Chapter - I

Introduction
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INTRODUCTION

Sports have become an important part of nation’s cultural as well as of other cultures throughout the world. Sports pervade society to such an extent that it has been described by many as a microcosm of society. In other words, sports mirror the values, structures and dynamics of our society. As such, sports reflect characteristics of society. (Coakely, 1988).

In describing sports as a game, sport is playful, is competition; is physical skill, strategy and chance; and is physical prowess. Wilkesson and Dodiles (1979) have found that a sport has the following seven functions in society.

1. Emotional release - Sports is a way to express emotion and relieve tension.
2. Affirmation of identity – Sports offers opportunities to be recognized and to express one’s individual qualities.
3. Social control – Sports provides a means of control over people in a society where is prevalent.
4. Socialization – Sports serves as a means of socializing those individuals who identify with it.
5. Change agent – Sports results in social change, new behavior patterns and is a factor that changes the courses of history.
6. Collective conscience - sports creates a communal sprit that brings people together in cohesive manner in search of common goals.
7. Success - Sports provides a feeling of success both for participant and the spectators.

1.1 TRAINING

The word ‘training’ means different things in different fields. In sports the word ‘training’ is generally understood to be a synonym of doing physical exercises. In a narrow sense, training is doing physical exercise for the improvement of performance. This concept is reflected in words or terms that are given to separate components of training (Technique training and strength training) or to separate methods or procedures of doing physical exercises (e.g. interval training and circuit training).

According to Hardayal Singh (1984) “Sports training is a process of preparation of sportsman, based on scientific and pedagogical principles for higher performance”.

Training and conditioning enables an athlete to compete at a higher level and prepares him for other events by getting fit and strong and by improving his skills. A trained individual is in a better state of physical fitness than the individual who follows a sedentary, and inactive life. When two individuals, one trained and the other one untrained, of approximately the same build are performing the same amount of moderate work, there is evidence to indicate that the trained individual has a lower pulse rate, larger stroke volume per beat, less rise in blood pressure, greater red and white blood cells counts, slower rate of breathing, lower rate of lactic acid formation and a faster return to normal blood pressure and heart rate. The heart becomes more efficient and is able to circulate
more blood while beating less frequently. Training results in a more efficient organism. Since a greater efficiency of heart action enables a larger flow of blood to reach the muscles and thus ensures an increased supply of fuel and oxygen, more work is performed at less cost, improvement in strength, power, neuromuscular coordination and endurance. There is better coordination and timing of movements and an improved state of physical fitness.

1.2 TRAINING PRINCIPLES

Stress and adaptation

All training responses are results of stress and adaptation. A stress is placed on the system and the body adapts to it. If the stress is not too intense, the adaptation will result in the body being stronger than before. Several important factors should be kept in mind.

- The adaptation will be specific to the stress
- All adaptation takes place during recovery.
- If the stress is too intense or too frequent, adaptation is not possible. This is often called “failing adaptation” and results in negative improvement in performance.

Specificity

The training must be specific to the requirements of the event. If the event requires strength, then strength training must be an integral part of the overall program. It does little good to have a shot putter run 10 miles each morning. Although strength is important to all athletes, a distance runner need not spend the same amount of time in strength training that a thrower or Jumper
would. The endurance athletes must spend the majority of their training time in endurance activities.

**Intensity**

Intensity of training must be individualized and relative to the requirements of the event and fitness of the athlete. A warm-up for one athlete may be a very intense workout for another. The intensity must not be so great that recovery cannot take place before the next workout period.

**Frequency and duration**

Most is not always better. As with the intensity, the frequency and duration of workouts must match the capabilities of the athlete. Some very intense workouts such as strength training or intense running may require more than 24 hours of recovery time. Thus, alternating workouts, or mixing hard-easy days are important factors in proper recovery.

**Genetic limitations**

Each individual is born with inherent limit of strength, speed and endurance. With proper training the athlete may reach the upper limit of his/her abilities. It is the responsibility of the coach to see that the athlete is placed in the event in which his/her abilities best meet the requirements of the event (Hardayal Singh, 1984).
### 1.3. EFFECTS OF TRAINING

