METHODS & PROCEDURE
CHAPTER-III

METHOD AND PROCEDURE

In the present study an attempt has been made to study the Physical fitness and morphological characteristics of hammer throwers in India.

In this chapter the selection of sample, selection of variable, criterion measure and reliability of the data, procedure of taking selected anthropometric measurements, physical fitness tests and statistical procedures for analyzing the data have been described.

3.1 SAMPLE:

For the study, a total number of 60 male and 30 female hammer thrower from the different places of India in 15th September 2007 to 30th December 2007 during the course of various coaching camps, training sessions; they were attending in connection with the national and international competitions were selected as subjects for the study.

In the study the performance data of each subject in all Tests was obtained as a part of the Hammer throw training programme. However it was not possible to conduct the tests of all the subjects at the period same time.
The data collected on all throwers were grouped into two group men and women Hammer throwers. Major groups were further divided into sub groups, 5 groups each, such as 40m-45m, 45m-50m, 50m-55m, 55m-60m and 60m-65m for men and 30m-35m........50m-55m for women category.

Before testing, the investigator had a meeting with the Hammer throwers in the presence of their coaches to ensure maximum co-operation on each test. 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 the 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 VARIABLE:

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

3.3 RELIABILITY OF THE DATA:

All the hammer throwers taken in the present study on the present performance with the standard implement of both men and women. The performance in hammer throws of the subjects
ranged between 40m to 65m for men and 30m to 55m for women. The sample selected for the study was considered appropriate as per the purpose of the investigation.

3.4 COLLECTION OF DATA:

The throwers were tested carefully arranging the tests and other training requirements in rotation on separate days. The investigator tried his best to conduct the tests for all the subjects, under similar and standard conditions; the tests were grouped and arranged in a sequence, which formed an integral part of training. The tests were planned as an integral part of the training in consultation with the coaches. The tests pertaining to barbell exercises were conducted during morning hours from 7.00 AM onwards. All the other tests such as throwing, jumping and spiriting were conducted in one session. The technical assistance of the qualified coaches and fellow master students were taken for the administration of the tests.

All the equipment needed for the tests were checked and counter checked to ensure accuracy and standardization. The shots with specific weights were weighted on standard weighing machine and were specially marked for the purpose of conducting the tests. A steel tape was used for the measurement of distances. Battery operated digital watches for the accuracy of 1/100\textsuperscript{th} of was used in order to record the time. Standard barbell
sets from the respective departments’ weight-training hall were utilized for the maximum strength and power tests.

A 15-20 minutes warm up was obligatory before the tests. The subjects were brought to a motivated condition to achieve their best performance. After the warm up the subjects were permitted to do few trials of the tests, to adjust to the nature and condition of the tests. The standard procedure of each test was always demonstrated and explained before the actual test.

The test results for maximum strength and power exercises were established according to IRM principle (one repetition maximum). Sufficient recovery pause between the attempts was given. For recording the performance in shot put three trails were given in all the tests. The best performance was considered for the purpose of analysis.

3.5 CRITERION MEASURE

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

1. Competitive performance was measured in meters. Minimum performance was 30m and 40m for women and men respectively.

2. Anthropometric measurements:

   Weight of the thrower was measured in kilogram. The Height, sitting height, full arm length, shoulder, hip width
humerus and femur bicondylar, upper arm, forearm, thigh and calf circumference were recorded in centimeters. Biceps, triceps, fore arm, subscapular, supra-iliac, thigh and calf skinfolds were measured in millimeters.

3. Percent body fat was estimated by Brozek et. al. (1963) 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. Physical fitness tests:
   1. Bench press, front squat, dead lift, snatch and clean was measured in kilograms.
   2. Vertical jump, triple jump, front shot throw and back shot throw was measured in centimeters.
   3. All the weight of hammers was measured in meters.
   4. Speed was measured in the terms of time taken by the subject to run a 30 meter to the nearest of 1/10th of a second.

