Chapter III

PROCEDURE

In this chapter the procedure adopted for the selection of subjects, selection of physical and physiological variables, criterion measures, reliability of data, procedure for administering the test and the method employed for statistical treatment of the data have been described.

Selection of the Subjects

Sixty male swimmers of 18 to 25 years of age belonging to sprint swimming group (n = 30) and long distance swimming group (n=30) who participated in the Open National Swimming Competition from various states of India in 1992-93 and/or 1993-94 were selected at random as subjects for this study.

All subjects belonged to well to do families and were with fairly well developed physique. The requirements of the study were explained to them in the presence of their coaches. They agreed voluntarily to undergo the tests. The procedure of the testing was explained to them so that there were no ambiguity regarding the efforts required on their part and the hardships they might have to endure. It was heartening to note that subjects took this as a challenge and were very enthusiastic to take part in their project to prove their mettle.
Selection of Variables

The selection of physical and physiological variables was done by using the following criteria:

1. Through review of all the available scientific literature pertaining to the physical and physiological variables which are related and likely to contribute to better swimming (short distance as well as long distance) performance.

2. A feasibility analysis as to which of the variables could be taken up for the investigation, keeping in view the availability of equipment, acceptability to the subjects and the legitimate time that could be devoted for tests and to keep the entire study unitary and investigated was made in consultation with experts.

Based on the above mentioned criteria the following physical and physiological variables were selected:

Physical Variables

1. Height
2. Body Composition a) Weight
   b) Percentage of body fat
   c) Lean body weight
3. Grip strength (right hand)
4. Grip strength (left hand)
5. Arm and Shoulder strength.
Physiological Variables

1. Maximum oxygen consumption (VO₂ max)
2. Peak flow rate
3. Air flow rate
4. Vital capacity
5. Resting heart rate
6. Positive breath holding capacity
7. Negative breath holding capacity.

Criterion Measures

Physical Variables

1. Standing height was recorded to the nearest half centimetre with the help of a non-elastic and flexible steel tape.
2. The weighing machine used for measuring weight.
3. Lang's Skinfold Caliper was used to measure skinfold thickness in millimetres.
4. The grip dynamometer used for measuring grip strength.

Physiological Parameters

1. The stop watch used for recording time for positive breath holding time, negative breath holding time and resting heart rate.
2. The peak flow meter used for measuring peak flow rate.

3. The air flow meter used for measuring air flow rate.

4. The Dry Spirometer used for measuring vital capacity.

5. Scores obtained by the subjects on vertical jump comparing to Lewis nomogram was considered as anaerobic power of the individual.

6. The mean heart rate obtained by the subjects on Astrand Bench Stepping test for five minutes comparing to Astrand Nomogram was considered as $VO_2$ max of the individual.

**Sprint Swimmer**

The swimmers those who have only participated in 50 metre and 100 metre freestyle event in Open National Swimming Competition in the year 1992-93 and/or 1993-94 have been considered as a sprint swimmer.

**Long Distance Swimmer**

The swimmers those who have only participated in 1500 metre freestyle swimming in Open National Swimming Competition in the year 1992-93 and/or 1993-94 have been considered as a Long Distance Swimmer.
Reliability of Data

Prior to the actual collection of data the reliability of the data was ensured by establishing the tester competency and instrument reliability.

Tester Competency

To ensure that the investigator was well versed with the techniques of conducting the tests and taking the measurements, the investigator had a number of practice sessions in testing procedure under guidance of my supervisor. All the measurements and tests were conducted by the investigator with the assistance of lecturers in physical education (swimming) and supervisor and SAI swimming coaches who were also well acquainted with the tests and measurements.

