Chapter 3
Materials and Methods
MATERIALS AND METHODS

3.1. Research Design

Research design plays a very significant role in making any research successful and reliable as it decides the fate of proposal and its outcome. The design of the study depends upon purpose of the research, the findings of the data collection and the other needs of the research. The present study was cross sectional in nature.

3.1.1. Sample Selection

Sample

A total of 522 collegiate athletes from both sexes, aged 18-25 years were selected purposively from various colleges of Delhi, namely Kamla Nehru College, Ramjas College, Gargi College, Daulatram College, Jamia Hamdard, Miranda House, SGTB Khalsa college, Jamia Milia Islamia, Amity, BCIP, SRCC College, Kirorimal College. The power of the study was 90%, \( \alpha = 0.05 \). Athletes from a total of six events were considered as sample, viz. sprinters (n=180), hurdlers (n= 113), middle distance runners (n= 113), long distance runners (n= 47), long jumpers (n= 40) and javelin throwers (n= 29). An equal number of controls (n= 501, 364 males and 137 females) were also taken from the same place for comparison.

Sample Size Determination

The appropriate sample size for a population based study is determined generally by three factors:

1. Estimated prevalence of variable of interest- strength measurements in this study.
2. The desired level of confidence and precision.
3. The acceptable margin of error.

Sample size was calculated by the following formula:

\[
 n = \frac{z^2 \cdot p \cdot (1-p)}{m^2}
\]
where \( n \) = required sample size
\[ t = \text{confidence interval at 95\% (standard value of 1.96)} \]
\[ p = \text{estimated prevalence of strength measurements in this study} \]
\[ m = \text{margin of error} \]

**Inclusion Criteria**

Followings were the inclusion criteria of the subjects:

1. Individuals aged 18–25 years were selected.
2. Both males and females were selected.
3. Athletes from various colleges of Delhi were considered.

**Exclusion Criteria**

Following were the exclusion criteria of the subjects:

1. Recent injury.
2. Systemic or mechanical pain.
3. Involvement in any other study.

**Place of Study**

The subjects were collected from various colleges of Delhi and the tests were conducted at The Sports Injury Center of Safdarjung Hospital of Delhi between 2010-2013.

**Table 3.1**

**Distribution of the subjects**

<table>
<thead>
<tr>
<th>Events</th>
<th>n</th>
<th>Males Absolute No.</th>
<th>Males percent</th>
<th>Females Absolute No.</th>
<th>Females percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprinters</td>
<td>180</td>
<td>127</td>
<td>70.55</td>
<td>53</td>
<td>29.44</td>
</tr>
<tr>
<td>Hurdles</td>
<td>113</td>
<td>91</td>
<td>80.53</td>
<td>22</td>
<td>19.46</td>
</tr>
<tr>
<td>Middle distance runners</td>
<td>113</td>
<td>82</td>
<td>72.56</td>
<td>31</td>
<td>27.43</td>
</tr>
<tr>
<td>Long distance runners</td>
<td>47</td>
<td>37</td>
<td>78.72</td>
<td>10</td>
<td>21.27</td>
</tr>
<tr>
<td>Long jumpers</td>
<td>40</td>
<td>26</td>
<td>65.00</td>
<td>14</td>
<td>35.00</td>
</tr>
<tr>
<td>Javelin throwers</td>
<td>29</td>
<td>15</td>
<td>51.72</td>
<td>14</td>
<td>48.27</td>
</tr>
<tr>
<td>Total</td>
<td>522</td>
<td>378</td>
<td>72.41</td>
<td>144</td>
<td>27.58</td>
</tr>
</tbody>
</table>
3.2. Methods

For any scientific investigation to be valid and reliable, correct methodology should be adopted that accounts for the success or failure of research work. Methodology is an essential part of every project, therefore, it must be carefully planned to get authentic results and conclusions.

