CHAPTER - III

PROCEDURE

In this chapter the selection of subjects, selection of variables, criterion measures, reliability of data, administration of tests, and statistical techniques for analysing the data have been described.

Sample

The sample consisted of 140 gymnasts in all who participated in XXIX Senior National Gymnastic Championship held at Cuttack from 5th March to 9th March, 1987; All India Inter University Championship held at Manipur University from 19th December to 23rd December, 1986; and National School Games of India held at Chandigarh from 7th January to 11th January, 1988. As the study was based on competitive performance, only those gymnasts were tested who qualified for competition 1b on the basis of their performance in competition 1a, i.e., compulsory exercises according to the rules of Gymnastics. Due to limited time during the competitions only 50 top gymnasts from the Senior National Championship, 40 from the All India Inter University Championship and 50 from the National School Games of India could be tested, thus making a total of 140. The subjects who participated at more than one level were eliminated. The subjects
were from all states, Union territories, Railways, Services and all the Indian universities which participated in the competitions cited above. The average age for the Senior National group was 25 years, for the All India Inter University 20 years, and for the National School group 16 years at the time of respective competition.

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 purposes of the study were 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 this investigation and agreed to extend full co-operation. The coaches of the respective teams assured that the subjects will be made available for the collection of data as and when required.

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 gymnastic performance and feasibility criteria, the following variables were selected for the study.

**Motor Fitness Components**

1. Speed
2. Agility
3. Strength Endurance
   (a) Arm strength endurance
   (b) Abdominal strength endurance
4. Power
   (a) Power of arms
   (b) Power of legs
5. Flexibility
   (a) Flexibility of the hip region (Side Split)
   (b) Flexibility of the hip region (Forward to rear Split)
   (c) Shoulder Flexibility
   (d) Spine Flexibility
6. Dynamic balance
7. Speed of movement.

**Anthropometric measurements**

Following anthropometric measurements were taken for the investigation:

1. Age
2. Weight
3. Height
4. Sitting height
5. Leg length
6. Arm length
7. Shoulder width.
8. Chest width
9. Hip width
10. Arm circumference
11. Chest circumference
12. Hip circumference
13. Thigh circumference
14. Calf circumference

Criterion Measures

1. Gymnastic performance was the point awarded to each gymnast by a panel of five qualified judges of the Gymnastic Federation of India at different levels of competitions as per "FIG" (Code of Points). Gymnastic performance was taken from competition i.e. Team Championship.

2. Speed was measured in terms of time taken by the subject to run a distance of 30 metres recorded to the nearest of 1/10th of a second.

3. Time taken to shuttle a distance of 10 yard four times recorded to the nearest 1/10th of a second was the measure of agility.
4. Horizontal distance covered with 6 lbs. medicine ball throw, recorded to the nearest centimetre was used to measure the power of arms.

5. Maximum number of chin-ups performed in one trial which measured the arm strength of the gymnast.

6. Maximum number of correctly executed bent knee sit-ups which measured the abdominal strength endurance.

7. Vertical distance jumped by the subject using Sargent Jump and recorded to the nearest centimetre was used to measure leg power.

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

9. Distance between thumbs of the hands recorded in nearest centimetre after executing backward rotation measured the shoulder flexibility.

10. Bridge-up test was chosen to measure the flexibility of the spine. Distance between heels and finger tips of the Gymnast was measured to the nearest centimetre.
11. Points scored out of hundred in performing modified bass dynamic balance test, was the measure of balance.

12. The distance score as obtained by using Nelson's speed of Movement test and converted into time score using the following formula measured the speed of movement.

\[
\text{Time} = \frac{2 \times \text{distance the stick falls}}{\text{Acceleration due to gravity}}
\]

**Anthropometric measurements**

Anthropometric measurements taken were: height, sitting height, arm length, leg length, shoulder width, hip width, chest width, arm circumference, chest circumference, hip circumference, thigh circumference and calf circumference in the nearest centimetre. Weight of the subjects was measured in kilograms to the accuracy of 100 gms.

**Reliability of the Data**

Before proceeding to collect the actual data, the reliability of the data was ensured by establishing instrument reliability, the tester's competence and the reliability of the tests.
Instruments Reliability

All the instruments required for the collection of data had been obtained from reputed suppliers of standard equipment which was procured by the Department of Physical Education, Panjab University, Chandigarh (India). Thus their calibrations were accepted as accurate enough for the purpose of this study.

