Chapter I
INTRODUCTION

Scientific truth is not a copy of an image passively received as the fruit of a laborious and endless dialogue between thought and reality. At any moment of history, man's practices reflect what he believes to be true at that time but the extent to which these are in accordance with the realities is dependent upon his powers of observation, his ability to perceive relationship and his capacity for advising theories which account for these relationships. His theories grow out of his observations and each theory he formulates, tends to make his observations more acute by establishing a perspective within which they may be more sharply focussed, thus enabling him to ask more pointed questions which will in turn, elicit more precise information to be used in testing the theory. As a result of this circular process, he may modify his theories, which will then modify his beliefs and practices. This motivates the next phase of the endless dialogue, and so the spiral of human knowledge about any area of man's life rises in ever widening cycles of theory tested and re-tested by fact.¹

History of any movement leads through the present and when the past is combined with the present trends for the future are frequently revealed. Trends in measurement, like trends in any other aspects of education are subject to change. They are dependent on the new knowledge and research that lead the way for new emphasis and attention and lead to a change in philosophy. Today is an age of automation, sophistication, and technological wonders beyond man's wildest dreams of a few years ago. It is also an age of explosion of knowledge. Therefore, a trend today may become an accepted practice tomorrow, of what may appear a trend may be only a passing fancy and may fade in the light of new information and evidence.²

In the modern scientific age, every field of human endeavour, systematic, objective and scientific procedure are followed in accordance with principles based on experience, understanding and application of the knowledge of science. The field of games and sports is no exception to this. In advanced countries like U.S.A., Germany (East and West), Russia, Australia etc. rapid progress in the field of games and sports has taken place, their international achievements have been possible due to research, experimentation and application of

scientific knowledge in the field of games and sports.

Today it is necessary for the physical educators and the coaches to recognise the vital part, science plays an important role in the successful conduct of physical education and athletic programmes. To contribute to the best of one's ability to all aspects of physical education and athletics will require a good understanding of the available scientific knowledge not only will such understanding results in better teams and better programmes of activities but also enables to guard the health of pupils. Then too knowing the reasons why to select a particular training programme for accomplishing a specific task scientific knowledge is essential.\(^3\)

The physiological characteristics play an effective role for the attainment of high level of sports performance. Among the various physiological parameters, the cardio-respiratory endurance is one of the most important physiological aspects that has to be optimally developed and trained in order to withstand the stresses and strains laid on the athlete either, during training or in competitive sport for the enhancement of athlete's sports performance. As such the cardio-respiratory endurance is the ability of an individual to carry

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work load for relatively prolonged period. It has very significant value in various sports and games, especially in long distance running, basketball, football, hockey and other vigorous and long duration games, therefore, adequate emphasis must be laid on the development of this important component of physical fitness depending upon the degree of the involvement and nature of task.  

At rest, physiological differences between an athlete with a high level of endurance is negligible. When they both start working the difference quickly appears. They are most striking during the most vigorous work. An athlete with greater endurance is characterized by the ability to withstand high level of lactic acid and to use larger volumes of oxygen and maintain lower heart rate during prolonged work. The return of the heart rate and lactic acid concentration to the normal is faster in a trained athlete. To summarize, an athlete with higher endurance can carry on exhausting work for a longer period and can establish a physiological steady state at higher levels of work. He can recover from work more quickly and thereby is enabled to start a second phase of work sooner than a person with less endurance.

At rest, it has been observed by many authors the blood pressure of endurance sportsman is lower than that of a non-sportsman. It rises under the stimulus of emotions before and during competition. During the competition the change in the systolic pressure is higher than that of diastolic pressure. If a continuous measuring of blood pressure during a period of training of endurance runner is carried out, it is observed that an originally higher systolic pressure diminishes with increased training load. After this period of hypotension the systolic pressure rises again.\(^5\)

When the exercise is performed, physical and chemical changes in the body are suddenly speeded up, the circulatory, respiratory and thermoregulatory systems automatically shifts into a high gear. These changes can be described in terms of nervous and endocrine message to various effect on organs of the body. Moreover, these changes can be expressed in terms of quantitative relation between demand and supply. After the exercise is over the recovery occurs so that initial state is reached again. The kinetics of recovery is not same all through. This pattern of recovery is affected by various factors like, physiological conditions of the subject, rate and intensity of

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work, type and mode of work and on the top of that the physiological ability of the subject to face and adjust to particular work stress. When exercise begins the pulse accelerates. The course of acceleration is worthy to study. While acceleration begins with the very first beat in which bodily movement occurs, a new steady frequency is not attained for some minutes, similarly, after the exercise is over, appreciable time is required for declaration. We may therefore, speak of transitional states between two steady states. The measurable rates at which those transitions occur are the speed with which the regulation shifts. The first transition is the onset, the second is the recovery and the latter is specially useful for visualizing recovery responses.6