<table>
<thead>
<tr>
<th>Training mean</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Principal Training Means</td>
<td></td>
</tr>
<tr>
<td>Physical exercise</td>
<td>Physical fitness (condition)</td>
</tr>
<tr>
<td>a. General exercises</td>
<td>Technique, Tactics</td>
</tr>
<tr>
<td>b. Special exercises</td>
<td>Recovery and Relaxation</td>
</tr>
<tr>
<td>c. Competition exercises</td>
<td>Psychic factors</td>
</tr>
<tr>
<td>2. Additional Training Means</td>
<td></td>
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<tr>
<td>A. Psychological Means</td>
<td></td>
</tr>
<tr>
<td>a. Ideo-motor training</td>
<td>Technique and tactics</td>
</tr>
<tr>
<td>b. Autogeneous training</td>
<td>Recovery and Relaxation</td>
</tr>
<tr>
<td>c. Other psychological Means</td>
<td>Control, activation,</td>
</tr>
<tr>
<td></td>
<td>Behavior control, Removal</td>
</tr>
<tr>
<td></td>
<td>of fear and complexes,</td>
</tr>
<tr>
<td></td>
<td>Psychic preparation.</td>
</tr>
<tr>
<td>B. Medical and Physiotherapeutic Means</td>
<td></td>
</tr>
<tr>
<td>a. Hygienic measures</td>
<td>Health, recovery and relaxation, prevention</td>
</tr>
<tr>
<td></td>
<td>against infections etc.</td>
</tr>
<tr>
<td>b. Massage</td>
<td>Recovery, Relaxation,</td>
</tr>
<tr>
<td></td>
<td>Rehabilitation</td>
</tr>
<tr>
<td></td>
<td>Control of activation.</td>
</tr>
<tr>
<td>c. Nutrition</td>
<td>Health, recovery, relaxation,</td>
</tr>
<tr>
<td></td>
<td>and Prevention</td>
</tr>
<tr>
<td></td>
<td>against infection etc.,</td>
</tr>
<tr>
<td>d. Hydro and electrotherapy</td>
<td>Recovery, Relaxation and</td>
</tr>
<tr>
<td></td>
<td>Rehabilitation.</td>
</tr>
<tr>
<td>C. Natural Means</td>
<td></td>
</tr>
<tr>
<td>a. Light, Air, Water</td>
<td>Health, resistance against</td>
</tr>
<tr>
<td></td>
<td>infection and diseases.</td>
</tr>
<tr>
<td>b. Weather conditions</td>
<td>After training load, health,</td>
</tr>
<tr>
<td></td>
<td>physical fitness</td>
</tr>
<tr>
<td>c. Attitude</td>
<td></td>
</tr>
<tr>
<td>D. Material Objects</td>
<td>Physical fitness (condition)</td>
</tr>
<tr>
<td>a. Audio – Visual aids</td>
<td>Technique and tactics</td>
</tr>
<tr>
<td>b. Equipment apparatus etc.</td>
<td></td>
</tr>
</tbody>
</table>

(Hardayal Singh, 1984)
1.4 EFFECTS OF TRAINING ON THE ANAEROBIC METABOLISM

It is true and somewhat disturbing that training does not substantially improve either the capacity or the power of the enzymes that regulate anaerobic metabolism. Training is beneficial, because it improves one's ability to tolerate greater amount of HAC (Higher acid concentration). Also, lower acid concentration (LAC) in trained individuals, working sub maximally may be due to improved oxygen intake. Physiologist continue to investigate this perplexing problem but, at the same time, any increase in the amount of the ATP and the ability to tolerate more HAC in trained muscle are attributed primarily to improved oxidative phenomena as a result of intensive training activities.

It is interesting to note that DonLash, outstanding Indiana distance runner of late 1930's ran 4.07:2 and 8.58 for the one mile and two mile runs. Jim Ryun, of more recent origin, recorded 3.51.1 and 8.25;2 with a similar aerobic capacity (80 to 81 ml of oxygen / kilogram of body weight/minute).

An examination of the sample training schedules of the two athletes during their prime reveals that Ryun's workout procedures were more demanding quantitatively and particularly in terms of quality. From this observation we might conclude that modern training and conditioning programs cannot enhance aerobic capacity any better than the less arduous programs of the 1930's. Also perhaps programs of middle distance and distance runners should be structured to maintain the capacity with further concentration on the development of efficiency and anaerobic capability. The general concept of this approach would be to stimulate the important body factors by repeatedly challenging the metabolic mechanisms
involved that do not depend on slower delivery of oxygen to the muscles for energy release.

