CHAPTER- III

METHODS AND PROCEDURE

In the present study an attempt has been made to study the relationship of morphological, physiological and motor abilities with performance of female gymnasts.

In this chapter the selection of sample, selection of variables, criterion measure and reliability of the data, procedure of taking selected anthropometric measurements, cardiovascular fitness, motor ability tests and statistical procedures for analysing the data have been described.

3.1 SAMPLE:

For the study, a total number of 94 female gymnasts (Mean age =19.6 yrs) from different universities who participated in All India Inter University Gymnastics Championship held at Patiala in Sept.2007 and Kurukshetra in Sept.2008 were selected as subjects for the study.

As the study was based on competitive performance, only those gymnasts who secured more than 20% marks were tested for the investigation. To make the comparison among them, the gymnasts were divided into two groups on the basis of their performance. The best 24 gymnasts were placed in (Group A)
high performance gymnasts and others who secured more than 20% marks were put in (Group B) low performance gymnasts.

Before testing, the investigator had a meeting with the gymnasts in the presence of their coaches and managers to ensure maximum co-operation on each occasion. The purpose of the study was explained to them, so that there was no ambiguity among the subjects regarding the efforts they had to put in for successful completion of the investigation. All the subjects were convinced of the need for the investigation and assured that the subjects will be made available for the collection of data.

3.2 SELECTION OF VARIABLES:

The investigator thoroughly went through scientific literature related to the sport of gymnastics that was available from books, magazines, journals and periodicals. Keeping in view the relevance of the variables to gymnastics performance and feasibility criteria, the variables were selected for the study.

3.3 RELIABILITY OF THE DATA:

All the gymnasts taken in the present study actually participated in the All India Inter university competitions. They were the best in their respective universities and due to that were able to participate in the competitions. The sample selected
for the study was considered appropriate as per the purpose of the investigation.

3.4 COLLECTION OF DATA:

Sufficient time for warming-up was provided before administering the tests. Each test was properly demonstrated and each gymnast was given one trial attempt where required.

Selected anthropometric measurements were taken in the morning from 6 A.M. to 8 A.M. daily during the competitions. All the anthropometric measurements were taken on the right side of the subject.

COMPETITIVE PERFORMANCE:

The official results of gymnastics performance were obtained from the organisers of the competitions. The evaluation of gymnastics performances was done by national qualified judges according to the 'Code of Points’ by “Federation International de-Gymnastique”.

3.5 CRITERION MEASURE:

The criterion measures chosen to test the hypotheses were as under:

1. Competitive performance was measured in marks. The total marks achieved by a gymnast in team championship
competition were taken as competitive performance score and marks obtained on each apparatus were recorded as apparatus score. A gymnast can score a maximum of 20 marks on each apparatus.

2. Anthropometric measurements:

Weight of the gymnast was measured in kilograms. The stature, sitting height, subischial length, humerus and femur bicondylar, upper arm, fore arm, thigh, hip, waist and calf circumferences were recorded in centimetres. Biceps, triceps, subscapular, supra-iliac, and calf skinfolds were measured in milimetres.

3. Percent body fat was estimated by Siri’s equation for which body density was calculated by equation devised by Durnin and Womersley. The somatotype rating was computed by using Heath- Carter method of somatotyping.

4. Motor Ability Tests:

1. Maximum number of sit-ups performed in one trial

2. Maximum number of push-ups performed in one trial

3. Maximum number of chin-ups performed in one trial
4. Horizontal distance jumped by the subject was recorded to the nearest centimetres was taken for standing broad jump.

5. Distance between the heels and outer side of palms of the gymnast was measured to the nearest centimetres for bridge test

6. Maximum distance of forward bending was measured to the nearest centimetres.

7. The distance between the Crotch of the subject and the ground on side split tests was measured to the nearest centimetres for the flexibility of hip region.

8. Speed was measured in terms of time taken by the subject to run a 30 metre to the nearest of 1/10th of a second.

3.6 TECHNIQUE OF TAKING ANTHROPOMETRIC MEASUREMENTS:

To get morphological characteristics, the following anthropometric measurements were taken on the right side of each gymnast by using the standard techniques given by Weiner and Lourie (1969) and Martin and Saller (1957). Standard instruments (i.e. anthropometric rod, sliding caliper, Harpenden...
Skinfold caliper, Gluck steel tape and weighing machine) were used to take selected measurements.

