Chapter III

PROCEDURE

In this chapter the selection of subjects, selection of variables, criterion measures, procedure for administering tests, administration of the graded exercise, experimental design, statistical technique for analysing the data and training programme have been described.

Selection of Subjects

Sixty male students in the age group of 15 to 17 years, studying in standard ten and eleven of the Scindya School, Gwalior Fort residing in the same school hostel were selected as the subjects for the study. The total number of students in these two standards was 150. To ensure that only untrained subjects were selected, forty six students who were undergoing training for participating in competitive sports on behalf of the school were eliminated from
the list. From among the rest, sixty students were selected using random sampling procedure of drawing lots. The investigator checked health records maintained by the school to ensure that the subjects selected were physically fit to undergo the vigorous training programme prescribed as the experimental process for the study.

The subjects belonged to a nation-wide cross section of upper middle class and upper class population. All the subjects had fairly well developed physique though most of them had not been participating in sports and games regularly. However, all of them had favourable attitude towards sports and games as they had been taking part in the required physical education programme as a part of the school curriculum. Every morning, except on sundays the students took part in a conditioning programme of 60 minutes which was a part of their hostel schedule.

Prior to the training programme, a meeting with all the selected subjects was held, in which the physical
education teachers of the school were also present. The requirements of the experimental treatments, testing procedures as well as training schedules were explained to them in detail, so that there was no ambiguity in their minds regarding the efforts required of them and the hard work they would have to put in. All the subjects agreed to co-operate in the experimental procedures which were explained to them. The physical education teachers also exhorted them to put in their best efforts in the interest of the scientific investigation and in order to enhance their own performance and achievement standards.

Selection of Variables

The research scholar had gone through both critical as well as allied literature related to the problem and listed a number of physiological variables which are likely to be influenced by aerobic and anaerobic training. Keeping in mind the feasibility criteria and the facilities and equipments available in the institution and the acceptability to the subjects
and the legitimate time that could be devoted for tests in relation to the treatment (experimental variables) requirements and to keep the entire study unitary and integrated was done in consultation with experts and through a pilot study.

With the above criteria in mind the following physiological variables were selected as they are directly related to the degree of work load which an individual had undertaken and are also associated with the efficient functioning of the cardio-respiratory systems.

1. Heart Rate
2. Blood Pressure
3. Haemoglobin Concentration
4. Cardio Pulmonary Index
5. Tidal Volume
6. Respiratory Rate
7. Minute ventilation and
8. Maximal oxygen consumption
Criterion Measures

The criterion measures chosen for testing the hypothesis were:

1. Number of heart beats per minute during resting and immediately after each grade of exercise.

2. Pressure exerted by the walls of the arteries on the circulating blood in terms of millimeters of mercury during resting and immediately after each grade of exercise.

3. Haemoglobin content in grams per 100 ml. of blood using Acid Haematin Method.

4. Cardio Pulmonary Index at Adynamic and Dynamic state.

5. Volume of air expired per breath recorded in millilitres during resting condition and immediately after each grade of exercise.

6. Number of breaths per minute during resting condition and immediately after each grade of exercise.
7. The volume of air breathed out per minute recorded in litres during resting and immediately after each grade of exercise.

8. Oxygen consumed in millilitres per minute using Fox equation.

Reliability of Data

All the variables - Heart Rate, Blood Pressure, Respiratory Rate, Tidal Volume, Minute Ventilation and Maximum Oxygen Consumption were tested for ten subjects from Scindya School, Gwalior Fort. All the variables were measured three times at resting condition and after each grade of exercise. The coefficient of correlation of the scores made in the first and second measurements of each of the above variables was taken as a measure of reliability. These are presented in Table I.
### TABLE I