The purpose during recovery from exercise is to restore the muscles and the rest of the body to their pre-exercise condition. Restoration of the body during recovery includes replenishing the energy stores that were depleted and removing lactic acid that was accumulated during exercise processes that require ATP energy. The oxygen consumed during the recovery period (oxygen debt) supply the immediate ATP energy required during the recovery period. The speed of removal of lactic acid from blood and muscle can be greatly increased by performing light exercise

rather than by resting during the recovery period. The different roles played by the metabolic energy systems during the transition from rest to exercise constitute only half of the energy picture. So the understanding of these systems functioning during the reverse transition i.e., from exercise to rest, more commonly called the recovery period. During recovery from exercise our energy demands is considerably less since we are no longer exercising. However, our oxygen consumption continues at a relatively high level for a period of time, the length of which is dependent on the intensity of preceding exercise.  

With allround development in the science of sports the new disciplines are emerging with micro specializations. The element of, scientific basis of selection is being indicated in the procedures of selection of athletes at various levels in some of the advanced countries. The knowledge from many scientific disciplines is being used for improving the criteria for selection of talent. The physical educationists have designed test procedures for evaluating the fitness of young children. The structure of performance for different games and events is being worked out. The general physical fitness of top ranking athletes has been evaluated. Proposals are

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7 Mathews and Fox, The Physiological Basis of Physical Education and Athletics, pp. 33-34.
coming up for the selection of potential athletes with the
designs of tests.  

The athletes themselves are mainly concerned with
improving their ability to cut off seconds or add centimetres
to their records. The scientist is interested in analysing why
the results improve or vary from time to time. Therefore, the
scientific objectives are:—

1. To evaluate quantitatively the influence of the various
factors upon the performance capacity in different tasks (Perfor-
mance requirements).

2. To examine how these factors vary with sex, age and
body size (capacity profile).

3. To study the effect such factors as training and
environment.  

Detailed knowledge in respect of physiological variables
of the athlete helps the physical education teachers and coaches
in the selection of athletes to participate in special types of
physical education activities.

8 H.S. Sodhi and L.S. Sidhu, Physique and Selection of

9 L. Matveyev, Fundamental of Sports Training (Moscow:
There will come a stage when further improvement will not be possible even with the most advanced and scientific methods of training, improvement of specific physiological mechanism requires precise knowledge and mastery over technique. Even with all knowledge and effect each athlete under training will not be able to achieve the high level performance. Only a few individuals can be champions and that requires highly efficient and precisely integrated physiological mechanism.  

Four methods are currently in use in the assessment of working capacity: i) Rope skipping, ii) Treadmill, iii) Bicycle ergometer, and iv) Step test.

1. **Rope Skipping**

Rope skipping can be performed indoor, it is an attractive alternative to jogging and other form of outdoor activity. Enthusiasm for skipping derives in part, from a belief that it is a particularly effective means of training the cardio-respiratory system.

2. **Treadmill**

One of the most widely used techniques for exercise physiology research is the treadmill. Treadmills come in all

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sizes and shapes some portable and other installed permanently in the laboratory floor. The specifications may vary but in general two variables should be provided, speed and inclination. The treadmill should have the capacity of varying speed between 0-16 mph and inclination between 0-20% thus providing a range of work loads that should meet the needs of most research designs. The grade is based on the incline that would result from the evaluation of 100 horizontal feet. Therefore 1% grade would be the rise of the belt equivalent to 1 foot vertical elevation taken at a distance of 100 horizontal feet. The treadmill has the advantages of ease of running or walking and of positioning so as to obtain various cardio-pulmonary measures.\footnote{David H. Clarke and H. Harrison Clarke, \textit{Research Process in Physical Education} 2nd ed. (Prentice Hall, Inc.: New Jersey, 1984), p.285.}

3. \textbf{Bicycle Ergometer} -

Another widely used device for work studies is the bicycle ergometer. In its simplest form, this ergometer is a stationary bicycle with a wheel adopted so that a belt can be passed around and attached to a spring balance. The work load can be changed while in motion simply by increasing the tension of the belt, which in turn is monitored on the scale. The addition of lead strips to the wheel gives the proper inertia
for smooth operation. The ergometer can be calibrated for work load by determining the distance the rim of the wheel is moved by one pedal revolution, then amount times the product of resistance and cadence (per min.) gives the total work accomplished in foot pounds or kilogram meters per min. The usual procedure is to employ a constant pedal rate (50-60 revolutions per min.), only the resistance is varied.\textsuperscript{12}

4. \textbf{Step Test -}

The most inexpensive and simple device for work is the step bench test. The height of the bench and cadence may vary, depending upon the objectives of the study and perhaps the age and sex of the subjects. This is also a particularly effective means of training the cardio-respiratory system.