Reliability of investigator in taking physical and physiological measurements was established by test retest method by computing coefficient of correlation between the scores obtained twice on twenty subjects. All the subjects had the swimming match practice at L.N.C.P.E., Gwalior. The coefficient of correlation has been shown in Table 1 and 2.
TABLE 1

COEFFICIENT OF CORRELATION FOR TESTER RELIABILITY
IN PHYSICAL MEASUREMENT

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Variables</th>
<th>Coefficient of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Height</td>
<td>.93*</td>
</tr>
<tr>
<td>2.</td>
<td>Weight</td>
<td>.99*</td>
</tr>
<tr>
<td>3.</td>
<td>Grip Strength - Right hand Left hand</td>
<td>.93* .92*</td>
</tr>
<tr>
<td>4.</td>
<td>Arm and Shoulder Strength</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Pull-ups</td>
<td>.91*</td>
</tr>
<tr>
<td></td>
<td>b) Push-ups</td>
<td>.92*</td>
</tr>
<tr>
<td>5.</td>
<td>Skinfold</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Biceps</td>
<td>.84*</td>
</tr>
<tr>
<td></td>
<td>b) Triceps</td>
<td>.86*</td>
</tr>
<tr>
<td></td>
<td>c) Sub-scapular region</td>
<td>.88*</td>
</tr>
<tr>
<td></td>
<td>d) Suprailiac region</td>
<td>.89*</td>
</tr>
</tbody>
</table>

N = 20

*Significant at .05 level of confidence.

$r_{.05} (18) = .444.$

From the table 1, it is evident that tester reliability was significantly high thus establishing the competency of the scholar to administer the tests.
### TABLE 2

**COEFFICIENT OF CORRELATION FOR TESTER RELIABILITY IN PHYSIOLOGICAL TESTS**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Variables</th>
<th>Coefficient of Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Vital Capacity</td>
<td>.92*</td>
</tr>
<tr>
<td>2.</td>
<td>Positive Breath Holding</td>
<td>.88*</td>
</tr>
<tr>
<td>3.</td>
<td>Negative Breath Holding</td>
<td>.86*</td>
</tr>
<tr>
<td>4.</td>
<td>Resting Pulse Rate</td>
<td>.96*</td>
</tr>
<tr>
<td>5.</td>
<td>VO$_2$ max</td>
<td>.88*</td>
</tr>
<tr>
<td>6.</td>
<td>Anaerobic Power</td>
<td>.92*</td>
</tr>
<tr>
<td>7.</td>
<td>Peak Flow Rate</td>
<td>.91*</td>
</tr>
<tr>
<td>8.</td>
<td>Air Flow Rate</td>
<td>.94*</td>
</tr>
</tbody>
</table>

N = 20

* Significant at .05 level of confidence.

$r_{.05} (18) = .444$.

From the Table 2, it is evident that tester reliability was significantly high thus establishing the competency of the scholar to administer the tests.

**Instrument Reliability**

1. The non-elastic and flexible steel tape used to record standing height was calibrated and approved for use by the Research
Laboratory of the Lakshmibai National College of Physical Education, Gwalior.

2. The weighing machine used for measuring weight was tested for reliability by weighing a twenty kilogram on it and thus tested for accuracy and by repeating the procedure with different weights, its reliability was examined and confirmed.

3. Lang's skinfold was a standard equipment and accurate enough for the purpose of this study.

4. The grip dynamometer used for measuring grip strength was manufactured and supplied by Anand Agencies, Pune.

5. The stop watches used were all calibrated and synchronised from the manufacturer that is Krishna Watch Company, Bombay.

6. The peak flow meter used for measuring peak flow rate was calibrated and supplied by Clement Clarke International Ltd., London, England.

7. The air flow meter was calibrated and supplied by Allen and Hans Bruyrs Division of Glaxo, Australia.

8. The Dry Spirometer used for measuring vital capacity was supplied by Hindustan Scientific Instrument Co., New Delhi, made in Germany.
Collection of Data

The data on physical and physiological variables were collected by employing the standard testing procedures available in the literature. These tests and procedures were selected keeping in mind their administrative feasibility, availability and suitability with regard to the subjects employed in the study.

Description of Tests

Standing Height

Instrument

A smooth wall with marked scale by Steel Tape.