**RELIABILITY COEFFICIENT OF TEST RETEST SCORES**

<table>
<thead>
<tr>
<th>Grades</th>
<th>Variable</th>
<th>Coefficient of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting</td>
<td>1. Heart Rate</td>
<td>.96</td>
</tr>
<tr>
<td></td>
<td>2. Systolic Blood Pressure</td>
<td>.92</td>
</tr>
<tr>
<td></td>
<td>3. Diastolic Blood Pressure</td>
<td>.98</td>
</tr>
<tr>
<td></td>
<td>4. Haemoglobin Concentration</td>
<td>.88</td>
</tr>
<tr>
<td></td>
<td>5. Cardio-Pulmonary Index (Adynamic)</td>
<td>.80</td>
</tr>
<tr>
<td></td>
<td>6. Tidal Volume</td>
<td>.81</td>
</tr>
<tr>
<td></td>
<td>7. Respiratory Rate</td>
<td>.92</td>
</tr>
<tr>
<td></td>
<td>8. Minute Ventilation</td>
<td>.84</td>
</tr>
<tr>
<td>After 60 watts Exercise</td>
<td>1. Heart Rate</td>
<td>.84</td>
</tr>
<tr>
<td></td>
<td>2. Systolic Blood Pressure</td>
<td>.92</td>
</tr>
<tr>
<td></td>
<td>3. Diastolic Blood Pressure</td>
<td>.96</td>
</tr>
<tr>
<td></td>
<td>4. Haemoglobin Concentration</td>
<td>.86</td>
</tr>
<tr>
<td></td>
<td>5. Cardio-Pulmonary Index (Dynamic)</td>
<td>.82</td>
</tr>
<tr>
<td></td>
<td>6. Tidal Volume</td>
<td>.82</td>
</tr>
<tr>
<td></td>
<td>7. Respiratory Rate</td>
<td>.94</td>
</tr>
<tr>
<td></td>
<td>8. Minute Ventilation</td>
<td>.82</td>
</tr>
</tbody>
</table>
### TABLE I (Continued)

<table>
<thead>
<tr>
<th>Grades</th>
<th>Variable</th>
<th>Coefficient of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Heart Rate</td>
<td>.94</td>
</tr>
<tr>
<td>2.</td>
<td>Systolic Blood Pressure</td>
<td>.94</td>
</tr>
<tr>
<td>After 90</td>
<td>3. Diastolic Blood Pressure</td>
<td>.92</td>
</tr>
<tr>
<td>watts</td>
<td>4. Haemoglobin Concentration</td>
<td>.81</td>
</tr>
<tr>
<td>Exercise</td>
<td>5. Tidal Volume</td>
<td>.80</td>
</tr>
<tr>
<td></td>
<td>6. Respiratory Rate</td>
<td>.92</td>
</tr>
<tr>
<td></td>
<td>7. Minute Ventilation</td>
<td>.87</td>
</tr>
</tbody>
</table>

|          | 1. Heart Rate                   | .92                         |
|          | 2. Systolic Blood Pressure      | .91                         |
| After 120| 3. Diastolic Blood Pressure     | .94                         |
| watts    | 4. Minute Ventilation           | .88                         |
| Exercise | 5. Haemoglobin Concentration    | .84                         |
|          | 6. Tidal Volume                 | .82                         |
|          | 7. Respiratory Rate             | .93                         |
### TABLE I (Continued)

<table>
<thead>
<tr>
<th>Grades</th>
<th>Variables</th>
<th>Coefficient of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Heart Rate</td>
<td>.95</td>
</tr>
<tr>
<td></td>
<td>2. Systolic Blood Pressure</td>
<td>.905</td>
</tr>
<tr>
<td></td>
<td>After 150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Diastolic Blood Pressure</td>
<td>.938</td>
</tr>
<tr>
<td>watts</td>
<td>4. Haemoglobin Concentration</td>
<td>.85</td>
</tr>
<tr>
<td>Exercise</td>
<td>5. Tidal Volume</td>
<td>.88</td>
</tr>
<tr>
<td></td>
<td>6. Respiratory Rate</td>
<td>.94</td>
</tr>
<tr>
<td></td>
<td>7. Minute Ventilation</td>
<td>.902</td>
</tr>
<tr>
<td></td>
<td>8. Maximum Oxygen Consumption</td>
<td>.956</td>
</tr>
</tbody>
</table>

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**Tester Reliability**

All measurements were taken by the investigator herself with the assistance of experienced Research Assistants and M.Phil Scholars working under her as and when needed. For all the measurements the investigator conducted pilot study and was well acquainted with the measurements. The investigator took a number of measurements under the guidance of Dr. R.N. Dey, Reader in
Exercise Physiology, Lakshimibai National College of Physical Education, Gwalior to ensure accuracy of measurements. Finally measurements in the various variables on five subjects chosen at random were taken both by the investigator and an expert under identical conditions. The reliability was established by product moment correlation method and the obtained correlation has been shown below:

**TABLE II**

**TESTER COMPETENCY FOR TESTS IN SELECTED PHYSIOLOGICAL VARIABLES**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Rate</td>
<td>.99</td>
</tr>
<tr>
<td>Systolic Blood Pressure</td>
<td>.99</td>
</tr>
<tr>
<td>Diastolic Blood Pressure</td>
<td>.98</td>
</tr>
<tr>
<td>Haemoglobin Concentration</td>
<td>.94</td>
</tr>
<tr>
<td>Cardio-Pulmonary Index</td>
<td>.94</td>
</tr>
<tr>
<td>Tidal Volume</td>
<td>.96</td>
</tr>
<tr>
<td>Respiratory Rate</td>
<td>.98</td>
</tr>
<tr>
<td>Maximum Oxygen Consumption</td>
<td>.96</td>
</tr>
</tbody>
</table>
Since very high correlation from 0.94 to 0.99 were obtained for the variables, the competency of tester to administer the test was accepted.

Instrument Reliability

The electrical cycle ergometer used in this study was supplied by the well known firm of Vankey Engineering Company Madras and it is calibrated by an engineer a few days before the commencement of this project. The other instruments such as Haemometer (Superior Company, West Germany), Sphygmomanometer (Doctor, Japan), Dry Spirometer (Technical Corporation private Limited, Lucknow), Stop watches (Modern Scientific Corporation, Gwalior), West Spirometer (Hindustan Scientific Instrument Company, New Delhi) has been supplied by well known manufacturers catering to the Research Laboratories and Pathology Laboratories and hence were considered accurate and reliable.

Pilot Study

Fifteen boys from X standard of Scindya School
Gwalior Fort were randomly selected for pilot study, to prepare the Aerobic and Anaerobic training schedule, to select work loads and to find out the circulatory and respiratory responses to the selected work load.

In order to determine the circulatory and respiratory responses to graded exercise, the grades were set on the electrical bicycle ergometer. The grades were 40%, 60%, 80% and 100% of the maximal mean work load which was 150 watts. So the working intensities were 60, 90, 120 and 150 watts on electric bicycle ergometer were used by the tester for the study. The duration of each workout was 5 minutes for each work load based on the assumption of subjects work capacity.

Before the administration of tests the subjects were given a chance to practice the prescribed tests so that they became familiar with the tests and knew exactly what was to be done. The apparatus used was explained to them prior to the administration of tests. Fourteen days were utilized for conducting the tests.
The experiments were done in the morning or afternoon, and no special care was taken to obtain basal conditions. Due to the number of subjects with different grades of exercise and the number of variables this was not accomplishable. However, no experiments were done in the one or two hours directly after a meal.

Procedure for Administering Tests

The necessary data was collected by administering the tests for the chosen variables after the experimental period of twelve weeks. All the tests were administered in the Gymnasium of Scindya School, Gwalior Fort.

As the aim of this work has been to determine the circulatory and respiratory responses to grades exercises, working procedures that bring cardiorespiratory system into action had to be chosen. Well suited working machines to give graded exercise are the bicycle ergometer and the treadmill. Since the bicycle ergometer is eliminating the effect of body weight while doing
the exercise at a particular load, this was chosen for this study.

**Administration of Graded Exercise**

The purpose of giving graded exercise was to give different strain to the cardiovascular system and find out the effect of that strain on the circulatory and respiratory variables among the three groups.

**Equipment:**

Electric Bicycle Ergometer and stop watch

**Description:**

The subject was asked to sit comfortably on the bicycle and asked to pedal approximately at 60 revolutions per second which is given in the speedometer of the instrument. Each subject was given practice in synchronising their frequency of pedalling with the reading in the speedometer, first without any resistance and then gradually increasing the resistance till 150 watts. After ensuring that the novelty of the atmosphere was worn out, and they had learnt the correct skill of
going through the test for consistent and reliable performance the following procedures were used.

1. The main electric connection to the bicycle ergometer was put on ten minutes prior to the test for warming it up.

2. The subject was asked to sit comfortably on the bicycle and blood pressure apparatus was wrapped on his left hand.

3. All the equipments (Spirometer, Stopwatches, Haemometer) were arranged on a desk near to the ergometer for taking the variables immediately after the exercise.