3.6 TECHNIQUE OF TAKING PHYSICAL FITNESS TESTS:

A. Maximum strength and power tests.
   1. Bench press (kg)
   2. Front squat (kg)
   3. Dead lift (kg)
4. Snatch (kg)
5. Clean (kg)

**B. Speed and explosive power tests.**

6. Vertical Jump (cm)
7. Triple jump (cm)
8. Back shot throw (cm)
9. Front shot throw (cm)
10. 30m standing start (Sec)

**C. Special strength tests.**

11. Hammer throw 7.25kg men & 4kg women with 1 turn (m)
12. Hammer throw 6.25 kg for men & 3 kg for women in m.
13. Hammer throw 5 kg for men & 2 kg for women in m.
14. Hammer throw 8 kg for men & 5 kg for women in m.

The detail of Physical fitness tests are as follow:-

**Bench Press (kg):**

The subject lay on the bench in a supine position. Two stands were kept on either side of the bench on which the weight load barbell was placed. He kept his feet apart on the ground. The subject held the barbell with overhand grip and with the help of the helpers, the barbell was lifted by the subject and brought closer to the required level. From this position he pressed the barbell up till there was no bend at the elbows. Again with the help of helpers the barbell was kept on the stand.
The subject was allowed five attempts to achieve his maximum weight with which he could do one repetition. The maximum weight bench-pressed was taken as score.

**Front Squat (kg):**

This test was similar to full squat except the barbell was resting in front of the subject on the shoulders with elbow pointing forward. The subject held the bar with overhand grip (hands shoulders width apart). The scoring system was same as for full squat.

**Dead Lift (kg):**

The official weight lifting rules were followed. The barbell loaded with weights lay on the floor in front of the subject. The subject stood with his feet shoulders width apart under and over the barbell one by one. The barbell is to lift by straightening in to an upright position while maintain straight arms.

**Snatch (kg):**

The official weight lifting rules were followed. The barbell loaded with weights lay on the floor in front of the subject. The subject stood same like in clean test except held the bar with wider grip. The subject pulled the bar by straightening his knees and back. The barbell was pulled up in a straight line and close to body and than the subject moved his body under the barbell by bending his knees slightly and straightening his elbows. The
maximum weight with which the subjects was able to do one correct clean was taken as the score of the subject.

**Clean (kg):**

The official weight lifting rules were followed. The barbell loaded with weight lay on the floor in front of the subject. The subject stood with his feet shoulder apart and under the barbell. From this position the subject bent his knees to squat down and to hold the barbell with overhand grip (hands shoulder width apart). The back was kept straight. From this position the subject pulled the barbell up by straightening his knees and back. The barbell was pulled up in a straight line and close to the body to shoulder level and than the subject moved his body under the barbell by bending his knees slightly. The barbell came to rest on shoulders with elbows pointing forward. Using the above mentioned technique the subject with in five attempts tried to clean with maximum possible weight with which the subject was able to do one correct clean was taken as the score of the subject.

**Vertical Jump (cm):**

A vertical height was marked on a wall in centimeters. The subject stood 20cm away from the wall and facing parallel to the wall. Lime powder was applied to the fingers of the subject to get a clear mark on the wall on touch. He made preparatory
movement by flexing the knees and swinging the arms back and took the vertical jump. The subject tried to touch the marked wall at maximum height. Three attempts were given to the subject. Best jump was the score of the subject.

**Standing Triple Jump (cm):**

A take of mark with white line was made five +1meter away from the edge of the pit. The landing area of the pit was leveled according to level of take of surface. The subject placed both feet comfortably apart just behind the take of line. He made preparatory movement by flexing the knees and swinging the arms back without touching the take of mark. No alternate leg in permitted while executing the hop. The measurement in centimeters was taken from the take off mark. Best jump was as the score of the subjects.