Procedure

The standing height was taken with the subject standing erect without shoes against a wall with a marked scale. The subject was instructed to keep the heels together, touching the wall with heels, buttock and back, head erect without tilt and to take and hold a full breath while hardboard was held vertically on his head, slightly pressing his head and touching the scales marked on the wall at a right angle. The subject was asked to step out by lowering the head and the reading indicated by the hardboard's lower was read on the scale. Height was recorded to the nearest centimetres.¹

Weight

Instrument
Weighing Machine.

Procedure
The weight of the subjects were taken on a weighing machine. The subjects wearing swimming costume only stood on the weighing machine and weight was recorded nearest to a half a kilogram.

Grip Strength

Instrument
Grip Dynamometer.

Procedure
The subject stood erect without any support, holding dynamometer in his right hand and thereafter in the lefthand. The concave edge of the dynamometer was placed between the first and second joints of the fingers with the dial towards the palm. Grip handle of the dynamometer was adjusted as per the size of hand of the subject. The elbow was slightly bent and hand described the sweeping arch downward as the subject squeezed the dynamometer. The subject was instructed not to touch or take support from any object while performing the test. Two trials were given and reading of the best trial was recorded to
the nearest 0.5 kilogram as score of the subject's one hand.²

Arm and Shoulder Strength

The arm and shoulder strength was calculated by applying the Roger's formula. The formula included the following.

1. Height (H) (in inches)
2. Weight (W) (in pounds)
3. Pull-ups (in number)
4. Push-ups (in number)

Arm and shoulder strength (push-ups + pull-ups) (W/10 + H-60) (If height of the subject is below the 61 inches, height is discarded in the formula).

Procedure

To compute arm strength index by applying Roger's formula, the following tests and measurements were taken.

1. The height of the subject was measured against a wall with a marked scale. The subject stood erect, bare footed with heel, hip, posterior thoracic region and back of the head touching the wall. The subject was instructed to take and hold a full breath while hardboard was held vertically on his head, slightly pressing his head and touching the scales marked on the wall at a right

²Clarke, Application of Measurement to Health and Physical Education, p. 128.
angle. The subject was asked to step out by lowering the head and the reading indicated by the hardboard's lower was read on the scale. Measurements are taken in inches.

2. The weight of the subject was measured in pounds by using weighing machine. The subject stood on the platform bared footed in swimming dress. The weight was recorded from the indicator dial of the machine and converted kgs. into pounds.

3. The pull-ups test was administered on the horizontal bar of three centimetres diameter fixed at a convenient height so that the subject's feet did not touch the floor while he was hanging with arm straight. From this hanging position he pulled himself up until the chin is crossed (over) the bar as well as arms were fully flexed. The subject was instructed avoid kicking and jerking movements maximum number of correctly executed pull-ups was considered as subjects score in this test.

4. The push-ups test was administered on the parallel bars. The subject stood at the end of the parallel bars, grasping one bar in each hand. He jumped to the front support of parallel bar with straight arms. From this position, he dipped his body down until the angle of the upper arm and forearm was less than 90°, then pushed-up to the front support position. This was counted as a complete push-up. The subject was instructed not to jerk or kick or stop and rest while executing the push-ups.
Maximum number of correctly executed push-ups was recorded as the subject's score in this test.

**Scoring**

With the help of Roger's Formula arm and shoulder strength was computed by using the recorded scores above mentioned measurements and tests and recorded in pounds.

**Percentage of Body Fat**

**Instrument**

Skinfold Caliper.

**Procedure**

The Lenge's skinfold caliper was used to assess the body fat. The right side of the body was used to determine the percentage of fat. The thickness of the skin and subcutaneous fat were grasped between the thumb and index finger and measurement was taken to the nearest milimetre from the four different specific sites using the caliper namely biceps, triceps, subscapular and suprailliac. The procedure of taking measurements are described as under:

**Biceps**: Biceps thickness was measured with the help of skinfold caliper. The subject stood with the arm by the side of the body and the elbow extended but relaxed position. A double layer of the skin and subcutaneous tissue was grasped with the biceps muscle on the front of the subject's right arm, half way
between the acromion and the elbow, where the skinfold runs, parallel to the long axis of the arm. The skinfold caliper was placed gently into grasped skin without removing the fingers and thickness of the skin was recorded from the indicator needle of dial. It was measured to the nearest millimetre.