4. One experienced helper was kept for following the instructions of the investigator strictly and for measuring each variable.

5. At first the subject was asked to pedal without any load for one minute. The load was increased gradually and the initial load was fixed in the loadometer of the instrument (60 watts). The load is gradually
Fig. I. Illustration of a Subject Performing Graded Exercise on Bicycle Ergometer.
increased in order to get acquainted with the new load and to avoid sudden strain, especially at the highest intensities. It can be mentioned that in no case any damage or overstrain in spite of the very high intensities was found.

6. Then the stop watch was started and the subject was asked to pedal with average intensity of 50 to 70 revolutions per minute which is determined by the speedometer of the instrument.

7. The subject pedalled in the same manner for five minutes and then the subject was asked to stop and immediately after all the variables were taken.

8. The load is brought back to zero immediately after five minutes of work.

9. In the same manner, all the subjects first performed on 60 watts load.

10. Similarly the next higher load was fixed at 90 watts followed by 120 and 150 watts adjusted in the loadmeter of the instrument and all the subjects
were asked to perform in the same manner. The variables were also recorded in the same methods followed previously.

11. All the necessary instructions were given to the subjects before performing work on the bicycle ergometer.

12. Due care was taken before and during the exercise period to check the load and speedometer of the instrument frequently.

Resting Pulse Rate

The Resting Pulse Rate was taken at a time when the subjects reported for tests in the morning. They were asked to lie down supine and rest for thirty minutes. The pulse rate was counted by palpating at the carotid artery. The score was expressed in terms of number of pulse beats per minute.

Pulse Rate after Exercise

Immediately after cessation of each grade of
exercise, the subject was asked to stop pedalling the bicycle ergometer and the pulse rate was counted by palpating the carotid artery at 15 seconds. The score was expressed in terms of number of pulse beats per minute.

Data on Resting Blood Pressure

A sphygmomanometer (dial type) and a stethoscope were used to measure the blood pressure (systolic and diastolic) of the subjects. Each subject was asked to sit relaxed in a chair. Extreme care was exercised in seeing that the subject was placed at ease and some time was allowed for the circulatory function to stabilize at resting level. The cuff of the sphygmomanometer was wrapped around the left upper arm of the subject just above the elbow. The cuff was then connected to the pressure pump and manometer. After closing the outlet valve of the pressure pump, the pressure in the inflatable rubber bag was rapidly raised to 160 mmHg by pumping which was sufficient to obliterate completely the bronchial artery so that the flow of blood through
Fig. 2. Illustration of Determining Exercise Pulse Rate.
the artery was arrested and radial pulse disappeared. The sound of pulsation was monitored by keeping the "chest piece" of the stethoscope over the bronchial artery and listening to the sound through the earpiece of the stethoscope as the pressure over the artery was being manipulated. The pressure is then gradually lowered by opening the valves. As soon as the pressure in the cuff fell just below the systolic pressure, it allowed the passage of small amount of blood through the compressed artery in to the distal segment. This produced a clear sharp tapping sound and the pressure shown on the dial was noted as soon as this sound was heard. This denoted the measure of systolic blood pressure. As the cuff pressure was lowered still further, more blood flowed through due to rebound relaxation of the arterial vessel and this was indicated by a louder sound. The pressure at which this sound could be muffled by manipulating the pressure pump was read on the manometer scale. This denoted the measure of the diastolic blood pressure.
These measurements were repeated twice for each subject and the latter was recorded as his scores in these variables.

Data on Blood Pressure After Exercise

The exercise stress employed and the procedure adopted for measuring the response of the circulatory system to different grades of exercise was the same as used for exercise pulse rate described earlier.

The measurement of systolic and diastolic blood pressure was recorded as described under resting blood pressure with the following modifications.

Before starting the exercise the sphygmomanometer was tucked to the cuff with the clip provided at the back of the sphygmomanometer for this purpose. The pressure pump attached to the sphygmomanometer was hung on the sphygmomanometer itself. Immediately on cessation of exercise, the subject rested his left fore arm on the left arm of the tester, to prevent venous occlusion. The pressure in inflatable cuff was rapidly
Fig. 3. Illustration of Determining Exercise Blood Pressure
raised to 250 mm. Hg. by inflating the cuff. The value of the systolic and diastolic pressure were recorded to the nearest mm. Hg. as described earlier.