- **Age:** The calendar age of each gymnast was taken into consideration. Decimal age was calculated from the date of birth and the date of measurement.

- **Weight:** The subject wearing minimal clothing, stood erect in the center on the platform of a portable weighing machine and the weight was recorded in kilograms, nearest to half a kilogram. The needle was checked before taking weight of each gymnast.

- **Stature:** It is the vertical distance from the point vertex to the horizontal floor. The subject was asked to stand erect with both heels touching each other along with a vertical wall. The hips and the upper scapular part to touch the vertical wall, toes about 30° apart. In this position the subject was asked to stretch upward and look forward so that his visual axis was parallel to the axis of the floor. The head was kept in Frankfort Plane. Vertical distance from vertex to the floor was then measured with an anthropometric rod in centimetres.

- **Sitting Height:** It is the vertical distance from the point vertex to the sitting surface of the subject when stretched.
The subject was asked to sit erect on a table with feet unsupported, the hands resting on the thighs. The head was oriented in the Frankfort Plane, gentle upward traction was exerted on the mastoid region and the distance between the vertex and the table (sitting surface of the subject) was measured with an anthropometric rod in centimetres.

- **Subischial Length:** Subischial length was obtained by subtracting the sitting height from stature.

- **Humerus Bicondylar Diameter:** It is the straight distance between the most lateral point and the most medial point of the lower end of humerus. The subject was asked to flex arm horizontally forming a right angle with the forearm. The width between the medial and lateral epicondylar of the humerus was measured with the sliding caliper in centimetres. Slight pressure was placed on the cross bars in order to compress the subcutaneous tissue.

- **Femur Bicondylar Diameter:** It is the straight distance between the most medial and most lateral point of the lower end of femur. The subject was seated on the chair with the knee bent at a right angle. The greatest distance between the lateral and medial epicondyler of the femur was measured with sliding caliper in centimetres. Slight
pressure was placed on the cross bars in order to compress the subcutaneous tissue.

- **Upper Arm Circumference:** It is the circumference of the upper arm at the level half ways between the top of acromion and radiale. The subject was asked to stand relax with arms hanging freely. The circumference was taken by flexible steel tape in centimetres.

- **Upper Arm Circumference (flexed):** It is the maximum circumference of the upper arm when the biceps muscle is fully contracted with elbow flexed. The tape was wrapped around the contracted upper arm taking care that it remains at right angles to the long axis of the upper arm and the largest value was taken by moving the tape in either direction where it is maximum. Measurements were taken on both the arms and the larger value was recorded.

- **Fore Arm Circumference:** It is the circumference of fore arm which is taken at the maximal bulging point. The subject was asked to stand relaxed with arms hanging freely. The flexible steel tape was wrapped at the maximum bulging point of the fore arm. The circumference was measured in centimetres.

- **Waist Circumference:** It measures the minimum girth of the abdomen above the naval cavity in centimetres with the
subject standing. The measuring tape was kept around the place where right and left abdomen walls were most sunk along the mid-axillary.

- **Thigh Circumference**: It is the circumference at the point half way between the landmarks trochantrion and femorale. The subject was asked to stand erect putting equal weight on both feet and keeping the apart. The measurement was taken by steel tape in centimetres.

- **Calf Circumference**: It is the maximum circumference of the calf. The subject was asked to stand erect by keeping feet apart with equal weight on the feet. The steel tape was wrapped at the most medially projecting point of the gastrocnemius of the leg. The measurement was taken in centimetres.

- **Hip Circumference**: The gymnast was asked to stand with both feet together. At a level from the maximal protrusion of the buttocks to the symphysis pubis, steel tape was wrapped and the measurement was recorded to the nearest centimetres.

**SKINFOLDS:**

All the skinfold measurements were taken with the help of Harpenden Skinfold Caliper. All the limb skinfolds were
measured exactly at the same level where the respective circumferences were taken. For every measurement a fold of skin and subcutaneous tissue was picked up firmly between thumb and forefinger of the left hand and pulled away from the underlying muscle. The edge of the plates on the branches of the caliper were then applied 1 cm below the fingers of the left hand and allowed to exert their full pressure before reaching the thickness of the fold. The subject stood relaxed, except for the calf skinfold which was taken with the subject sitting.