Triceps: Triceps thickness of the subject was measured with the help of skinfold calipers. The subject stood with the arm by the side and the elbow extended but in relaxed position. A double layer of skin and subcutaneous tissue was grasped with the thumb and forefinger of the left hand over the triceps muscle on the back of the right arm, half way between the acromian and the elbow, where the skinfold runs parallel to the long axis of the arm. The skinfold calipers was placed gently into the grasped skin without removing the finger and thickness of the skin was recorded from the indicator needle of the dial. It was recorded to the nearest milimetres.

Sub-scapular: Thickness was measured using skinfold calipers. The subject stood with shoulder erect but relaxed and arms by the sides. A double layer of skin and subcutaneous tissue were grasped with the thumb and forefinger of the left hand lateral to the inferior angle of the right scapula, where the skinfold runs downward and outward in the direction of the ribs. The skinfold calipers was placed gently into the grasped skin without removing the fingers at about 45 degree from vertical and hori-
zontal planes. The thickness of the skin was recorded as indicated by the indicator needle of dial. It was measured to the nearest millimeter.

Suprailiac: Suprailiac thickness was measured with the help of skinfold calipers. The subject stood in a normal erect posture. A double layer of skin and subcutaneous tissue were grasped with the thumb and forefinger of the left hand in a position one to two inches above the right anterior superior iliac spine, where the anterior superior skinfold runs forward and slightly downward. The skinfold caliper was placed into the grasped skin without remaining the finger and thickness of the skin was recorded from the indicator needle of dial. It was measured to the nearest millimetre.

The sum of the skinfold thickness of all four sites of the body was converted into percentage body fat with the help of standard table suggested by Durnin and Rehman.\(^3\)

**Lean Body Weight**

The total body weight minus the weight of the body's fat give the lean body weight. The weight of the fat was deducted from each subject's total body weight recorded. The weight of

fat was calculated by using the following formula:

\[
\text{Fat Weight} = \frac{\text{Body Weight} \times \text{Percentage Value of Fat}}{100}
\]

**Resting Heart Rate**

Resting pulse rate was recorded while the subject was in supine position early in the morning. The subject was instructed to be the supine for 15 to 20 minutes. Then finger tips were put on radial artery and the pulse beats were counted for 60 seconds. Scores recorded in beats per minute.

**Vital Capacity**

**Instrument**

Dry Spirometer.

**Procedure**

Vital capacity was measured by dry spirometer in milliliters. The spirometer was equipped with a good length of metal pipe (2 to 3 inches). The metal pipe was disinfected by an antiseptic solution after use by each subject.

The subject was asked to take a deep breath before the test, then after the fullest possible inhalation the subject exhaled slowly and steadily bending forward over the pipe till all the air within his control was exhaled.

Care was taken to prevent air from escaping either through the nose or around the edges of the mouth piece and was also
ensured that a second breath was not taken by the subject during the test. In case of doubt the test was repeated. Every time the dial was reorganised to bring to the zero point, each time after use. Three chances were given and the best reading was recorded.

**Scoring**

The final score of vital capacity of a subject was calculated by millilitres/square metre of body surface area.

\[ V_{O_2} \text{max (Maximal Oxygen Consumption)} \]

**Instrument**

Metronome, bench (18" high), stop watch.

**Procedure**

Each subject was asked to stand near the 18 inches high bench. On the command "Ready", "Start" the subject began stepping up and down the bench to a four count rhythm which is explained as follows:

On count one the subject stepped on the bench with one foot, on count two the subject lifted the body up by straightening the leg already placed on the bench and placed the second foot also on the bench, keeping the trunk upright. On count three the subject placed one foot on the floor, and on count four the other foot was also brought down to the floor. The subject was
allowed to lead off with either foot or to change the loading foot during the test. The subject was not permitted to step-up with a jump and was instructed to extend the knees fully when both the feet were on the bench or the floor. The four count rhythm was maintained with the help of a Metronome. The stepping exercise continued for a maximum of five minutes at the rate of 30 steps per minute, unless the subject was forced to stop through exhaustion. In either case the duration of exercise was recorded in seconds, 300 seconds being the maximum. Immediately after the subject stopped the exercise he was asked to rest in a chair and immediately the investigator recorded the pulse rate of the subject for a duration of 30 seconds.