1.5 EFFECTS OF TRAINING ON THE AEROBIC METABOLISM

Based primarily on increase or enlargement of chemical factories (mitochondria) in muscle, endurance exercise helps to raise the level of some enzymes, increasing the capacity to generate ATP. Some researchers have reported that endurance exercise can adaptively change anaerobic type muscle tissue to an aerobic variety by increasing the size and number of these components. However, this interpretation is still under investigation, because of insensitive analytical laboratory procedures.

While physiologists know that an increase in maximal cardiac output accounts for about half of the rise in VO2 Max that occurs with training, studies indicate that this merely delivers the oxygen to a larger mass of working muscle, rather than more oxygen to the individual cells. An increase in muscle mitochondria (able to extract a greater percentage of O2 form blood) accounts for the other half of the improvement in VO2 Max. Not so strangely this implies that there is apt to be less oxygen tension in both the muscle and in the venous blood (greater artery, venous oxygen and difference) of the trained individual during work requiring the VO2 Max.

Holloszy hypothesizes that:

(a) an increase in muscle mitochondria can result in VO2 Max even if O2 supply and
(b) the increase in VO2 does not have to be proportional to increase in mitochondria.

This statement implies that after training, a relatively large increase in mitochondria will extract more O₂ and increase the O₂ update (but to a lesser extent). This makes a relative degree of hypoxia in the muscle compatible with the increase in VO₂ Max (Steben, 1984).

1.6 TRAINING PHYSIOLOGY

The following table represents an approximate breakdown of anaerobic and aerobic components of the most common distance training methods.

<table>
<thead>
<tr>
<th>95%</th>
<th>85%</th>
<th>55%</th>
<th>25%</th>
<th>5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endurance [Aerobic]</td>
<td>Speed</td>
<td>Strength [Anaerobic]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>15%</td>
<td>45%</td>
<td>75%</td>
<td>95%</td>
</tr>
</tbody>
</table>

Quantity

LSD Fartlek Interval Repetition Sprint (Quantity)

From the above table it can be shown that aerobic capacity is most affected by LSD, Fartlek and interval training methods. On the other hand, anaerobic capacity is more affected by sprint, repetition and interval method. Since an endurance athlete utilizes both aerobic and anaerobic capacities in competition, this explains why variety of training method is valuable in developing the fullest abilities of the athlete. (Vern Gambetta, 1981).
1.7 INTENSITIES OF TRAINING

Intensity refers to the power or rate of doing work and is commonly thought of as the pace at which one runs or the explosiveness with which weights are lifted. In endurance events, heart rate is linearly related with physical work capacity and oxygen uptake. If they are to derive any conditioning benefit from the work, athletes must exercise at 70 to 80 percent of their age predicted maximum heart rate, corresponding to 57 to 58 percent of maximum oxygen uptake. (Steben, 1984)

1.8 IMPORTANCE OF INTENSITIES OF TRAINING

An activity can be carried out with different intensities, which will have different effect on the organism. Hence in practice, the total range of intensity is divided into various zones. This is important for planning, implementation and evaluation of training. The highest intensity, which can be achieved by the sportsman is taken as 100% and making this as a reference point the various intensity zones are made. In endurance training many a time the intensity zones are made according to the heart rate.

The example of intensity in different sports are listed below:

<table>
<thead>
<tr>
<th>Sports</th>
<th>Intensity</th>
<th>Unit of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running, Swimming etc.,</td>
<td>Speed</td>
<td>Meter / Second km / hr</td>
</tr>
<tr>
<td>Weight training</td>
<td>Magnitude of Resistance, Speed as overcoming the Resistance</td>
<td>Kilograms kg / sec kgm / sec</td>
</tr>
<tr>
<td>Jumps and throws</td>
<td>Distance, Height</td>
<td>Meter; Centimeter</td>
</tr>
<tr>
<td>Games and combative</td>
<td>Tempo / pace of Game or Combat</td>
<td>Uncertain: difficult To measure; actions/min</td>
</tr>
</tbody>
</table>


### Intensity Zones

<table>
<thead>
<tr>
<th>Strength</th>
<th>Training Carl 1977</th>
<th>Endurance Training (Martin 1977)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnitude of Resistance</td>
<td>Intensity Speed Zone</td>
<td>Heart rate</td>
</tr>
<tr>
<td>30 - 50% of Max. weight lifted</td>
<td>30 - 50% max. low running speed</td>
<td>130 - 140 / min</td>
</tr>
<tr>
<td>50 - 70%</td>
<td>Light 50 - 60%</td>
<td>140 - 150 / min</td>
</tr>
<tr>
<td>70 - 80%</td>
<td>Medium 60 - 75%</td>
<td>150 - 165 / min</td>
</tr>
<tr>
<td>80 - 90%</td>
<td>Sub maximum 75 - 85%</td>
<td>165 - 180 / min</td>
</tr>
<tr>
<td>90 - 100%</td>
<td>Maximum 85 - 100%</td>
<td>&gt;=180 / min</td>
</tr>
</tbody>
</table>