Estimation of Blood Haemoglobin Content at Rest

Sahli’s Acid Haematin Method was used for the estimation of haemoglobin content in the blood, using Sahli Haemometer supplied by superior Company, West Germany.

The haemometer pipette, the haemometer tube and the stirrer were throughly cleaned and dried. In the haemometer tube N/10 Hydrochloric Acid was taken up to the 20th division on the percentage scale. The tube was then placed in the comparator in the space provided for it. The pricking needle was sterilised by swabbing it with rectified spirit and then heated over the flame of a spirit lamp. The top of the left ring finger of the subject was cleaned using rectified spirit. The finger was allowed to dry up and then punctured boldly with the pricking needle. Exactly 20 cubic mm of blood was drawn in to the pipette by sunction.
The pipette was then dipped into the N/10 hydrochloric acid contained in the haemometer tube and thoroughly mixed by rinsing the pipette with the acid several times. The tube was then allowed to stand in the comparator for about ten minutes for the maximum colour development. Then distilled water was added drop by drop to the mixture. On every drop of distilled water added to solution, it was stirred to ensure thorough mixing. The colour of the mixture was matched against the colour standard of the haemometer removing the stirrer. After the colour of the mixture exactly matched with that of the standard, the tube was taken out of the comparator and the stirrer was removed from the tube. The reading on the haemoglobin scale on the tube was read at the level of the lower meniscus of the solution avoiding parallax error. The scale was provided in grams of haemoglobin content per 100 ml. of blood.
Blood Hemoglobin content after Exercise

Blood Hemoglobin content was determined immediately after each grade of exercise in the same manner described earlier; estimation of blood Hemoglobin content was done.

Fig. 4. Illustration of Collecting Blood from the Subject for the Determination of Percentage of Haemoglobin in the Blood.
Blood Haemoglobin content after Exercise

Blood Haemoglobin content was estimated immediately after each grade of exercise in the same manner described under estimation of blood haemoglobin content at rest.

Cardio-Pulmonary Index

The purpose of this test was to measure the functional capacity of the cardiovascular and pulmonary system of the subjects. It was measured in two different phases:

1. Adynamic
2. Dynamic

Equipment:

Wet Spirometer, Stopwatches, Sphygmomanometer and Stethoscope.

Description:

Seven different variables were measured to calculate the C.P.I. of the subjects as follows:
It was measured with the dry spirometer graduated in litres. In the standing position the subject took two deep breaths before starting the test and then after fullest inhalation the subject placed the mouth piece attached to the spirometer, in the mouth, taking care to see that no air escaped through the edges of the mouth piece. The subject exhaled slowly and steadily while bending forward slightly until the maximum volume of air could be expelled without taking in a second breath. The subjects were instructed to take care that they blew out only through the mouth and not by the nose even partially. The nose of the each subject was clipped by a nose clip to prevent the air from escaping through the nose.

Scoring:

The score of the vital capacity for each subject was recorded per 100 ml.¹

¹Encyclopedia of Sports Science and Medicine, pp.274-277.
The purpose was to measure the time for which the subject could hold his breath.

Fig. 5. Illustration of Determining Vital Capacity
Maximum Breath Holding:

The purpose was to measure the time for which the subject could hold his breath.

Equipments:

Stop Watch

Description:

A suitable chair was provided to the subject to sit comfortably. The subject was asked to take maximum inhalation and hold it for whatever time it was possible for him to do so. As soon as his chest movement was observed to have stopped consequent to full inspiration, his nose was piched with a clip and simultaneously a stop watch was started. The subject was asked to prevent the leakage of air through the mouth and was instructed to keep his mouth closed. But as soon as he opened his mouth to take in breath or he was unable to hold breath any longer, the stop watch was stopped.
Scoring:

The time of holding the breath was recorded to the nearest second. Best of the two successive attempts with a suitable rest interval in between was recorded as his score.²

Maximum Expiratory Pressure:

The purpose was to measure the expiratory capacity of the subject after a complete inhalation.