**Scoring**

The $\text{VO}_2\text{max}$ was recorded in litres/minutes for the heart rate achieved in the 6th minute after the exercise. Astrand Nomogram\(^4\) along with the body weight of the subject was utilised for the prediction of maximal oxygen consumption. (Figure 1) The final score was obtained in milliters/minute/kg, body weight.

**Anaerobic Power**

**Equipment**

Weighing machine, marked black board, chalk powder.

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Procedure

Each subject was weighed only in the morning on a weighing machine (fully calibrated) and weight was recorded to 5 g. An attempt was made to familiarize the subject with the environment of the test until the subject was fully described. The subjects were seated in batches and appraised of the objectives of the test. Each subject was seated in the supine position and a standard loading was applied. A black line or marker line was marked in segments measuring 20 cm in upward and downward direction. By taking a crouched position with knees bent approximately to 90° angle, the subject positions in this position to evaluate the possibility of a double jump and loaps upward as far as possible. The subject then swung the arms forcefully forward and upward. As the subject reaches the highest point of the jump he swings the arms upward and downward, motion being timed to coincide with height of the jump. The specified movements in executing the jump are extremely important.

Each subject was given three chances. The subjects were asked to stand close to the wall with one side against the wall and touch the black board, the powder left a mark on the board, and this reading too was recorded. The difference between the initial reading (standing) and final reading (jump) was calculated.

Fig. 1: ASTRAND - ASTRAND NOMOGRAM FOR PREDICTION VO₂max FROM HEART RATE AND BODY WEIGHT.
Procedure

Each subject was weighed early in the morning on a weighing machine fully calibrated. The weight was recorded in kg. to the nearest 500 gms.

Sargent Jump

The subjects were assembled in batches and appraised of the objectives of the test and the test was fully described. A black board was fixed on the wall and was marked in segments measuring from the ground upward. In this jump, the individual swings his arm downward and backward taking a crouch position with knees bent approximately to a right angle. The subject pauses in this position to eliminate the possibility of a double jump and leaps upward as high as possible, swinging the arms forcefully forward and upward. As the subject reaches the highest point of the jump he swings the arm forward and downward, motion being timed to coincide with height of the jump. The specified movements in executing the jump are extremely important. Each subject was given three chances. The subjects were asked to stand close to the wall with one side towards the wall and touch the board with fully stretched hand and the reading was recorded. He then put chalk powder on fingers and jumped. As he jumped and touched the black board, the powder left a mark on the board and this reading too was recorded. The difference between the initial reading (standing) and final reading (jump) was calculated
and this was considered the score of vertical jump.

**Scoring**

The number of centimetres between the reach and the jump measured to the nearest centimetre was the score taken and the best trial measured.

Anaerobic power was recorded in kg.-m/sec. for the best trial in the Sargent jump. Lewis Nomogram\(^5\) along with the body weights of the subjects was utilised for the prediction of anaerobic power (Figure 2).

**Air Flow Rate**

**Instrument**

Air flow meter, nose clip.

**Procedure**

Air flow rate was measured by air flow meter. The instrument has a detachable mouth piece connected to a small plastic drum which has a graduated dial with markings ranging from 0 to 100 (one litre). The dial also has an indicator which revolves, when air blows into the small plastic drum like apparatus. When the indicator comes to rest at some point along the gradual dial, the reading on the dial shows the air flow rate in litres/

\(^5\) Mathew and Fox, *The Physiological Basis of Physical Education and Athletics*, p. 620.
minute. After noting down the reading the dial in rotated clockwise or anti-clockwise, so that the indicator points to zero again.