Tester's Competence and Reliability of Tests

The tester's competence was evaluated together with the reliability of the tests. To determine reliability of the tests, the performance of ten subjects selected at random on the selected variables was recorded twice under similar conditions by the investigator and the Pearson's Product Moment Correlation was calculated between the two measures of each variable. The reliability coefficients thus obtained have been presented in Table 1 and 2.
### Table 1

Reliability Coefficients of Test-Retest Scores of Selected Motor-Fitness Components

<table>
<thead>
<tr>
<th>No.</th>
<th>Tests</th>
<th>Coefficient of Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 M Run</td>
<td>.89</td>
</tr>
<tr>
<td>2</td>
<td>4 x 10 Y shuttle Run</td>
<td>.85</td>
</tr>
<tr>
<td>3</td>
<td>Medicine ball put</td>
<td>.81</td>
</tr>
<tr>
<td>4</td>
<td>Chin-ups</td>
<td>.68</td>
</tr>
<tr>
<td>5</td>
<td>Bent-knee sit-ups</td>
<td>.83</td>
</tr>
<tr>
<td>6</td>
<td>Sargent jump</td>
<td>.88</td>
</tr>
<tr>
<td>7</td>
<td>Side Split</td>
<td>.91</td>
</tr>
<tr>
<td>8</td>
<td>Forward to Rear Split</td>
<td>.90</td>
</tr>
<tr>
<td>9</td>
<td>Shoulder Rotation</td>
<td>.85</td>
</tr>
<tr>
<td>10</td>
<td>Bridge up Test</td>
<td>.90</td>
</tr>
<tr>
<td>11</td>
<td>Dynamic balance</td>
<td>.82</td>
</tr>
<tr>
<td>12</td>
<td>Speed of movement</td>
<td>.78</td>
</tr>
</tbody>
</table>

$P < .05$

$r_{.05}(9) = 0.602$
Table 2

Reliability Coefficients of Test Retest Scores of Selected Anthropometric measurements

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Tests</th>
<th>Coefficients of Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Height</td>
<td>.99</td>
</tr>
<tr>
<td>2</td>
<td>Weight</td>
<td>.98</td>
</tr>
<tr>
<td>3</td>
<td>Sitting Height</td>
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<tr>
<td>4</td>
<td>Arm Length</td>
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</tr>
<tr>
<td>5</td>
<td>Leg Length</td>
<td>.99</td>
</tr>
<tr>
<td>6</td>
<td>Shoulder width</td>
<td>.98</td>
</tr>
<tr>
<td>7</td>
<td>Chest width</td>
<td>.97</td>
</tr>
<tr>
<td>8</td>
<td>Hip width</td>
<td>.98</td>
</tr>
<tr>
<td>9</td>
<td>Arm circumference</td>
<td>.97</td>
</tr>
<tr>
<td>10</td>
<td>Chest circumference</td>
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</tr>
<tr>
<td>11</td>
<td>Hip circumference</td>
<td>.97</td>
</tr>
<tr>
<td>12</td>
<td>Thigh circumference</td>
<td>.99</td>
</tr>
<tr>
<td>13</td>
<td>Calf circumference</td>
<td>.98</td>
</tr>
</tbody>
</table>

$P < .05$

$r_{05}(9) = 0.602$
From the test-retest coefficients of correlation in Table 1 and 2 it was obvious that the tester's reliability was high - thus establishing the competence of the investigator to administer the tests.

The correlation coefficients also indicated the reliability of the tests selected, as very high correlations were obtained when the tests were repeated.

Collection of Data

At all the three different levels of achievement, the gymnasts were tested for selected motor fitness components. Sufficient time for warming-up was provided before administering the tests. Each test was properly demonstrated by the investigator himself 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 all the three different levels of competitions. The investigator had sufficient training to take anthropometric measurements before starting the present work. All the anthropometric measurements were taken on the right side of the subjects.

The official results of gymnastic performance were obtained from the organisers of different level competitions. The evaluation of gymnastic
performances was done by national qualified judges in all the three competitions according to the "Federation Internationale de-Gymnastique" (Code of points).

Administration of Tests

Selected Motor-Fitness components:

30 Metre Run:

For Gymnasts 30M Run has been considered to be the best measure of running speed because a gymnast has to accelerate himself within 25 metres for jumping from the Beat-Board to perform his vault on the vaulting horse.