**Backward Shot Throw (7kg) Men & (4kg) Women in cm:**

The athlete stood just close to the line marked facing back of the throwing direction holding a 7kg shot. Both the arms were straight; feet shoulder width apart with flexed knees and trunk slightly bent forward. The shot was swung downward releasing the shot backward over the head to achieve an optimum parabola to cover the maximum distance. Three trials were given and best distance was taken as score.
**Forward Shot Throw (7kg) and (4kg) Women in cm:**

The athlete stood just close to the line marked facing towards the throwing direction holding a 7kg shot. Both the arms were straight, feet, shoulder width apart. From this position athlete bent down keeping trunk slightly bent forward. From squat position athlete lifted up and released the shot forward. Three trials were given and best distance was taken as score.

**30m Standing Start (Sec.):**

30m distance was measured on the track and two finishing posts were pegged on both sides of finish line. The subject was required to stand in a semi crouch position at starting line. At the signal from starter the subject had to accelerate and cover the 30m distance in minimum possible time. Two trials were given to the subject and best performance was recorded as the score.

**Hammer Throw (7.25kg) One Turn in meters:**

The athlete was given three trials to throw 7.25kg hammer with one turn. Standard IAAF rules were followed. The best distance was taken as score.

**Hammer Throw (6.25kg) in meters:**

The procedure was same as for one turn throw with 7kg. But instead of one turn he was allowed to take as many turns as he wanted.
Hammer Throw (5kg) in meters:

Standard IAAF rules were followed during throw. The athlete was given three trials to throw 5kg hammer. There was no limitation on number of turns during throw.

Hammer Throw (8kg) in meters:

The procedure was same as for hammer throw with 5kg. Instead of 5kg the weight was taken as 8kg.

Hammer Throw (4kg) With One Turn for Women in meters:

Standard IAAF rules were followed during throw. The athlete was given three trials to throw 4kg hammer with one turn.

Hammer Throw (3kg) For Women in meters:

Standard IAAF rules were followed during throw. The athlete was given three trials to throw 3kg hammer.

Hammer Throw (2kg) For Women in meters:

Standard IAAF rules were followed during throw. The athlete was given three trials to throw 2kg hammer.

Hammer Throw (5kg) For Woman in meters:

Standard IAAF rules were followed during throw. The athlete was given three trials to throw 5kg hammer. There was no limitation on number of turns during throw.


3.7 TECHNIQUE OF TAKING ANTHROPOMETRIC MEASUREMENTS:

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

1. Age (Years)
2. Weight in (kg)

LINEAR MEASUREMENTS:

3. Height in (cm)
4. Sitting height (cm)
5. Acromial height (cm)
6. Dactylion height (cm)

DIAMETERS:

7. Humerus biconylar (cm)
8. Wrist diameter (cm)
9. Femur bicondylar (cm)
10. Ankle diameter (cm)
**BREADTHS:**

11. Biacromial breadth (cm)
12. Biliocristal breadth (cm)

**CIRCUMFERENCES:**

13. Upper arm Circumference (cm)
14. Forearm circumference (cm)
15. Thigh circumference (cm)
16. Calf Circumference (cm)

**SKINFOLDS:**

17. Biceps Skinfold (mm)
18. Triceps Skinfold (mm)
19. Forearm skinfold (mm)
20. Subscapular Skinfold (mm)
21. Supraspinale Skinfold (mm)
22. Suprailiac Skinfold (mm)
23. Thigh skinfold (mm)
24. Calf Skinfold (mm)
The detail of Anthropometry measurements are as follow:-

**AGE (YEARS):**

The calendar age of each thrower was taken into consideration. Decimal age was calculated from the date of birth and the date of measurement.

**BODY WEIGHT (KG):**

It is the nude weight of the body when the bowels are empty and is taken on the weighing machine. The weight of the cloths was subtracted from his recorded weight. The weight was recorded in kilograms.