It has been established that the load must have some minimum intensity in order to have some effect on organism. In endurance training the heart rate must be above 140 beats/min. In strength training for beginners, the intensity must be above 30%. But for advanced athletes, it should be above 75%. One must differentiate between an effective and ineffective zone of intensity. With the improvement in training state, the effective zone of intensity shifts to higher and higher level. (Hardayal Singh, 1984).

### 1.9 FREQUENCY OF TRAINING

Frequency is how many times a day or week training sessions are undertaken. It may also relate the number of repetitions in a set of exercises, as in common in weight training and interval workouts. Because fatigue, frequency in repetitive activities such as in interval training or intermittent training should be carefully controlled particularly if duration and intensity factors are felt constant.
the fact that training effects are both gained or lost rather quickly is of equal importance. Regular, continual stimulation is necessary to maintain efficiency, although modes of training can make. Many form and variety is very important. Motivation will vary, however, some athletes may become very disturbed if their habitual routine is altered.

1.10 IMPORTANCE OF FREQUENCIES OF TRAINING

It is number of times a motor stimulus (repetitions) is given. In cyclic activities like swimming, running etc., there is no frequency of stimulus as there is only one long duration stimulus. In interval and repetition methods; it is the number of repetitions. In weight training, it is the number of repetitions of an exercise. It is the case in jumps, throws and freehand exercise. In activities where duration of stimulus may be considered for the calculation of load volume, the frequency is taken as the volume of load (e.g., Jumps, throws and gymnastics). Frequency and intensity are interdependent. The higher the intensity, the lower will be the frequency and vice versa. (Vern Gambetta, 1981).

1.11 DENSITY OF TRAINING

If the training activity is done with pauses in between then the intensity is affected to a large extent by the density. The density characterizes the temporal relationship between load and recovery phases in a training session. Most commonly it is referred to as the rest period between two motor stimuli. If more stimuli are given in certain time period, then the training is more dense i.e. the
density is high. The density is determined by the aim and objective of the training activity. The role of density is two fold

a) The fatigue over come in the pause

b) The adaptation process are started

Optimum density ensures the effectiveness of load and prevents premature exhaustion. (Shaver, 1981).

1.12 BICYCLE ERGOMETER

The term “bicycle ergometer” has traditionally been used, but most ergometers have just one wheel, so that “cycle ergometer” is a more appropriate term. In many cases, the cycle ergometer is preferred instrument for use in routine studies of physical power and adaptation to exercise. Mechanically and electronically braked bicycle ergometer has flywheel with a belt around it connected with a small spinning at one end to an adjustable tension lever at the other end. A pendulum balance indicates the resistance on flywheel, while it is turning. By increasing the tension on the belt, more friction is applied to the flywheel, and there is an increase in resistance. The force is determined as the breaking power and is given in kilograms or the number of pedal revolutions times the flywheel circumference. (Per Olof, 1988).

The work intensity on the mechanically braked bike is increased by

1. Placing more resistance on the flywheel

2. Increasing pedaling speed (or)

3. Both.
The most common method is to have the subject pedal at a constant rate (e.g. 50 rpm) and increase work by placing more resistance on flywheel. (Per Olof ,1988)

1.13 VARIOUS TYPES AND METHODS OF CYCLE ERGOMETER TRAINING

Several different ergometers are available for testing, and methods for calculating work various among bikes. NASA scientists used an electronically braked computer controlled bike on extended space flights. The bike adjusted the resistance to account for changes in pedaling rate and heart rate. The power output for common cycle ergometer pedaling rates is provided. Unlike a treadmill, a standard method of increasing works intensity (e.g. the brake treadmill protocol) is not appropriate for general bicycle ergometer testing, because people vary in leg strength and fitness level that affect heart rates response to ergometer exercise. For this reason, different initial workloads are recommended for men and women, and work intensity is increased at different rates based on the person’s heart rate response. The procedures suggested by the YMCA, the suggested starting intensity is 150 kpm min⁻¹ (25 watts) for women and 600 to 900 kpm.min⁻¹ (100 to 150 watts) for men. However, the level may need to be altered depending on the fitness level and leg strength of the subject being tested.
BICYCLE ERGOMETER WORK INTENSITY IN kpm. min\(^{-1}\) AND VO\(_2\) ml.min\(^{-1}\) FOR SELECTED RESISTANCE LEVELS AND PEDALING RATES 50, 60, 70 AND 80 REVOLUTIONS PER MINUTE