- **Biceps Skinfold**: This skinfold was picked up on the front of the arm about 1 cm. above the level marked on the skin for the arm circumference and directly in line with the centre of the cubical fossa.

- **Triceps Skinfold**: With the subject arm hanging loosely, a fold was picked up at the back of the arm, directly in line with the point of the elbow, at the same level as that for the biceps skinfold.

- **Subscapular Skinfold**: The subscapular skinfold was picked up just beneath the inferior angle of the scapula in a direction which was obliquely downwards and outwards at 45°.
• **Supra-iliac Skinfold**: This fold was picked up approximately 1 cm. above and 2 cm. medial to the anterior superior iliac spine on a diagonal, line going downwards and inwards at 45°.

• **Calf Skinfold**: A vertical skinfold was picked up on the medial side of the lower leg, at the level of the maximum girth of the calf.

**BODY COMPOSITION:**

**Percent Body Fat**: For the estimation of percent body fat, body density was calculated by using the following equation devised by Durnin and Womersley (1974).

**Body Density**

(For 16-19 years)

\[ 1.1549 - 0.0678 \times \log (\text{Biceps} + \text{Triceps} + \text{Subscapular} + \text{Supra-iliac Skinfolds}) \]

(For 20-29 year)

\[ 1.1599 - 0.0717 \times \log (\text{Biceps} + \text{Triceps} + \text{Subscapular} + \text{Supra-iliac Skinfolds}) \]

The calculated body density was converted into percent body fat using the formula devised by Siri (1961).
**Percent Body fat** = \( \frac{495}{\text{Body density}} - 450 \)

**Percent lean body mass** = 100 – Percent body fat

**BODY INDICES:**

1. **Sitting height/Height Ratio:**
   
   This was obtained by the formula given below:
   
   Sitting Height/Height X 100

2. **Leg Length/Height Ratio:**
   
   This was calculated by the following formula:
   
   Leg Length/Height X 100

**SOMATOTYPING:**

Heath-Carter somatotype method (1980) has been used to make the somatotype ratings. (Appendix -1)

Ten anthropometric measurements were taken to calculate somatotype rating. They are height, weight, four skinfolds, two bony breadths and two limbs girths.
3.7 TECHNIQUES OF TAKING MOTOR ABILITY TESTS:

A. Strength Tests

To measure the strength of legs, arms and abdomen, the following tests were conducted:

1. Sit ups (jack knife) (Max. Numbers)
2. Push ups on ground (Max. Numbers)
3. Chin-ups (Max. Numbers)
4. Standing broad jump (cm)

B. Flexibility Tests

To measure the flexibility in arms and legs, the following three tests were taken.

1. Forward bending (Trunk flexion) (cm)
2. Bridge (Trunk extension) (cm)
3. Side Split (Flexibility of hips) (cm)

C. Speed Test

The following test was conducted to measure the sprinting ability of the gymnast.

1. 30 metre sprint (sec.)
STRENGTH TESTS:

1. **Sit-ups (Jack Knife):**

   **Purpose:** To measure the strength endurance of abdominal muscles.

   **Equipment:** Mats

   **Procedure:** The subject was asked to assume supine position on the mat with arms stretched over her head. She was instructed to raise the trunk and legs simultaneously so as to touch the hands to her feet, without bending the knees. This constitutes one sit-up.

   **Scoring:** The total number of sit-ups performed by the subject without any pause between the sit-ups was taken as score of the subject.

2. **Push-ups:**

   **Purpose:** To measure arms and shoulder girdle strength endurance.

   **Procedure:** The subject was asked to assume starting position as the front leaning rest. In this position she was asked to keep arms straight, hands resting on the floor with shoulder width apart, back and legs straight with the feet together and the weight was supported on the hands
and feet. Then she was instructed to lower herself with arms bent until her chest touches the floor and then pushes back up to the starting position. This counts one push–up throughout this the subject was asked to maintain straight line body position.

**Scoring:** The total number of push-ups performed by the subject without any pause between the push-ups was taken as score of the subject.