Equipment:

Manometer and mouth piece

Description:

The rubber of the manometer from the blood pressure apparatus was removed and a suitable mouth piece was fixed at the end. The apparatus was placed at such a height that all subjects could perform the test standing erect. The subject took deep breath

²Ibid.
Fig. 7. Illustration of Determining Maximum Expiratory Pressure.
before starting the test and then after fullest inhalation the subject placed the mouth piece attached to the apparatus in his mouth, taking care to see that no air escaped through edges of the mouth piece. The subject was instructed to take deep breath and blow in to the manometer as forcefully as possible while bending forward slightly until the maximum volume of the air could be expelled without taking a second breath and to maintain the highest pressure at least for three seconds.

Scoring:

Best of the three trials with interval formed the score of the subject and was recorded in mm. Hg.  

Age:

The actuarial age in years in respect of each subject was recorded for the calculation of Cardio-Pulmonary Index.  

\[^{3}\text{Ibid.}\]

\[^{4}\text{Ibid.}\]
Blood Pressure:

The purpose was to measure the systolic and diastolic pressure.

Equipment:

Sphygmomanometer (dial type) and Stethoscope

Description:

Each subject was asked to sit relaxed in a chair. Extreme care was exercised in seeing that the subject was placed at ease and some time was allowed for the circulatory function to stabilize at resting level. The same method was used which is given under Resting Blood Pressure.

Scoring:

The pressure was taken in four different positions, i.e. sitting, supine, quick standing and standing for one minute. Where the variation in systolic was greater than ten percent the general average was
employed, where the variation was less than ten percent the standing level was used. It was measured in mmHg, which formed the score of the subject.

**Pulse Rate:**

It was taken to calculate the C.P.I. of the subjects.

**Description:**

The subjects were asked to take rest before taking the pulse rate. It was counted by palpating the carotid artery.

**Scoring:**

The pulse rate was counted in four different positions: sitting, supine, quick standing and after standing for one minute. If the variation in the four positions was greater than ten beats per minute then the average rate was taken as the score of the subject. But if the variation was less than nine beats then standing pulse rate was taken for each of the subjects.\(^5\)

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\(^5\)Ibid.
After conducting the test of various variables of the Cardio-pulmonary Index, it was calculated by using the formula.\(^6\)

\[
\text{CPI} = \frac{\text{VC} + \text{MBH} + \text{MEP} + \text{Age}}{\text{SP} + \text{DP} + \text{PR}}
\]

Where

- \(\text{VC}\) = Vital Capacity
- \(\text{MBH}\) = Maximum breath-holding
- \(\text{MEP}\) = Maximum Expiratory Pressure
- \(\text{Age}\) = Actuarial age
- \(\text{SP}\) = Systolic Pressure
- \(\text{DP}\) = Diastolic Pressure
- \(\text{PR}\) = Pulse Rate

Cardio-Pulmonary Index (Dynamic)

It was measured after giving 60 watts cycling exercise for five minutes to the subjects. After completion of the exercise the six parameters i.e. vital capacity, maximum breath holding, maximum expiratory pressure, systolic blood pressure, diastolic blood pressure and pulse rate were promptly determined. The

\[\text{ibid}\]
age factor, of course remained the same. After test the CPI was calculated as mentioned before. 7

Resting Tidal Volume

Tidal volume was measured with a wet spirometer graduated in litres and placed at such a height that all subjects could perform the test standing erect. The spirometer bell was immersed in the water filled in the spirometer drum. It was ensured that the pointer of the scale was at the Zero mark at the beginning of the test. The subject took normal breath and then, placed the mouth piece attached to the hose connected to the drum of the spirometer, in his mouth, taking care to see that no air escaped through the edges of the mouth piece. The subject exhaled normally. The subjects were instructed to take care that they blew out only through the mouth and not by the nose even partially. The nose of each subject was clipped by a nose clip to prevent the air from escaping through the nose. The score of tidal

7Ibid.
Tidal Volume After Exercising

Fig. 8. Illustration of Determining Tidal Volume.
volume for each subject was recorded in litres and then B.T.P.S correction factors were applied.

Tidal Volume After Exercise

Immediately after cessation of each grade of exercise the subject was asked to stop pedalling the bicycle ergometer and the tidal volume was measured as described under resting tidal volume.

Resting Respiratory Rate

The Resting Respiratory Rate was taken at a time when the subjects reported for tests in the morning. They were asked to lie down supine and rest for thirty minutes. The respiratory rate was counted by observing the movement of abdomen of the subject. The score was expressed in terms of number of respiration per minute.