In the modern scientific age similar types of tests are used by different coaches and physical education teachers for assessing the cardio-respiratory endurance. The coaches and physical educators want their sportsmen/trainees to extract maximum achievement from their training procedure without causing too much strain on them. This is only possible if they can select the best test for assessing cardio-respiratory endurance. The test which will be most appropriate for measuring

\textsuperscript{12}Ibid., p. 286.
cardio-respiratory endurance will show maximum hyperaction after work relationship between the maximum work load, sub-maximum work load and recovery rate. More specially, with the manifestation of endurance the testing procedure must be selected with a view to realizing the demand.

Therefore, in this study the research scholar has made an attempt to find out comparative and relationship of performance in skipping, treadmill, bicycle ergometer and Harvard Step test.

Statement of the Problem

Skipping, treadmill, bicycle ergometer and Harvard Step test all are used to measure cardio-respiratory endurance. The purpose of the study was to determine the comparative and relationship of performance in skipping, treadmill, bicycle ergometer and Harvard Step test and to observe recovery rates followed by maximal and sub-maximal exercises among low, intermediate and high fitness groups.

Delimitations

1. The study was delimited to the male students of M.L.B. Arts and Commerce College, Gwalior who were not involved
in daily physical activity, they constitute a sedentary group (low fitness group) and the students of Lakshmibai National College of Physical Education, Gwalior who were involved in daily physical activity but did not participate interversity/combined university/interstate/National level in any games and sports discipline they constitute professional physical education group (intermediate group) and the students from Lakshmibai National College of Physical Education, Gwalior who were involved in daily physical activity as well as participated in the All India Inter University/All India Combined University/Interstate/National Level in any games and sports discipline, they constitute a professional physical education of high fitness group.

2. Each group consisted of 30 subjects, which was assumed to be sufficient enough for the purpose of the study.

3. To measure the cardio-respiratory endurance skipping, treadmill, bicycle ergometer and harvard step test was used.

4. The study was restricted to the maximal and sub-maximal working capacities.

5. The study was further delimited to the use of recovery heart rate, blood pressure (systolic and diastolic) and respiratory rate Post (0 minute), 1st, 3rd, 5th, 7th, 9th, 11th, 13th, and 15th minutes after the cessation of maximal and sub-maximal work as criterion measure for among group comparisons.
Limitations

1. The subjects were from different communities and therefore, the influence exerted by such factors might interfere with the purpose of this study was recognised as a limitation of this study.

2. Non-availability of sophisticated technique to record some complicated physiological variables were considered as a limitation of the study.

3. The subjects were selected from different sports disciplines and their specific fitness level were different. This might also be considered as a limitation of the study.

Hypothesis

1. It was hypothesised that there might be significant differences in recovery responses among different groups, on skipping, treadmill, bicycle ergometer and Harvard step test.

2. It was further hypothesised that there might be relationship of performances in skipping, treadmill, bicycle ergometer and Harvard step test.
Definition and Explanation of Terms

Cardio-respiratory Endurance

Cardio-respiratory endurance has been defined as the ability of the lungs and heart to take in and transport adequate amounts of oxygen to the working muscles, allowing activities that involve large muscle masses, to be performed overlong periods of time. Cardio-respiratory has an additional implication as to recover from severe exercise. 13

Heart Rate

The distention of the arterial walls at the beginning of systolic ejection of blood is not confined to aorta but travels down the arteries as a wave followed by a wave of recoil. In the arteries that lie close to the body such as radial artery of the wrist, the arrival of the wave of distention and subsequent recoil may be felt as a distance throb pulse which offers and a convenient method of counting the heart rate. 14

13 Mathews and Fox, The Physiological Basis of Physical Education and Athletics, p.545.
14 Morehouse and Miller, Physiology of Exercise, p.239.
Blood Pressure

Blood pressure is the pressure exerted on the walls of the arteries as the heart pumps blood through the body. Systolic pressure is obtained when blood is ejected into the arteries, diastolic pressure is obtained when the blood drains from the arteries. ¹⁵

Respiratory Rate

The number of inspiration or expiration in one minute is known as respiratory rate.

Maximal Load

Maximal load can be defined as the highest load which the individual can carry out for a period of three minutes.

Sub-maximal Load

Sub-maximal load can be defined as the load lower than the maximal. Physiologically, it is said the sub-maximal load is approximately 2/3 of the maximal load.

Significance of the Study

1. The findings of the study will help to suggest the most reliable and valid cardio-respiratory fitness test for subjects of various fitness level.

2. The findings of the present study will help the physical education teachers/coaches to plan the training programme on a broader scientific basis.

3. The investigation may help physical educators and coaches to objectively assess the cardio-respiratory efficiency of the students using different modes of exercise.

4. This study will add a new knowledge in the area of exercise physiology.