3. **Chin-ups:**

**Purpose:** To measure strength endurance of the arms and shoulder muscles.

**Equipment:** Uneven bars, magnesium carbonate power.

**Procedure:** The subject was instructed to hold the high bar with both hands with over grip at shoulder width and to assume a stationary hanging position. From this position without bending and swinging her lower body, she was asked to pull herself upward till her chin was above the bar. The subject will then asked to lower her body downward till she assumes complete hang position. This constitutes one chin-up. In this manner, the subject
executed as many chin-ups as possible without any pause in between the repetitions.

**Scoring:** The total numbers of chin-ups performed by the subject were taken as score for chin-ups.

4. **Standing Broad Jump:**

**Purpose:** To measures the explosive strength of leg muscles.

**Equipment:** Measuring tape and chalk.

**Procedure:** The subject was instructed to stand with her toes just behind the take-off line and jump from both feet simultaneously with a free arms swing. The distance was measured from the nearest edge of the take-off line to the closest point to contact of foot or any other body part. The subject was allowed to make preparatory movements by bending knees and swinging arms. Jumping was performed forward without touching the take-off line. No double jump was allowed.

**Scoring:** Three trials were permitted in succession and the best distance in centimetres was taken as subject’s score.
II. **FLEXIBILITY TESTS:**

1. **Trunk Flexion (Forward bending):**

   **Purpose:** To measure the range of forward trunk flexion and the stretch ability of the hamstring muscles.

   **Equipment:** A box of 45 cm. height, fixed with measuring scale of 10 cm. in upward direction and of 45 cm. in downward direction.

   **Procedure:** The subject was asked to stand bare footed on the box, toes of both the feet touching each other and extended to the edge of the box. The subject was asked to bend forward-downward along the scale as much as possible by keeping the knees absolutely straight. Both the hands were kept parallel and brought at a maximum reach on the scale. This position was held for two seconds. The minimum reach from the scale was recorded as score of trunk flexion. Each subject was given two attempts immediately one after the other. The better of two was taken into consideration for scoring purpose.

   **Scoring:** Distance was recorded from the scale in centimetres.
2. **Bridge (Trunk Extension):**

**Purpose:** The test measures the range of extension of the spine.

**Equipment:** Mats, measuring steel tape and chalk.

**Procedure:** From back lying position on the mat with folded knees and feet apart, the subject was asked to make bridge on the mat with extended elbows and knees behind the line of feet. The point, where she touches the outer side of the palms was marked with chalk. The distance from the straight line where she had placed the heels to the outer side of the palm was measured.

**Scoring:** The distance between heels and outer side of the palm was measured in centimetres for scoring purpose.

3. **Side split (flexibility of hips):**

**Purpose:** To measure the flexibility of hip joint.

**Equipment:** Measuring tape, chalk.

**Procedure:** The subject was asked to stand straight and from this position, she was asked to split her legs to side position to maximum extend without bending the trunk with steady motion and lower the crotch as near to the
floor as possible. As the gymnast reached her lowest point, the case was raised upward till the ruler guide rested under her crotch. The reading was taken in the window of the flexometer case to the nearest centimetres.

**Scoring:** The distance between the Crotch of the subject and the ground on side split tests was measured to the nearest centimetre for the flexibility of hip region.

**III. SPEED:**

**30 Metre Sprint:**

**Purpose:** To measure the sprinting ability of the subject.

**Equipment:** Stop watches.

**Procedure:** The subject was asked to assume standing start position at the starting line. Two subjects ran at a time. The starter, positioned behind the subjects, gave the command 'on your marks', 'set' and clapped her hands above her head as a signal to start the sprint. The subject runs as fast as possible to the finish line which was marked at 30 metres away from the starting line. Two time keepers for each subject stood on the side of the finishing line. They started their stop watches when they saw the starter clapping her hands and stopped the watches when
the chest of the subject crossed the plane of the finishing line. Each subject was given two attempts. Better attempt was considered for scoring purpose.

**Scoring:** The time taken by the subject to cover a distance of 30 metre was recorded in seconds by 1/10 of a second.

### 3.8 Technique of Measuring Cardiovascular Fitness:

Skubic and Hodgkins (1963) three minute step test was taken to measure cardiovascular fitness of the gymnast.