3.2.1 Tools for Data Collection

1. Isokinetic dynamometer (Humac Norm< USA)
2. Harpenden skinfold caliper
3. Sliding caliper
4. Anthropometer (Biocraft # 3AN-1)
5. Measuring tape
6. Weighing machine
7. Sit and reach box
8. Audio-clip and cones
9. Data collecting Performa

3.2.2 Parameters Measured

1. Trunk strength
2. Shoulder strength
3. Elbow strength
4. Wrist strength
5. Hip strength
6. Knee strength
7. Ankle strength
8. Height
9. Body weight
10. Body Mass Index  
11. Percent body fat  
12. Percent lean body mass  
13. Humerus biepiconylar diameter  
14. Femur biepiconylar diameter  
15. Upper arm circumference  
16. Chest circumference  
17. Hip circumference  
18. Wrist circumference  
19. Ankle circumference  
20. Shoulder width  
21. Biceps skinfold  
22. Triceps skinfold  
23. Subscapular skinfold  
24. Suprailiac skinfold  
25. Calf Skinfold  
26. Sit and reach test  
27. Multistage test

3.2.3. Procedure of Data Collection

Age of the subjects was estimated from their respective colleges’ registers. The study was approved by the Institutional ethical committee. The subjects were informed about the purpose of the trial and had to give their signed informed consent before being enrolled.

a. Strength measurements

All the strength measurements were taken on each subject by following standard technique recommended manufacturer in the manual. All the measurements were taken on both sides of the subjects except trunk strength. The following dynamometric
strength measurements were taken by the Isokinetic Strength Dynamometer (CSMI Humac Norm Pvt. Ltd, Model 770):

**Warm up procedure**: All subjects warmed up for 10 minutes on an unloaded ergometric bicycle (for upper extremity), stationary bicycle (for lower extremity) and 5-8 minute warm up of stretching exercises of upper, lower extremities and trunk. After warming up, the subjects were positioned on dynamometer for each part. Three sub-maximal repetitions were performed for adaptation to the speed and familiarization of movement pattern. After instruction and familiarization with trials subjects performed 3 maximal concentric flexion – extension for peripheral joints and trunk during which the participants received standardized verbal encouragement to achieve maximum strength in each contraction with rest of 10 sec. in each repetition. The parameter evaluated was peak torque (PT).

![Isokinetic dynamometer](image)

**Fig. 3.1: Isokinetic dynamometer**

1. **Trunk strength**: To test the trunk flexion and extension, the TEF modular component was attached to the dynamometer unit. The subject was asked to stand on the foot plate of TEF modular component. The axis of dynamometer was aligned with subjects L5-S1 mid – axillary line (vertical alignment) and horizontal
alignment 3.5cm below tip of iliac crest at L5-S1 level. The chest strap and pelvic strap was secured. The subjects lower limb were stabilized by thigh and leg stabilizer pad. Each subject was tested in an upright position. The range of motion was extending from 70 degree of flexion to 10 degrees of extension. Trunk flexion and extension strength was assessed at a constant velocity of 45 deg/sec through 60 degree total range of motion and peak torque values were recorded in Newton meters.

2. **Shoulder strength:** To test shoulder strength, the shoulder adapter was attached into long end of input arm and secured. Handgrip flexion / extension component was secured. The subject was asked to lie in supine position and the shoulder axis of rotation was aligned with dynamometer axis. The instantaneous axis of rotation changes throughout the movement. The compromise axis was medial to the acromian process when the limb was in neutral position. The chest strap and the pelvic strap was restrained to stabilize and the subject was asked to hold handgrip bar. A programme in humac norm was chosen to carry out shoulder flexion and extension. The range of motion was extending from 90 degree of flexion to 10 degrees of extension. Shoulder flexion and extension strength was assessed at a constant velocity of 60 deg/sec through 80 degree total range of motion and peak torque (Nm) values were recorded.

Fig. 3.2: Shoulder strength measurement
3. **Elbow strength:** Following the warm-up, subjects were placed in a supine position and stabilized using midthoracic and pelvic stabilization straps. The glenohumeral joint was abducted 45° and the upper arm placed on a stabilization pad. The dynamometer input axis was aligned with the lateral epicondyle of the humerus with the subject grasping the input adapter handle with the forearm in neutral rotation. Range of motion for testing occurred between 10° and 90° of elbow flexion. A programme in humac norm was chosen to carry out elbow flexion and extension. Elbow flexion and extension strength was assessed at a constant velocity of 60 deg/sec through 80 degree total range of motion and peak torque value was recorded in Newton meters.