<table>
<thead>
<tr>
<th>KP</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>150</td>
<td>180</td>
<td>210</td>
<td>240</td>
<td>600</td>
<td>660</td>
<td>720</td>
<td>780</td>
</tr>
<tr>
<td>1.0</td>
<td>300</td>
<td>360</td>
<td>420</td>
<td>480</td>
<td>900</td>
<td>1020</td>
<td>1140</td>
<td>1260</td>
</tr>
<tr>
<td>1.5</td>
<td>450</td>
<td>540</td>
<td>630</td>
<td>720</td>
<td>1200</td>
<td>1380</td>
<td>1560</td>
<td>1740</td>
</tr>
<tr>
<td>2.0</td>
<td>600</td>
<td>720</td>
<td>840</td>
<td>960</td>
<td>1500</td>
<td>1740</td>
<td>1980</td>
<td>2200</td>
</tr>
<tr>
<td>2.5</td>
<td>750</td>
<td>900</td>
<td>1050</td>
<td>1200</td>
<td>1800</td>
<td>2100</td>
<td>2400</td>
<td>2700</td>
</tr>
<tr>
<td>3.0</td>
<td>900</td>
<td>1080</td>
<td>1260</td>
<td>1440</td>
<td>2100</td>
<td>2460</td>
<td>2820</td>
<td>3180</td>
</tr>
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<td>1050</td>
<td>1260</td>
<td>1470</td>
<td>1680</td>
<td>2400</td>
<td>2820</td>
<td>3240</td>
<td>3660</td>
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<tr>
<td>4.0</td>
<td>1200</td>
<td>1440</td>
<td>1680</td>
<td>1920</td>
<td>2700</td>
<td>3180</td>
<td>3660</td>
<td>4140</td>
</tr>
<tr>
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<td>1620</td>
<td>1890</td>
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<td>3000</td>
<td>3540</td>
<td>4080</td>
<td>4620</td>
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<td>1500</td>
<td>1800</td>
<td>2100</td>
<td></td>
<td>3300</td>
<td>3900</td>
<td>4500</td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>1650</td>
<td>1980</td>
<td></td>
<td>3600</td>
<td>4260</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>1800</td>
<td></td>
<td></td>
<td>3900</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.14 EFFECTS AND ADVANTAGES OF BICYCLE ERGOMETER TRAINING

(a) Energy output can be predicted with greater accuracy in cycling than for any other type of exercise. Within limits, the mechanical efficiency is independent of the body weight. This is a definite advantage in studies, which require repeated examinations over the years.
(b) The work rate can however be selected simply according to the subject’s gross body weight, calculated lean body mass, etc. (for e.g. 1 or 2 watts kg\(^{-1}\) initially).

(c) A cycle ergometer operated with a mechanical brake is inexpensive.

(d) It is easy to move from place to place and is not dependent on the availability of electrical power.

(e) Since the subject on the cycle ergometer exercises in a sitting or lying position with arms and chest relatively immobile, it is simple to obtain good ECG cycles and to perform studies with indwelling catheters.

(f) During the sub maximal exercise, a pedal frequency from 40 to 50 revolutions / min produces the lowest \(O_2\) uptake, i.e. the greatest mechanical efficiency, and therefore also a relatively low pulse rate.

(g) Cycle ergometers producing a constant load, even with relatively large variations in pedal frequency, have certain advantages.

(h) Respiration is also affected by the pedal frequency. (Astrand, 1988).

1.15 EFFECTS OF BICYCLE ERGOMETER TRAINING ON PHYSIOLOGICAL VARIABLES

Usually the subject is asked to try to maintain a certain pedal frequency, such as 50 or 60 rpm. It should be emphasized that it is by no means essential that the chosen pedal frequency is optimal, as long as the mechanical efficiency is known. Respiration is affected by pedal frequency. A quick and quite effective procedure to measure a subject’s maximal aerobic power, the cycle ergometer is used.
Many types of cycle ergometer can be adapted or are specially built for arm exercise. It is a useful tool when testing individuals who cannot perform leg exercises. Approximately 70 percent of the maximal oxygen uptake is attained in leg exercise when exercising with arms. It should also be pointed out that the heart rate and arterial blood pressure are significantly higher at a given oxygen uptake and cardiac output in arms exercise are compared with leg exercise. A test engaging the arms is also of interest when studying subjects who are specially trained in arms exercises. (Astrand, 1988).