**Purpose:** To measure the cardiovascular fitness of the gymnast.

**Equipment:** Stop watch, 18 inches high bench, metronome (optional), stethoscope (optional).

Skubic and Hodgkins proposed a three-minute step test for girls and women. The reliability coefficient for the test was reported as .82. In subsequent studies, Skubic and Hodgkins (1963 and 1964) developed national norms for their Cardiovascular Efficiency Test. Norms were prepared separately for junior high school girls, senior high school girls, and college women in accordance with six ratings: excellent, very good, good, fair, poor, and very poor (Appendix 2). The samples upon which the norms are based were 2360 women from 66 colleges, 1362
senior high school and 686 junior high school girls from 55 secondary schools throughout the country.

**Procedure:** The tester demonstrated the stepping up style to be followed by the gymnasts during the test. The metronome was set to a speed of 96 beats per minute. The subject was asked to start the stepping up and down exercise in consonance with the sounds of metronome or by starting the stopwatch at a signal `go`. The subject was given instructions that on the command `up` or the first sound of the metronome, she placed one foot on the bench, on the second command `up` or the second sound of the metronome, she placed other foot on the bench with the body erect straightening the legs and back. Immediately after reaching the erect posture, she steps down one foot at a time as the tester gives command `down` (third sounds of the metronome) and on the next command of `down` (fourth sound of metronome) she stepped down other foot. The subjects were instructed to repeat the stepping up and down exercise in the above manner for three minutes at the pace of 24 steps per minute. The subject was also asked to take off and step –down with the same foot each time. The tester started the stop watch simultaneously with the first take off by the subject and stops the watch after exactly three minutes by giving the `stop` signal to the subject who immediately sits down on the bench. In case, any gymnast stops
the exercise or slows down the pace of the exercise due to fatigue or exhaustion, her duration of exercise performed at the correct pace was noted (in seconds) and was asked to stop and sit down. Exactly one minute after the exercise, the tester starts counting the pulse rate and records the same for 30 seconds at the carotid artery by palpation.

**Scoring:**

\[
\text{CES} = \frac{\text{number of seconds completed} \times 100}{5.6 \times \text{pulse count}}
\]

### 3.9 COMPETITIVE PERFORMANCE:

The official results of the All India Inter University Gymnastics Championship were considered as competitive performance. A jury of qualified judges evaluates the performance of each gymnast according to the 'code of the points for women' by Federation International de Gymnastics.

### 3.10 STATISTICAL COMPUTATIONS

**Statistics:**

It is the mathematical teaching or process of gathering, describing, organizing, analysis and interpreting numerical data. It is a basic tool of measurement and research. In the field of physical education statistics turned to be an essential tool. For
the better interpretation of the results and the presentation of data, the following methods were used:

**STATISTICAL ANALYSIS OF THE DATA:**

The data collected by the above mentioned procedures has been statistically analyzed by the following statistical formulas.

**Arithmetic Mean (\( \bar{X} \))**

It is calculated to measure the central tendency of each parameter.

\[
\bar{X} = \frac{\sum x}{n}
\]

- \( X \) = Stands for scores
- \( N \) = Denotes the number of observations
- \( \Sigma \) = The sum of all the observation.

**Correlation Co-efficient (r):**

Zero Order Product Moment method of correlation was used to compute relationship of variables with competitive performance.

The term correlation co-efficient indicates the degree of association between two continuously variable characters. This may be either positive or negative. The values of \( r \) varies with in
limits from -1 to +1. It is computed by the following formula of Product-Moment Method.

\[
r = \frac{N\sum xy - \sum x \times \sum y}{\sqrt{[N\sum x^2 - (\sum x)^2][N\sum y^2 - (\sum y)^2]}}
\]

Where \( x \) and \( y \) are the two observed variables

\( N \) is the number of paired values and \( \Sigma \) denotes summations.

**TEST OF SIGNIFICANCE:**

The `t` test was applied to determine the significance of differences in means of the selected variables between high performance and low performance gymnasts. The level of significance has been taken as 5% in the present study. The values of `t` was obtained by applying the following formula:

\[
\text{`t'} = \frac{x_1 - x_2}{\sqrt{(S.E.M_1)^2 + (S.E.M_2)^2}}
\]

Where  \( x_1 \) = Means of first group  
\( x_2 \) = Means of second group  
\( S.E.M_1 \) = Standard error of mean of first group  
\( S.E.M_2 \) = Standard error of mean of second group
The critical value of the statistics at 5% level is read in tables of students `t' for degree of freedom. If the calculated value of `t' is more than the critical value, the difference between the two groups is said to be significant.