Two subjects were tested at a time. They were asked to take standing start behind the starting line. The clapper was clapped after the caution "ready" was given to the subjects. The starter stood in such a position, so that the 'V' of the clapper (open before clap) was visible to the time keepers. As the 'V' closed when the clap was executed, the time keepers at the finish line pressed the buttons of their watches to start them. The subjects sprinted as fast as possible across the finish line and the stop watches were stopped as and when the concerned subject covered the distance.

The final score was the average of the time recorded for each subject by two time-keepers in seconds upto 1/10th of a second.
2. **Shuttle Run 4/10y**

The purpose of shuttle-run test was to measure the agility of the performer in running and changing directions.

A measuring tape, stop watches, and two blocks of wood (2"x2"x4" were used in this test.

Each subject started behind the starting line on the signal "Go". The subject ran to the blocks, which were placed exactly 10 yards from the starting line and picked one of the blocks, returned to the starting line and placed the block behind the line. The same process was repeated with the second block. Two trials were permitted for each subject. Some rest was allowed between the two trials.

The score was the total time taken to complete the course recorded to 1/10th of a second. The test of the two trials was considered as the subject's score.

3. **Two Hand Medicine Ball-Put**

For measuring power of arms and shoulder girdle two hand medicine ball put (6 lbs) Test was employed.

For this test the subject was asked to sit in a straight back chair and hold the ball in both hands with
the ball drawn back against the chest and just under
the chin. He then pushed the ball upward and outward
for maximum distance. The rope was placed around the
gymnast's chest and caught to the rear by a partner
in order to eliminate rocking action during the push.
So the subject's action was primarily with the arms.

The distance of the best of two trials measured
to the nearest centimeter was recorded as subject's
score.

4. Chin-ups

For measuring the muscular strength endurance
of the arm and shoulder girdle in pulling the body
upward, chin-ups test was employed.

The chin-ups test was administered on a standard
horizontal bar of 28 mm diameter fixed at convenient
height so that the subject's feet did not touch the floor
while he was hanging with arms straight. The subject
was instructed to grasp the bar in an under-hand grip
at shoulder width apart from a fully extended hanging
position. He then pulled himself up until the chin was
above the bar and lowered himself until his arms were
fully extended. The subject was instructed to avoid
kicking and jerking movements. The maximum number of
correctly executed chin-ups was considered as subject's score.

5. Bent Knee Sit-ups:

Bent knee sit-ups test was used for measuring strength endurance of the abdom.

From a lying position on the back, the subject placed his knees over the yard stick while sliding his heels as close to his seat as possible. The yard stick was held tightly under the knees until the subject was instructed to slowly slide his feet forward. At the point where the yard stick dropped on the mat, the tester marked the heel line and seat line in order to indicate how far the feet should remain from the seat during the bent knee-sit-ups exercise. Keeping the fingers inter-laced behind his neck, he performed sit-ups alternating a left elbow touch of the inside right knee and a right elbow touch of the inside left knee. The exercise was repeated as many times as possible.

The total number of repetitions was recorded as score of the subject. However, repetitions were not counted when finger tips did not maintain contact behind the head, or when the knees were not touched, or when the subject pushed off the floor with the elbow.
6. **Vertical Jump**

Sargent Jump was used to measure the power of the legs in jumping vertically upward.

For this test, a smooth surface of at least 12 feet from the floor was chosen. Markings were clearly made on the wall starting from four feet and six inches above. A measuring tape and several chalk pieces were used.

The subject stood with one side towards the wall with heels together and with a piece of chalk in his hand. In this position the subject stretched his arm upward as high as possible, keeping his heels firmly in contact with the ground and made a mark on the wall with the chalk. Then from the desired jump position, with preferred side to the wall, he jumped as high as possible and at the peak of the jump made another mark above the first one.

The distance between the two marks measured to the nearest centimeter was the score and the best of three trials was recorded.

7. **Side Split Test**

Side Split Test was used for measuring extension in spreading the legs apart.
From the standing position the subject was asked to extend his legs apart from side to side and lower the crotch as near to the floor as possible. The subject was instructed to spread the legs without bouncing. As the subject reached his lowest point, the case was raised upward until the ruler guide rested under his crotch. The reading was taken in the window of flexomeasure case to the nearest centimeter.

8. Front-to-Rear Split Test

Front-to-Rear Split Test was used for measuring extension in spreading the legs apart from front-to-rear.

