and duration and thus helps to build sustained hematological modifications, contributing to better fitness and higher levels of performance.
1. The study will solve the problem as which training is more appropriate between aerobic training and anaerobic training to significant improvement in biochemical variables.

2. The result of the study will be helpful to predict the best Athletes through the significant difference of the biochemical variables in producing national and international Athletes.

3. The results of the study would be of great interest to exercise physiologists, physical educators, coaches and athletes as they would be able to scientifically understand and assess the biochemical variations and modifications resulting from regular training.

4. The findings of the study will be of great value in designing and administering physical fitness programmes and remedial programmes for those who stand in need of special attention.

5. The findings of this study will contribute to the body of knowledge in the field of exercise physiology.

6. The results of the study would add to the quantum of knowledge in the area of physical education and sports in general as well as aerobic, anaerobic training and sports bio-chemistry in specific.
7. This investigation would give basic knowledge to the sports Scientists to envisage and further conduct research in aerobic and anaerobic training.

**Definitions of the Operational Terms**

**Aerobic**

This word, by itself, simply means “with oxygen,” but it comes alive when used as an adjective to describe exercise (Wilmore and Costil, 1994).

**Anaerobic**

This word, by itself, simply means “without oxygen,” - doing physical activity without oxygen (Wilmore and Costil, 1994).

**Athletes**

Those students who have undergone any systematic programme of conditioning or training and those who have represented their school/college/university in any game/sports, were considered as athlete and classified as such.

**Non-Athletes**

For the purpose of this study, those students who have not represented their school/college/university in any of the game or
sport and those who have not undergone any systematic physical conditioning or training were considered as non-athlete.

**Training**

Training has been explained as a programme of exercise to improve the skills and increase the energy capacities of an athlete for a particular event (Singh, 1999).

**Biochemical Variables**

Biochemical variables, for the purpose of this study, have been defined as, those related to the blood and its bio-chemical composition.

**Cholesterol**

Cholesterol is a white, waxy, solid found associated with fats but chemically different from them (Deb 1996). A cyclic hydrocarbon alcohol commonly classified as a lipid because it is insoluble in water but soluble in a number of organic solvents. It is the major sterol in all vertebrate cells and the most common sterol of eukaryotes. In vertebrates, the highest concentration of cholesterol is in the myelin sheath that surrounds nerves and in the plasma membrane that surrounds all cells.
**Protein**

All living tissues contain proteins; they are polymers of amino acids, joined by peptide bonds. The name was coined by the Dutch chemist Gerard Johann Mulder (1838) meaning ‘of the first importance’. There are twenty main amino acids in proteins, and one protein may contain several hundred or over a thousand amino acids and so enormous variety of different proteins occur in nature, i.e. in foods and our bodies (Bender and Bender, 2005).

**Hemoglobin**

The iron-containing respiratory pigment in red blood cells of vertebrates, consists of about 6 percent heme and 94 percent globin (American Heritage Dictionary, 2008).

**Pyruvic acid**

An intermediate in the metabolism of carbohydrates, formed by the anaerobic metabolism of glucose may either be converted to acetyl CoA, and oxidized through the citric acid cycle, or be reduced to lactic acid. The oxidation to acetyl CoA is thiamin dependent, and blood concentrations of pyruvate and lactate rise in thiamin deficiency (Bender and Bender, 2005).
**Lactic acid**

The acid is produced by the anaerobic fermentation of carbohydrates. Originally discovered in sour milk, it is responsible for the flavour of fermented milk and for the precipitation of the casein curd in cottage cheese. It is produced by fermentation in silage, pickles, sauerkraut, cocoa, and tobacco and its value here is in suppressing the growth of unwanted organisms, and as the product of glucose metabolism in muscle under conditions of maximum exertion (Bender and Bender, 2005).

**Blood urea**

The blood urea nitrogen (BUN) test is a measure of the amount of nitrogen in the blood that comes from urea. Urea is a substance secreted by the liver, and removed from the blood by the kidneys (Bender and Bender, 2005).

**Blood Sugar**

Sugar is the chief source of energy. Glucose is considered a simple sugar, found in blood and it is the main sugar that the body manufactures. The body makes glucose from all three elements of food-protein, fat and carbohydrates-but the largest part from carbohydrates.
Glucose serves as the major source of energy for living cells. It is carried to each cell through the bloodstream. Cells, however, cannot use glucose without the help of insulin. Glucose is also known as dextrose. Glucose refers to the blood sugar circulating in blood at a constant level and which is used by the muscle during muscular activity (Ronald et al, 2001).