**Height (cm)**

It is erect body length from the solos of the feet to the Vertics. Vertics is the most superior or the height point on the head when the head is in Frankfort plane. The Anthropometer is used to measure the height of the subject. The subject should stand erect on a horizontal surface, taking care that his heels were touching each other. Slight upward pressure was applied below the mastoid process in order to help in stretching to the fullest. The head should be held so that his Frankfort plane becomes horizontal. The road was held vertically and the horizontal arm was brought down so that it touches the highest point on the head in the mid sagittal plane and the measurement was taken in centimeters.
**Sitting Height (cm)**

The subject sat erect on the table with his feet unsupported. The right angle formed at the knee almost but not completely touched the edge of the table. The hands rested on the thigh. The head was oriented in the Frankontal plane and the distance between the highest point on the head and the sitting surface was taken, while gentle upward traction was exerted in the mastoids region.

**Acromial Height, Right (cm)**

The subject stood with arms straight and tightly placed against the body and the palms of the hands turned inwards. The highest point on the lateral border of the acromion process was determined from the standing surface.

**Dactylion Height, Right (cm)**

The subject stood with arms straight and tightly placed against the body and the palms of the hands turned inwards. The distance of the lowest point of the middle finger from the standing surface was taken. Special care was taken to keep the hand straight and to avoid it following the curve of the thigh.

**Biacromial Diameter (cm)**

The subject should stand erect and the shoulder dropping a little forward. The measurement is taken between the outside
edges of both the acromion processes, from the backside of the subject.

**Biiliocristal Diameter (cm)**

The subject should stand erect, and the investigator behind him. The bars of the Anthropometer were applied to the iliac crests so as to give the maximum width. The overlying soft tissue should be pressed hard in order to obtain the real measurement that represents the development of the bone.

**Wrist Diameter (cm)**

It is the maximum width between two lateral styloid processes of radial and ulna. Strong pressure is applied to compress the soft tissue before noting the measurement. Usually the caliper is oblique and not perpendicular to the long axis of the bone.

**Humerus Biepicondylar (cm)**

It is the maximum diameter across the outermost points on the epicondyles of the distal end of the humerus. The arm of the subject should be bent at the right angle and the width across the two points is taken with the sliding caliper. Measurements were taken on both the sides and the large value was recorded.

**Femur Biepicondyar (cm)**
It is the maximum width across the outermost points on the epicondyles of the distal end of the femur. The subject sits on the chair with the knee bent at the right angle. The caliper is applied to the epicondyles of the femur. Measurements are taken on both the sides and the large value is recorded.

**Ankle Diameter (cm)**

It is the breadth of the ankle across the two malleoli. The subject should sit on a table with legs hanging freely. The caliper arms are placed on two malleoli and pressure is exerted before taking the measurement.

**Upper arm circumference (cm)**

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 either direction where it was maximum. Measurements were taken on both the arms and the large value was recorded.

**Forearm Circumference (cm)**

It is the maximum circumference of the fore arm usually recorded proximal to the elbow joint. The arm of the subject should be hanging normally and relaxed and the measurement at the level of maximum development.
Thigh Circumference (cm)

It is the circumference of the thigh just beneath the gluteal fold with the body weight equally supported by the two legs. It is measured horizontally.

Calf Circumference (cm)

The subject was asked to stand erect, both the feet about 15 to 23 cm apart and body weight equally supported on both the legs. The tape was passed around the leg at right angle to its long axis and the maximum value was taken. Measurements are taken on both the legs and the large value was recorded.

Biceps Skinfold (mm)

The subject stood erect, arms normally hanging down by the side. The skinfold was picked up over the triceps muscle of the right arm midway between inferior border of the acromion process and the external superior border of the head of radius in line with the cubital fossa. Pickup the skinfold at the above mentioned site and measure with a skinfold cliper in millimeters.

Triceps Skinfold (mm)

The subject stood erect, arms normally hanging down by the side. The skinfold was picked up over the triceps muscle of the right arm midway between the acromion process and the superior border of radius in line with the glecranon process. The fold should be parallel to the long axis of the arm. Pickup
the skinfold at the above mentioned site and measure with a skinfold cliper in millimeters.