Respiratory Rate After Exercise

Immediately after cessation of each grade of exercise the subject was asked to stop pedalling the bicycle ergometer and the respiratory rate was counted
by observing the movement of abdomen at 15 minutes. The score was expressed in terms of number of respiration per minute.

Resting Minute Ventilation

Resting Minute Ventilation is calculated by using the formula.

\[
\text{Minute Ventilation} = \text{Tidal volume} \times \text{Respiratory Rate}
\]

\[
(\text{litres per min. BTPS}) \times (\text{Litres per minute BTPS}) = (\text{breaths per minute})
\]

The procedure for Resting Tidal Volume and Resting Respiratory Rate for finding out Minute Ventilation was same as given under Resting Tidal volume and Resting Respiratory Rate.

Minute Ventilation After Exercise

This was also calculated using the same formula but the value of Tidal Volume and Respiratory Rate was substituted from the respective Tidal Volume after exercise and respective Respiratory Rate after exercise for each grade of exercise.
Maximal Oxygen Consumption ($\text{VO}_2\text{ max.}$)

The purpose of this test was to determine the subjects' maximal aerobic power ($\text{Max. VO}_2$). It is the first choice in measuring to assess a person's cardio-respiratory fitness.\(^8\)

Equipments:

**Electrical Bicycle Ergometer and Stop Watches.**

Description:

The subject was asked to sit comfortably on the bicycle and asked to pedal at 60 revolutions per second which is given in the speedometer of the instrument. In this frequency elicits the highest maximum $\text{VO}_2$ compared with 50, 70 and 80 revolutions per minute.\(^9\) Each subject was given practice in synchronising their frequency

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\(^8\) Fox, and Mathews, *The Physiological basis of Physical Education and Athletics*, p.623.

of pedalling with the reading in the speedometer, first without any resistance, and then gradually increasing the resistance till 150 watts. After ensuring that the novelty of atmosphere was worn out, and thus they had learnt the correct skill of going through the test for consistent and reliable performance, the test was undertaken.

At first the subject was asked to pedal without any load for one minute. The load was increased and fixed at 150 watts in the loadmeter of the instrument. The stop watch is started simultaneously with this. The subject pedalled in the same manner for five minutes. The heart rate responses were recorded during the fifth minute of the exercise. The VO$_2$ max. was predicted by using the following equation given by Fox.  

\[
\text{Predicted Max. VO}_2 \, (\text{liters per min}) = 6.3 - 0.0193 \times \text{HR (sub)}.
\]

---

Based on this equation, the ready recker prepared by Fox and Mathews\textsuperscript{11} is given in Appendix A.

All the necessary instructions were given to the subjects before performing work on the bicycle ergometer and due care was taken before and during the exercise period to check the load and speedometer of the instrument frequently.

**Experimental Design**

Random Group Experimental Design was adopted for this study. Equal numbers of subjects were assigned randomly to three groups, of twenty subjects each. The experimental treatments were also assigned randomly to the two groups and one group served as the control. The two experimental groups were administered two different kinds of training programmes for the development of cardio-respiratory endurance. One group was trained with the method of Aerobic Interval Running Method (Group Ae) and the second group with the method of Anaerobic

\textsuperscript{11}Ibid.
Interval Running Method. (Group An.). The experimental groups were given Aerobic and Anaerobic training programme for a period of twelve weeks, excluding the period utilized for tests. The training sessions were conducted thrice a week i.e. on Mondays, Wednesdays and Fridays for Anaerobic training group and Tuesdays, Thursdays, and Saturdays for Aerobic training group. This was in accordance with the physiological principle as stated by Mathewes and Fox,¹² that seven to eight weeks interval training programme with three work outs per week is effective in improving cardio-respiratory system. Measurements of circulatory and respiratory responses to graded exercises were taken after the experimental period of twelve weeks. The subjects were exempted from attending the required programme of Physical education of the school and also advised to refrain from all kinds of Physical stress so that their physical activities remained uniform but for

¹²Fox and Mathews, Physiological Foundations of Physical Education and Athletics, PP.183-184.
the differential experimental programmes prescribed.