1.16 EFFECTS OF BICYCLE ERGOMETER TRAINING ON KINANTHROPOMETRY

The area has been defined as the quantitative interface between anatomy and physiology. It puts the individual athlete into objective focus and provides a clear appraisal of his or her structural status at any given time or more importantly, provides for quantification of differential growth as training influences.
### THE QUANTITATIVE INTERFACE BETWEEN ANATOMY AND PHYSIOLOGY

**Identification Specification Application Relevance**

<table>
<thead>
<tr>
<th>Kinanthropometry</th>
<th>For the study of human</th>
<th>To help understand</th>
<th>With implications for Medicine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement</td>
<td>Size</td>
<td>Growth</td>
<td>Education</td>
</tr>
<tr>
<td>Human Measurement</td>
<td>SHAPE</td>
<td>Exercise</td>
<td>Government</td>
</tr>
<tr>
<td></td>
<td>Proportion composition maturation</td>
<td>Performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gross function</td>
<td>Nutrition</td>
<td>With respect for individual rights in the service of human kind.</td>
</tr>
</tbody>
</table>

Bicycle ergometer training is used for longitudinal evaluations which gives an indication of changing status reflecting the endowment of individual and growth and training influences. And also arm shoulder girdle endurance is affected when exercise for arms by cycle ergometer. Due to cycle ergometer training there is a negative correlation between percent of the body weight and the basic ability, and correlation is even higher between percent of body weight and basic ability. (Ross, 1982)

### 1.17 RELATIONSHIP OF BICYCLE, TREADMILL AND STEP TRAININGS

**Bicycle ergometer vs treadmill**

The major advantages of a bicycle ergometer over a treadmill are that the ergometer is portable and less expensive. Additionally, upper body
movement is minimal, making it easier to measure exercise heart rate and blood pressure. The major disadvantage of cycle ergometer is that the most Americans are not accustomed to bicycle riding and fail to reach the true maximum, their legs fatigue prior to reaching maximal exercise. For this reason maximum tests are more often administered on a treadmill. Lower heart rate and VO₂ values ranging from 5% to 25% have been reported. For this reason, maximal cycle ergometer tests are not normally used if accurate estimates of VO₂ Max or heart rate are needed.

Single and double stage model may be used to estimate VO₂ Max from sub maximal treadmill exercise. A sub-maximal test requires the subject to reach a steady state heart rate for a given work level; therefore, the sub maximal work stages need to be at least of three minutes duration.

Task specificity is an important criterion to consider when selecting a testing mode. For example special cycle ergometer (USOTC) and test protocols are used to measure VO₂ Max of Olympic cyclists. Astronauts trained on the ergometer on earth and tested their aerobic capacity in space at zero gravity. (Baumgartner, 1987).

**Step test**

In field studies, a step test may be the only realistic test alternative. It is more difficult, however, to standardize and offer limited possibilities for varying the demand on the oxygen transporting system. There is equipment available, however, which provides automatic adjustment of the stepping height from 20 to 50 centimeters. At maximal effort, the stepping pace must be high, and there is
always the risk that the subject may stumble when approaching a maximal rate of work. Besides, in the unaccustomed subject, the aftermath is sore muscles. It is even more difficult to perform recordings such as ECG on exercising subjects during a step test than in the case during the treadmill test. (Astrand, 1988)

1.18 TRAINING AND PHYSIOLOGICAL FUNCTIONS

VO₂ Max

In attributing maximal values to measurement the question arises as to whether the ceiling of physiological capacity was realized during the cycle exercise test. Consequently, recognized criteria are applied when assessing VO₂ max. Data collected during graded exercise to volitional exhaustion may merely reflect the relevance of subjects to work at VO₂ Max at high intensity. For well-trained individual with a body weight about 70 kg, the normal amplitude of the VO₂ Max at rest would be less than 0.5 % of the mean value. It is difficult to pick up this against the background of biological variation and measurement error associated with VO₂ Max. Faria and Drumond (1983) used different intensities and frequencies of cycle exercise and duplicate measurements at each point. Reilly and Brooks (1982) used longitudinal design to eliminate variability between subjects as well as a cross-sectional approach. The co-efficient of variation of VO₂ Max was 2.9 %. Both research groups, concluded that VO₂ Max is a stable function independent of the training.