**Forearm Skinfold (mm)**

Forearm skinfold is measured midway between the superior border of the head of radius and its styloid process at the wrist. The skinfold is picked up on the lateral side and in line with the long axis of the forearm at the marked mid point of the radius bone.

**Subscapular Skinfold (mm)**

The subject stands erect and his shoulders are relaxed. The skinfold is picked up slightly below the most inferior angle of the right Scapula. The skinfold should be pointing downwards and outwards. Pickup the skinfold at the above mentioned site and measure with a skinfold cliper in millimeters.

**Suprailiac Skinfold (mm)**

The suprailiac skinfold is taken one centimeter above and two centimeter medial to the interior superior iliac spine. Pickup the skinfold at the above mentioned site and measure with a skinfold cliper in millimeters.

**Supraspinale Skinfold (mm)**

The subject stands erect and asked to inspire normally and hold his breath. The skinfold is picked up about 2 to 5 cm above the anterior superior iliac spine on the line to the anterior
axillary border of right side pointing forwards and downwards. Pickup the skinfold at the above mentioned site and measure with a skinfold cliper in millimeters.

**Thigh Skinfold (mm)**

The thigh skinfold is measured in the middle of the mid inguinal point and the proximal line of the patella when the knee is bent at right angle. The skinfold is picked over the quadriceps muscles, i.e. on the anterior aspect of the thigh and fold should be pointing downwards.

**Calf Skinfold (mm)**

The subject is asked to sit on a chair with his knee bent at right angle. The skinfold is picked up on the medial side of the right calf slightly above the level of the maximum girth. The fold should be parallel to the long axis of the leg. Pickup the skinfold at the above mentioned site and measure with a skinfold cliper in millimeters.

The following parameters have been observed on each athlete:-

1. Age (Years)
2. Height (cm)
3. Sitting height (cm)
4. Weight (kg)
5. Height-Weight Ratio
6. Ponder Index
7. Three skinfolds (mm)
8. Full arm length (cm)
9. Body Fat (% kg)
10. Muscle Mass (% kg)
11. Bone Mass (% kg)
12. Somatotype
   a. Endomorphy
   b. Mesomorphy
   c. Ectomorphy

**BODY COMPOSITION:**

**Calculation of Percent Body fat:** After obtaining the four skinfold thicknesses i.e. biceps, triceps, subscapular and suprailiac the body density was computed by following the technique described by Durnin and Womersley (1974). This involved the following steps:

a) Addition of four skinfolds values to get total skinfold value.

b) Calculation of body density by using Durning and Womersley (1974) formulae appropriate to the age and sex category of the subject. The formulae are given below:-

**Body Density:**

For Males
Body density for 17 – 19 yrs. =
1.1620 – 0.0630 Log (Biceps + Triceps + Subscapular + Suprailliac Skinfold)

Body density for 20 – 29 yrs. =
1.1631 – 0.0632 Log (Biceps + Triceps + Subscapular + Suprailliac Skinfold)

Body density for 30 – 39 yrs. =
1.1422 – 0.0544 Log (Biceps + Triceps + Subscapular + Suprailliac Skinfold)

For Females:

Body density for 17 – 19 yrs. =
1.1549 – 0.0678 Log (Biceps + Triceps + Subscapular + Suprailliac Skinfold)

Body density for 20 – 29 yrs. =
1.1599 – 0.0717 Log (Biceps + Triceps + Subscapular + Suprailliac Skinfold)

Body density for 30 – 39 yrs. =
1.1423 – 0.0326 Log (Biceps + Triceps + Subscapular + Suprailliac Skinfold)

Body density calculated with the help of above mentioned equations was converted to percent body fat by using the formula devised by Brozek et al. (1963).
Calculation of Body Fat (kg.) or Total Body Fat:

\[ \text{Percent Body Fat} = \left[ \frac{\text{Body Density} - 4.12}{4.570} \right] \times 100 \]

Total Body Fat + Decimal Friction of \% body fat \times body weight.