Accordingly the subject was asked to relax and hold the instrument in one of his hands and put the mouth piece in. He then kept the mouth piece in position and was asked to inhale through the mouth to the maximum extent of the mouth piece with a forced blow. The expelled air caused the indicator to move along the graduated dial. The reading before the indicator came to a rest was recorded as the volume of air in litres per minute. Three chances were taken and the best reading was recorded to the nearest two points to give the final score. The mouth piece was disinfected with dettal, to be used by each subject every time. The final scores were calculated in Lit./min./sq. metre of body surface area.

**Fig. 2 : LEWIS NOMOGRAM FOR DETERMINING ANAEROBIC POWER FROM JUMP – REACH SCORE AND BODY WEIGHT.**
minute. After noting down the reading the dial in rotated clockwise or anti-clockwise, so that the indicator points to zero again.\(^6\)

Accordingly the subject was asked to stand and hold the instrument in one of his hands and put the nose clip on. He then kept the mouth piece in position and was asked to inhale through the mouth to the maximum capacity, then expell the maximum possible air by a blow-out into the mouth piece with a forced blow. The expelled air caused the inside indicator move along the graduated dial. The reading where the indicator came to a rest was recorded as the air flow rate of the subject in litres per minute. Three chances were given and the best reading was recorded to the nearest two decimal points as the final score. The mouth piece was disinfected with dettal, after use by each subject every time. The final scores were calculated in Lit./min./sq. metre of body surface area.

**Peak Flow Rate**

**Instrument**

Peak flow meter, nose clip.

**Procedure**

The mini wright peak flow meter supplied by Clement Clarke International Ltd., London was used for measuring the

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\(^6\) Brar, (Unpublished Ph.D. Dissertation, Jiwaji University, 1982).
peak flow rate. The subject was asked to stand and hold the instrument in one of his hands in such a way that the fingers did not obstruct the slot. The instrument was held in hand lightly with the slot facing away from the hand, with the flattened part of the plastic mouth piece in horizontal position. The subject to be tested had the nose clip on and kept the mouth piece in position. He was asked to inhale through his mouth to the maximum capacity. He then inhaled the maximum possible amount of air by blowing out into the mouth piece with a hard blow. The inhaled air caused the marker to move up the scale. The value, where the marker came to rest was recorded as the peak flow rate in litres per minute. Then the marker was gently pushed to the lower end. Three chances were given and the best reading was recorded as the final score. The mouth piece was disinfected with the dettol after use by each subject. The final scores were calculated in lit./minute/sq.metre of body surface area.

Positive Breath Holding Time

Instrument

Stop watch, nose clip.

Procedure

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 stopped, after taking full inspiration, his nose was pinched 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 was stopped.

**Scoring**

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

**Negative Breath Holding Time**

**Instrument**

Stop watch, nose clip.

**Procedure**

The subject stood erect comfortably. After deep breathing in and out a couple of time, the subject was asked to have a deep inspiration and breath it out to the maximum extent possible by contracting the intercostal muscles and abdominal muscles and hold out the breath for the maximum time duration that he could.

As soon as his chest and abdominal movements ceased, a nose-clip was fixed and simultaneously a stop watch started. When the subject opened his mouth to take a breath and was
no longer able to hold the breath, the stop watch was stopped and the breath holding time was noted and recorded to the nearest second.

Better of the two successive attempts, with suitable rest period in between, was recorded the subject's score in seconds.

**Body Surface Area**

Body surface area was computed with the help of Dubious Surface Area formula. 7

Body Surface Area formula:

\[ A = H \times 0.735 \times W \times 0.425 \times 71.84 \]

\[ A = \text{Surface area in square centimetres.} \]

\[ H = \text{Height in centimetres} \]

\[ W = \text{Weight in kilograms.} \]

Surface area in square centimetre divided by 1000 = Surface area in square metres.

**Statistical Analysis of Data**

To examine the significance of the difference between National Level sprint and long distance swimmers 't' ratio has been computed.

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To determine the selected physical and physiological profiles of National Level sprint and long distance swimmers the mean and standard deviation have been evaluated for all the variables.