From the standing position the subject was asked to extend his legs apart from front to rear and lower the crotch as near to the floor as possible. The subject was instructed to spread his legs with steady motion without bouncing. As the subject reached his lowest point, the case was raised upward until the ruler guide rested under his crotch. The reading was taken in the window of the flexomeasure case to the nearest centimetre.

9. Shoulder Rotation Test

This test was used to measure the extent to which the shoulders will rotate with as narrow a grip as possible.
The subject grasped one end of the calibrated rod with his left hand and grasped the rod with right hand in a like manner a few centimeters away. The initial width of the hands was decided by the subject. With extended arms to full length in front of the chest he rotated the rod over the head. As the subject met resistance in rotating the shoulders it was allowed to slide within the grip of right hand so that the arms could be spread and allowed to lower the rod until it was resting across his back. He kept the arms locked and rotated to the starting position. Distance between the thumbs of the hands on the rod was recorded to the 1/10th of the centimeter. The least amount of distance indicated better level of performance.

10. Bridge-up test

Bridge up test was used to measure the range of extension of the spine. For this test the subject was instructed to assume a supine (back lying) position on the mat. From this position he raised his trunk up by supporting his body weight on hands and feet. The subject brought his feet and hand as close as possible with fingers pointing the heels. The examiner measured the distance between the heels and the finger tips to the nearest centimetre with the steel tape to record his score.
11. Modified Bass Test of Dynamic balance

Modified Bass Test of Dynamic balance was used to measure the ability of a gymnast to jump accurately and maintain balance during movement and after movement which is very essential in executing gymnastic movements and to maintain proper balance at the time of landing on different apparatuses.

The subject stood with his right foot on the starting mark and leaped to the first tape mark with his left foot and tried to hold a steady position on the ball of his left foot for as many seconds as possible up to five seconds (Both the stop watch and counts were used). After five seconds he leaped to the second tape mark with right foot, and so on, alternating the foot from tape to tape. The subject was asked to stand on each tape mark for five seconds in such a way that the foot completely covered the tape mark so that it could not be seen.

The score for each mark successfully covered was five points, and in addition, one point was awarded for each second the balance was held up to five seconds per mark. Thus, a subject could get a maximum of ten points per mark and total of 100 points per test.

The subject had to lose five points for improper
landing such as (a) failing to step upon the tape mark after a leap; (b) touching the heel or any other part of the body to the floor other than the ball of the supporting foot upon landing; (c) failure to completely cover the mark with the ball of the foot. The subject was allowed to reposition himself for the five second balance on the ball of the foot after making a landing error.

The subject had to lose points at the rate of one point per second for (a) touching any part of the body with the floor other than the ball of the supporting foot, or (b) moving the foot while in balance position, or (c) if he lost his balance he was to step back on the proper marker and then leap to the next marker. Total number of points was the subject's score.

12. **Nelson's Speed of movement**

Nelson's speed of movement test was used to measure speed of movement of the hands. It was suitable for different age levels. The equipment needed was a yard stick, a table, a chair and a chalk piece.

The subject was asked to sit in a chair, facing the table, with his hands resting on the edge of the table. The palms were kept facing each other with the inside border of the little fingers along two
lines which were marked on the edge of the table 12" apart. A small mark exactly between the two marks was made to facilitate positioning of the stick prior to release. The investigator held the stick near the top so that it hanged midway between the subject's palms with the 'base line' of the stick positioned evenly with the upper edge of the subject's index fingers and the subject looked on the concentration zone. After the preparatory command "ready" was given, the stick was dropped and the subject stopped it as quickly as possible with an inward horizontal movement of the arms. The subject was instructed not to move his hands up or down when he was clapping the hands together. Twenty trials were given and the distance the stick falls through the hands before it was stopped every time was recorded. The reading was taken from the stick at the point just above the upper edge of the hands after catch. The average of the middle ten trials, after the slowest and fastest five trials having been eliminated, was taken as the distance score. This distance score was then converted to time score by applying the following formula:

\[
\frac{\text{Time}}{2} \times \frac{\text{Distance the stick falls}}{\text{Acceleration due to gravity}}
\]
Selected Anthropometric measurements

All the segments of the right side of the body were considered for taking the measurements. The following standard techniques were used for each measurement taken on all the subjects.

1. **Age:**

   The calendar age of each subject was taken into consideration. Then decimal age was calculated from the date of birth and the date of measurement.