Lean Body Fat (in percent and kilograms):

a) Percent Lean Body Mass: The formulae to calculate percent lean body mass of the subject is as follows:

\[ \text{Percent Lean Body Mass} = 100 - \% \text{fat}. \]

b) Lean Body Mass in kilogram: This was calculated by subtracting the current fat mass in kg. from the current body mass or weight in kg and was represented by the following equations:

\[ \text{Lean Body Mass in kg.} = \text{Body mass in kg.} - \text{Fat mass in kg}. \]

**Somatotype:**

Heath and Carter (1967) and Carter (1975) have defined somatotypes as follows:

“A somatotype is a description of the present morphological conformation. It is expressed in a three numeral rating,
consisting of numeral represents the evaluation of three primary components of physique which describe individual variations in human morphology and composition”.

**Endomorphy:** refers to relative fatness in individual physiques; it also refers to relative leanness. That is first component ratings are evaluations of degrees of fatness which lie on a continuum from the lowest recorded values to the highest recorded values.

**Mesomorphy:** refers to relative musculo-skeletal development per unit of height. Second component ratings are evaluations of musculo-skeletal development which lie on a continuum from lowest to highest degrees recorded. The second component is thought of as “Lean Body Mass Relative to Height”.

**Ectomorphy:** refers to relative linearity of individual physiques. Third component ratings are based largely, but not entirely, on height/cube root of weight ratios. Ectomorphy ratings evaluate the form and degree of longitudinal distribution of the first and the second component.

**The Heath-Carter Anthropometric Somatotype Method**

was used for estimating the somatotype. The ten anthropometric measurements needed for obtaining the somatotype were: Height, Weight, Triceps Skinfold, Subscapular Skinfold, Supra-Spinale Skinfold, Calf Skinfold, Humerus Biepicondylar
Diameter, Femur Biepicondylar Diameter, Biceps Girth and Calf Girth.

**Endomorphy Rating:**

The measurements required for endomorphy ratings are skinfolds at triceps, subscapular (as already described above) and supraspinale.

Supraspinale (R): For taking the supraspinale (R) measurement, the fold was raised 5 to 7 cm above the anterior superior iliac spine on a line to the anterior axillary border and on a diagonal line going downward and inward at 45°.

The exact decimal rating of endomorphy was assigned from the measurements directly using the following equation of Carter (1980).

\[
Endomorphy = 0.7182 + 0.1451(x) - 0.00068(x^2) + 0.000014(x^3)
\]

\[
Height \ corrected \ Endomorphy = x \times (170.18/\text{height in cm.})
\]

Where as \(x = (Tricep + \text{Subscapular} + \text{Supraspinale skinfolds})\)

**Mesomorphy Rating:**

The measurements required for mesomorphy ratings are humerus biepicondylar, femur biepicondylar, upper arm circumference, calf circumference and calf skinfolds.
Humerus Bipicondylar in cm (R): The width between the medial and lateral epicondyles of the humerus was recorded keeping the upper arm horizontal and forming a right angle with the forearm.

The sliding caliper was applied at an angle approximately bisecting the angle of elbow and slight pressure was applied on the cross bars in order to compress the subcutaneous tissues. It was measured across the styloid processes of radius and ulna. The reading was recorded with a sliding caliper by applying pressure to compress the subcutaneous tissues.

Femur Bipicondylar (R): The subject was seated on the chair with knee bent at the right angle. The maximum distance between lateral and medial epicondyles of the femur was measured with the help of sliding caliper. The nodes of the caliper were placed on the medial and lateral points of femur at an angle of 45° approximately.

Upper Arm Circumference flexed (L & R): The measurement was taken at the greatest girth of the upper arm when subject flexed the upper arm fully.