In order to find out the differential effects of the two treatment methods and one control, analysis of variance by F test was carried out with respect to the mean gains or losses in each criterion measure. The Scheffe's Test\(^{13}\) was applied in cases where F ratio had shown significance to find out which of the differences of the paired means were significant.

**Administration of the Training Programme**

The training Schedule prepared by the investigator was applied to all the experimental groups and the training was personally supervised by the investigator with the help of the physical education teachers of the Scindiya school, Fort, who strictly followed the instructions of the investigator. The training was carried out thrice a week. The details of each training method are as under.

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The training stimulus or activity selected for the anaerobic group was 80 meter runs. The intensity stimulus was so prescribed that the pulse rate of the subjects rose to a level between 170 to 180 beats per minute, which was considered as the main indication of the training effect on anaerobic energy systems. A duration of 15 days was considered sufficient for adaptation of the body system to the exercise load. This is based on the conclusion of Harre Dietrick et.al.; who have indicated that a load cannot be raised in a linear way i.e. from day to day; but one maintains a certain level of load for two to three weeks and then makes stronger demands so that the increased load can be felt suddenly.

The volume of stimulus was fixed at six repetitions of 80 meter runs during the first two weeks. The load was increased in stages. For the

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first eight weeks the volume of training was increased and other factors were kept constant i.e. two repetitions were increased at the end of every two weeks. For the next four week the intensity at stimulus was increased by reducing the time run of each 80 meter to 13 to 15 sec. from 15 to 17 sec. at the ninth and tenth weeks and so on. Thus, the volume of training was kept constant, 12 repetitions of 80 meter run.

The permitted time for each run, the number of repetitions, and duration of density phase were fixed after conducting a pilot study with ten subjects, who were selected at random. They were made to run at various intensities to find out the time run required to raise the pulse rate between 170 and 180 beats per minute. After each run the pulse of each subject was recorded with the help of five post graduate assistants. Each run with a new intensity was repeated only when the subjects were fully recovered from the previous run. The recovery time was also found out for each person and the average of that was 6 minutes which was
taken as a rest duration after each work out. It was found that 80 meter run in 15 to 17 seconds was sufficient to raise the pulse rate to a level between 170 and 180 beats per minute. Six repetitions were adequate for the students as they were not a trained group and they would not be able to stand a more intense load. The distance of each training run was determined as 80 meter. So that the anaerobic energy system would be the predominant factor. The pilot study revealed that six minute recovery period was found adequate to lower the pulse rate to normal after a workout.

Aerobic Training Programme

The distance to run 15 minutes was empirically determined so that the heart rate of the subject rose to 150 per minute ensuring an intensity of work load of the maximum work capacity i.e. submaximum load. This required a distance of 0.5 KM, approximately. Two repetition of such running was prescribed with an active rest (walking) period in between successive runs so that
the heart rate did not go down below 120 per minute. The duration of rest period was found to be 10 minutes approximately. The total duration of the training session was 60 minutes approximately.

Progression in distance of run prescribed every two weeks is given in Table 4

**TABLE 4**

**BIWEEKLY SCHEDULE OF STIMULUS VOLUME AND STIMULUS INTENSITY OF TRAINING FOR THE AEROBIC GROUP**

<table>
<thead>
<tr>
<th>Week</th>
<th>Distance (Km.)</th>
<th>Stimulus Volume (Repetitions)</th>
<th>Stimulus Intensity (Duration of run in Min.)</th>
<th>Duration of Rest (Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st and 2nd</td>
<td>0.5 to 1.0</td>
<td>2</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>3rd and 4th</td>
<td>1.0 to 1.5</td>
<td>2</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>5th and 6th</td>
<td>1.5 to 2.0</td>
<td>2</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>7th and 8th</td>
<td>2 to 2.5</td>
<td>2</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>9th and 10th</td>
<td>2.5 to 3.0</td>
<td>2</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>11th and 12th</td>
<td>3 to 3.5</td>
<td>2</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

The distance of running was fixed at two repetitions of .5 KM to 1 KM run within 15 minutes duration during the first two weeks. The load was increased in stages by increasing the distance of run by .5 KM and other factors were kept constant i.e. .5 KM were increased at the end of every two weeks.

The permitted distance for each run, the number of repetitions and the duration of density phase were fixed after conducting a pilot study with ten subjects.