This is sharp contrast to the value predicted from sub-maximal heart rate, demonstrated an error is estimating VO₂ Max not usually recognized.
Heart Rate

The maximal heart rate consistently shows an influence of training. This is compatible with expectations of any biological function as it approaches the ceiling of physiological range. Physiological variables have been examined post exercise, especially for short periods after graded ergometry test to exhaustion. The excess of oxygen consumption for 3 minutes following a VO$_2$ Max exercise protocol was found to be invariant with training.

The rhythm in heart rate is not paralleled by the VO$_2$ Max and VE throughout the range of sub-maximal rates. This seems to apply to arm exercise as well as leg exercise. In a longitudinal study of one subject, the rhythm in VO$_2$ Max was gradually lost as the exercise intensity increased. The heart rate at a moderate exercise level was explained by variations in body weight. No training variation during moderate exercise was found for VO$_2$ Max or the respiratory change ratio. This suggests that choice of substrate as fuel for exercising muscle is not determined by training, once diet, environment, temperature and activity are controlled.

Anaerobic power

Performance in short term exercise at different intensities in training may show change in anaerobic power. A study of arms ergometry by Reilly and Down (1986) failed to find change in anaerobic power or anaerobic capacity as expressed by the 30 seconds Wingate anaerobic test. Subjects were well warmed up prior to exercise and were well motivated to work all out for its duration. In such conditions the intensity variation in power production may be less than the
measurement error associated with this test. The conclusion that the maximal anaerobic power of the arms is a relatively stable function which is not significantly altered by training leaves unexplained by the biological source of rhythms in motor performance that are usually noted.

1.19 TRAINING AND SPORTS PERFORMANCE

In human beings a variety of physiological functions such as heart rate, oxygen uptake, temperature and urinary excretion show distinct changes in the course of training, with the values falling to their lowest during rest. This phenomenon is accepted one in sports field. These changes occur in most individuals although there are apparently a few exceptions some individuals show reversed change.

These changes in physiological functions have been found to be associated with changes in performance. This relationship appears to exist especially in the case of heart rate and performance. In general, the lowest performance is observed in the high heart rate. A similar relationship may exist also in the case of athletic performance. Roahl et al. (1986) reported that the swimmers performed significantly better in the low heart rate (P < 0.001).

As sports performance represents a cluster of abilities, which may not be encompassed by a single biological rhythm finding, may be specific to the sport in question. Analysis of French International Sabre fencers showed that their best scores as for as they related to speed and skill were at high intensity. In field and court games, players may have to play tournament at start from different intensities, the skills of these games differ from those executed in Sabre fencing or
track and field athletics and so may not share a common training. Without sensitive measure of the quality of individual performance in match play, inferences may be valid. Nevertheless an underlying training can be detected if the self-selected levels of activity during play at different intensities of training are examined.

1.20 OBJECTIVES OF THE STUDY

Though there are several training methods, which are recommended for the improvement of sports performance, the bicycle ergometer training has not been conducted in an exhaustive manner in India, since athletes are facing at source some unique challenges. Because, now a days all athletes are having the physique but they differ in physiological levels. We cannot control the physiological level of an individual. If an athlete faces any problem, automatically the physiological level of an individual may be disturbed.

Therefore, the investigator reviewed several literatures and found that there was no study on different intensities and frequencies of bicycle ergometer training on athletic performance. In order to know the effect of varied intensities and frequencies of bicycle ergometer training on selected physiological, kinanthropometric and performance variables, the investigator has selected this study. So the findings of this study will definitely help to understand the importance of bicycle ergometer training in athletic performance, especially in Indian conditions.
1.21 STATEMENT OF THE PROBLEM

The purpose of the study was to find out the effects of varied intensities and frequencies of bicycle ergometer training on selected physiological, kinanthropometric and performance variables of college men students.

1.22 SIGNIFICANCE OF THE STUDY

The competitive nature of a human being is as old as his/her origin. Every individual or nation wants to establish his or her supremacy over other individuals or nations. This fact stimulates, inspires and motivates every one to sweat and strive to run faster, jump higher, throw further and exhibit great speed, power, strength, endurance and skills in the international sports arena.

The findings of this study will be of significance in the following ways.

1. The findings of the study may add to the existing source of knowledge with regard to the bicycle ergometer training to improve the performance in athletics of college men students.