2. **Body Weight:**

   A reliable portable weighing machine from a standard company was used for this purpose. The machine was checked against known weights often before use. The pointer was set on zero and the subject was asked to stand erect in the centre of the platform of weighing machine with minimum clothing i.e. (short only). Wearing of short alone was kept consistent for all the subjects in order to maintain accuracy. All the subjects were weighed at the same time of the day and to the same degrees of accuracy. The reading was taken from vertical angle and the weight was recorded to the nearest 1/10 of kilogram.

1. **Height**

   The height was measured with anthropometric rod. The subject was asked to stand against a wall with his
heels, buttocks, upper back and back of the head making firm contact with the wall so that he may stretch to his full height. The heels were together and arms hanging down on the sides. Then the horizontal moveable bar of the anthropometric rod was pressed firmly over the subject's head and the height was recorded to the nearest centimetre. All the subjects were measured in gymnastic uniform without shoes.

4. **Sitting Height**

For measuring sitting height, the subject was asked to sit on a table with his back stretched, thighs resting on the table top and the legs hanging freely downward. Distance from the table top to vertex was recorded to nearest centimetre.

5. **Leg Length**

Leg length was obtained by subtracting sitting height from the total height of the subject.

\[
\text{Leg length} = \text{total height} - \text{sitting height}.
\]

6. **Arm Length**

Arm length was measured from the acromion process on the right shoulder to the tip of middle finger to the nearest centimetre.

7. **Shoulder width**

A sliding calliper with one arm fixed was used for this measurement.
The subject was asked to sit erect on a small bench and the calliper was adjusted to the two acromion points from behind him. The distance between the two bars of the calliper was recorded to the nearest centimetre.

9. Chest Width:

A sliding calliper with one bar fixed was used for measuring chest width.

The subject was asked to stand in an erect position with heels together and arms raised up to shoulder level. The calliper was adjusted in line with the nipples with the fixed bar held against left wall of the chest and the moveable bar brought in touch with the opposite wall and the distance between the two bars of the calliper recorded to the nearest centimetre.

9. Hip Width

For measuring hip width the subject was asked to stand erect and the maximum measurement in the region of the trochanters was recorded to the nearest 1/10 of centimetre with a sliding calliper.

10. Arm Circumference

A steel tape was used for measuring upper arm circumference.
The subject was instructed to stand in an easy position with arms extended and hanging in normal position. A mark was drawn in between the acromion and olecranon process with a skin marking pencil to determine the site for measurement. The measuring tape was wrapped on the land mark around the arm in light contact and the measurement was recorded to the nearest 1/10th of centimetre.

11. Chest Circumference

The chest circumference of the subject was taken in relaxed position. Steel tape was used to take the measurement. The subject was asked to stand in an easy position with arms raised a little up. The tape was then wrapped around the chest of the subject so that it touched the inferior angles of the scapulas at the back and directly above the nipples in front. The measurement was recorded to the nearest centimetre.

12. Hip Circumference

The subject 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 centimetre.
13. **Thigh Circumference**

The subject stood with his feet slightly apart and with his body weight equally distributed on both legs. The steel tape was placed around the thigh horizontally with its top edge just under the fold of the buttocks and the measurement was recorded to the nearest centimetre.

14. **Calf Circumference**

For this measurement, the subject was asked to stand with his feet slightly apart with his body weight equally distributed on both legs. The tape was wrapped around the calf at most built part and the circumference was obtained in nearest centimetre.

**Statistical Procedure**

1. The relationship of motor-fitness and anthropometric variables to gymnastic performance was established by computing Pearson's Product Moment Correlation (zero order).

2. The relative importance of motor-fitness and anthropometric variables to gymnastic performance was also found by eliminating or partialling out the effect of one or the other variable through partial correlation (First Order).
3. The combined contribution of motor-fitness components and anthropometric measurements each considered separately to gymnastic performance was obtained through multiple correlation.

4. To compare the subjects belonging to the three selected levels i.e. SN (Senior National), IU (Inter University) and NS (National Schools) on the selected motor fitness components and anthropometric measurements, analysis of variance (F ratio) was applied. In case of significant F-ratios, Sheffe's test of post hoc differences was applied to study the significance of differences between the ordered paired means.

5. The level of significance chosen to test the hypotheses was 0.05.

5. Multiple Regression equations were developed to predict gymnastic performance at different levels based on selected motor fitness components and anthropometric measurements.