Calf Circumference (R): It is the maximum circumference of the calf. The subject was asked to stand erect by keeping feet apart with equal weight on both the feet. The steel tape was
wrapped around the most developed gastrocnemius muscle of the right lower leg. The measurement was taken in centimeters.

Calf Skinfold (R) in mm. The skinfold was measured vertically on the medial side of the lower leg, where the maximum development of calf muscle was found out. The subject was seated on the chair with knee bent at 90°.

With the following equation of Carter (1980) exact decimal rating of mesomorphy was obtained from the measurements directly.

\[
\text{Mesomorphy} = (0.858 \, \text{Humerus width} + 0.601 \, \text{Femur width} \\
+ 0.188 \, \text{Corrected arm girth} + 0.161 \, \text{corrected calf girth}) \\
- (\text{height} \times 0.131) + 4.50
\]

Corrected Arm Girth can be obtained as:

\[
\text{Corrected arm girth} = \text{Upper arm circumference flexed in cm.}
\]

\[
\text{Corrected arm girth} = \text{Upper arm circumference in cm. flexed} \\
- (\text{Biceps} + \text{Triceps skinfolds})
\]

The values of Biceps and Triceps were in mm and they had to convert into centimeters.
Calculation of corrected Calf Girth:

\[
\text{Corrected calf girth} = \text{Calf circumference in cm.} - \left( \frac{\text{Bicep skinfold in cm.}}{2} + \frac{\text{Tricep skinfold in cm.}}{3} \right)
\]

The value of calf skinfold was in mm. and was converted to cm. by dividing it with 10.

**Ectomorphy Rating**:

The third component was directly calculated from height – weight ratio (HWR) by using the equations of Carter (1980).

\[
\text{Height} - \text{Weight Ratio (HWR)} = \frac{\text{Height in cm.}}{\sqrt{\text{Body weight in kg.}}}
\]

The equation of Carter (1980) are as follows:

\[
\text{Ectomorphy} = \text{HWR} \times 0.732 - 28.58
\]

If HWR < 40.75 but > 38.25, then

\[
\text{Ectomorphy} = \text{HWR} \times 0.463 - 17.63
\]

If HWR ≥ 38.25, then a rating of 0.1 is assigned.

Energy Intake < Energy Expenditure = Weight Loss

Energy Intake = Energy Expenditure = Weight Maintenance
3.8 STATISTICAL COMPUTATIONS

The following statistical methods have been applied for the computation of results from the raw data:

1. **Arithmetic Mean \((\bar{X})\)**: It is calculated to measure the central tendency of parameter which is the ‘typical value’ in the distribution of particular parameter. All the individual values of the variables are added and then the sum is divided by the total number of individuals:

\[
\bar{X} = \frac{\sum X}{N}
\]

Where \((\bar{X})\) = Mean value

\[\sum X = \text{Sum of all the individual values.}\]

\[N = \text{Number of individuals.}\]

2. **Standard Deviation \(\sigma\)** (**S.D)**:

Standard deviation is a measure of the variation and is universally used to show the scatter of individual measurements around the mean of all the measurements in a given distribution. By definition, it is the square root of the average of the scattered deviations of the measurements from their mean. It is calculated as follows:

\[
\text{Standard Deviation } \sigma = \sqrt{\frac{\sum x^2 - (\frac{\sum x}{N})^2}{N - 1}}
\]
Where $\sum x^2$ = Sum of the squares of the individual value.

$(\sum x)^2$ = the square of the sum of the individual values.

3. **Standard Error of Mean (S.E.M):**

The standard error of mean indicates the magnitude of sampling error. It is useful in estimating the average dispersion of arithmetic mean around the true mean and is calculated as follows:

$$S.E.\ M. = \frac{\sigma}{\sqrt{N}}$$

Where $\sigma$ = Standard Deviation

$N$ = Number of Observations.

It is ratio of the standard deviation to the square root of the number of observations.