2. The findings of this study will add to the quantum of knowledge in the level improvement of physiology and kinanthropometric variables.

3. This study may help in preparing the athletes for future competitions.

4. The findings of this study may also help the physical education teachers and coaches to know about the importance of physiological, kinanthropometric variables and influence of bicycle ergometer training on sports performance.
1.23 HYPOTHESES

1. It was hypothesized that there would be significant change on selected physiological, kinanthropometric and performance variables between 50 revolutions and 60 revolutions (intensities) of bicycle ergometer training.

2. It was hypothesized that there would be significant change on selected physiological, kinanthropometric and performance variables between 3 days per week and 5 days per week (frequencies) of bicycle ergometer training.

3. It was hypothesized that there would be significant improvement on selected physiological, kinanthropometric and performance variables due to influence of interaction effect of varied intensities and frequencies of bicycle ergometer training.

1.24 DELIMITATIONS

1. In this study, 120 men students were selected as subjects at random and their age was between 18 and 25 years.

2. In this study, the following variables were selected

1. Dependent variables
   a) Physiological variables
      1. Resting pulse rate
      2. Anaerobic power
      3. VO2 Max
   b) Kinanthropometric variables
      1. Body weight
      2. Body fat
      3. Lean body mass
c) Performance variables

1. 100 metres Run
2. 400 metres Run
3. 800 metres Run

3. Independent variables

a) Intensities of training

1. Pedal at cadence of 50 revolutions per minute of bicycle ergometer training.
2. Pedal at cadence of 60 revolutions per minute of bicycle ergometer training.

b) Frequencies

1. 3 days per week training
2. 5 days per week training

1.25 LIMITATIONS

The following factors were the limitations in this study

1. No effort was made to control the nature of life, climatic condition, nutritional features, time of testing, physiological factors and other factors that affect metabolic function.

2. No attempt was made to determine whether the subjects are having the same degree of motivation during the various stages of testing.
1.26 DEFINITION AND EXPLANATIONS OF THE TERMS

**Resting pulse rate**

Morehouse and Miller (1976) have defined resting pulse rate as the distention of the arterial walls at the beginning of systolic ejection of blood which is not confined to aorta but travels down arteries as a wave followed by a wave of recoil. The arteries that lie close to the body such as radial artery of the wrist, the arrival of the wave of distension are subsequent recoil may be felt as a pulse which offers a convenience method of counting the pulse rate.

Shaver (1981) has defined the resting pulse rate as arterial wall distension which travels as a wave down the arteries per minute.

**Anaerobic power**

According to Steben (1984) the anaerobic power refers to the absence of oxygen. It is equated with intensity activity, yet initiates all activities. It functions in a deficit of oxygen, is the immediate precursor for all aerobic metabolism, and occurs simultaneously with it in most strenuous that require more than 10 seconds to complete.

Hardayal Singh (1984) has defined the anaerobic power as the ability to overcome heavy resistance with high speed, here the energy for muscle contraction is primarily obtained through the breakdown of phosphagens.

It is ability to jump, sprint, put the shot, throw the javelin or perform fast starts are few examples of athlete's converting energy to power. Power is performance of work expressed per unit of time. The term explosive power has been associated with an anaerobic metabolism. The development of power is
related to muscular strength and especially to the amount and rate of utilization of 
ATP,CP system.

**VO₂ Max (Maximal Oxygen Update)**

VO₂ Max is the maximal volume of oxygen one can consume during 
exhaustive work and is measured by slowly and systematically increasing work 
intensity until exhaustion is reached. (Baumgarter, 1987)

**Lean body mass (LBM)**

Lean body mass is defined as the total body weight less the weight of 
the subcutaneous mass.

\[ \text{L.B.M} = \text{Total body weight (kg)} - \text{Total weight of the fat (kg)} \]

Lean body weight (LBW), the quantitative expression of the lean body mass 
(LBM) includes all of the body tissue such as bone, muscle, nerve, fibre coverings 
etc. with the exception of stored “depot” fat as was pointed out earlier, the LBW 
generally remains relatively constant while most body weight changes are brought 
about by changes in fat content. (Shaver, 1981)

**Body fat**

Total weight of the fat is calculated using the following equation.

\[ \text{Total weight of fat (kg)} = \text{Body weight} \times \text{percentage of fat / 100} \]

**Athletic performance**

Performance is the psycho – socio-biological process of doing some 
actions of tackling some sports task or demands. (Hardayal Singh, 1987).