4. **Co-efficient of Variations (C.V):**

It is commonly used in such problems where we want to compare the variability of two or more than two groups. It is designed as the ratio of standard deviation to mean, expressed as a percentage.

$$C.V. = \frac{\sigma}{\bar{X}} \times 100$$

Where $\sigma$ = Standard deviation

$\bar{X}$ = Mean of the Sample.
5. **Test of Significance (t):**

The ‘t’ test is applied to know whether the difference between the means of two samples is significant or not at any particular level of significance.

The value ‘t’ is obtained by applying the following formula:

\[
t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right) \times [(n_1 - 1)\sigma_1^2 + (n_2 - 1)\sigma_2^2]}}
\]

Where \( \sigma = \) represent the standard deviations.

\( \bar{X}_1 \) & \( \bar{X}_2 \) = means

\( n_1 \) & \( n_2 \) = the number of subjects for the respective groups.

6. **Analysis of Variance (ANOVA) One Way:**

It is used to test the significance of the differences among the sample means when the numbers of samples are more than two. The process of computing ANOVA is as follows:

i) Take the total of the values of individual items in all the samples i.e,

\[
\sum X_{ij} \quad i = 1,2,3, \ldots \ldots \]

\[
j = 1,2,3, \ldots \ldots
\]

and call it as T.

ii) Work out the correction factor as under:
iii) Find out the square of all the item values one by one and then take its total. Subtract the correction factor from this total and the result is the sum of squares for total variance. Symbolically, we can write:

\[ \text{Correction factor c. f.} = \frac{(T)^2}{n} \]

\[ \text{Total ss} = \sum x^2_{i,j} \quad i = 1,2,3, \ldots \ldots \ldots \]

\[ j = 1,2,3, \ldots \ldots \ldots \ldots \]

iv) Obtain the square of each sample total \((T_j)^2\) and divide such square value of each sample by the number of items in the concerning sample and take the total of the result thus obtained. Subtract the correction factor from this total and the result is the sum of squares for variance between the samples. Symbolically, we can write:

\[ ss \text{ between} = \sum \frac{(T_j)^2}{n_j} - \frac{(T)^2}{n} \quad j = 1,2,3, \ldots \ldots \ldots \]

Where subscript \(j\) represents different samples or categories.
v) The sum of squares within the sample can be found out by subtracting the result of (iv) step from the results of (iii) step stated above and can be written as under:

\[
ss\ within = \left\{ \sum x_{ij}^2 - \frac{(T)^2}{n} \right\} - \left\{ \sum \frac{T_j^2}{n_j} - \frac{(T)^2}{n} \right\}
\]

\[
= \sum x_{ij}^2 - \sum \frac{(T_j)^2}{n_j}
\]

### ANOVA

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares S.S.</th>
<th>Mean Sum of Squares M.S.S.</th>
<th>F.Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Sample</td>
<td>C-1</td>
<td>SSB</td>
<td>*MSSB=SSB/C-1</td>
<td>-</td>
</tr>
<tr>
<td>Within the samples</td>
<td>N-C</td>
<td>SSW</td>
<td>MSSW=SWW/N-C</td>
<td>MSSB/MSSW</td>
</tr>
<tr>
<td>Total</td>
<td>N-1</td>
<td>TSS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Here:

SSB : Sum of square between samples

SSW : Sum of square within samples

MSSB : Mean sum of square between samples

MSSW : Mean sum of square within samples

To calculate the test of significance as:

\[F=\frac{MSSB}{MSSW}\]  this F is with d.f. as (C-1, N-C)

The level of significance is taken as 0.05 and 0.01.
7. **Post-hoc Test**: 

Wherever ANOVA shows the significant difference among the sample means, Post-hoc Test (Multiple range was applied to see the differences in difference pairs.

The Post-hoc t-test for this was –

\[
Post \text{ hoc } t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{MSSW}{n_1} + \frac{1}{n_2}}}
\]