![Fig. 3.3: Elbow strength measurement](image)

4. **Wrist strength:** To test the movement pattern of wrist flexion and extension, the dynamometer input axis was aligned with the diagonal axis of the distal radius and ulna (approximately where the hand meets the wrist). Subjects were in a seated position and placed their forearm in a supinated (palm up) position in the forearm ‘‘V’’ pad for stabilisation throughout testing. A strap was used to stabilise the forearm and secure the seat belt. Range of motion stops were applied to ensure that all subjects used identical ranges of motion bilaterally. A programme in humac norm was chosen to carry out wrist flexion and extension. The range of motion used in this testing protocol consisted of 0–40° of wrist flexion and 0–30° of wrist extension and peak torque value was recorded in Newton meters.
5. **Hip strength:** To test the hip flexion and extension after the warm up procedure subjects were placed in supine lying position. The hip/knee adapter was inserted into long end of dynamometer input arm and secured with hip / knee pad and foot rest. The axis of dynamometer was aligned with the greater trochanter of femur. Range of motion for testing occurred between 10° and 80° of hip flexion. A programme in humac norm was chosen to carry out hip flexion and extension and was assessed at a constant velocity of 60 deg/sec through 70 degree total range of motion. Strength scores were reported as the peak torque (Newton meters) throughout the range of motion.

6. **Knee strength:** To test the knee flexion and extension after the warm up procedure subjects were placed in sitting position on dynamometer chair with back rest angle at 85 degree, the knee/hip adapter was inserted into the long end of dynamometer input arm. The axis of dynamometer was aligned with the line passing transversely with the femoral condyles. Subjects were stabilized by pelvis strap, thigh strap and trunk strap in order to avoid any compensatory movement. Tibial pad was attached approximately 3cm above the ankle. The magnitude of the movement was limited between between 0° and 90° of knee flexion. A programme in humac norm was chosen to carry out knee flexion and extension and was assessed at a constant velocity of 60 deg/sec through 90° total range of motion. Strength scores were reported as the peak torque (Newton meters) throughout the range of motion.

![Fig. 3.4: Knee strength measurement](image)
7. **Ankle strength:** To test the ankle flexion and extension after the warm up procedure subjects were placed in supine position on dynamometer with chair back angle 0°, the thigh stabilizer pad was inserted into thigh/forearm stabilizer tube, then stabilizer tube was inserted into chair receiving tube, secured at a proper position for the height of subjects ankle. The footplate was inserted into ankle adapter tube labeled PF/DF and this was attached with the short end of input arm. The footrest was inserted into chair receiving tube, the subject foot was stabilized on footplate and the thigh tube height was adjusted so subject knee at 90 degree of flexion. The axis of dynamometer was aligned with the axis of ankle which passes obliquely through tip of medial malleolus (trochlea of talus exiting just distal to tip of tibia) and lateral malleolus. Subjects were stabilized by pelvis strap and thigh strap in order to avoid any compensatory movement. The magnitude of the movement was limited between 15° ankle extension and 35° of ankle flexion. A programme in humac norm was chosen to carry out ankle extension-flexion and was assessed at a constant velocity of 60 deg/sec through 50° total range of motion. Strength scores were reported as the peak torque (Newton meters) throughout the range of motion.

Gravity correction was not recommended by the manufacturer and therefore was not used.

b. **Anthropometric measurements**

The following anthropometric measurements were taken:

1. **Height**

   Instrument used: Anthropometer.

   It measured the vertical distance from the vertex to floor. Vertex is the highest point on the head. The subject was asked to stand erect and the head was in Frankfort horizontal plane. The unit of height was measured in cm.

   **Procedure**

   The subject was asked to stand erect on a horizontal surface stretching the body as much as possible. The heels of the subject were touching each other and head was on
Frankfort horizontal plane. The anthropometer was placed on mid sagittal plane of the subject. The moving cross bar of the anthropometer was allowed to touch the vertex of the subject lightly and results were recorded from the reading scale of the vertically placed anthropometer in centimeters.

2. **Body weight**

   Instrument used: Weighing machine.

   It measured the total body weight of the subject with minimum clothes, when the bowel was empty.

   **Procedure**

   The subject was asked to stand erect on the weighing machine with bare feet and the reading was taken from the reading scale on the machine in kg.

3. **Body mass index**

   **Procedure**

   Body mass index was calculated by dividing weight in kilograms by square of height of the subject in metres. Hence it is represented by:

   \[
   \text{BMI} = \frac{\text{Body mass (kg)}}{(\text{Height (m)})^2}
   \]

4. **Percent body fat** (Siri, 1956)

   Procedure manually: Percent body fat = \{\(\frac{4.95}{\text{Body density}}-4.5\)\} * 100

   Body density (Durnin and Womersley, 1974)

   \[
   \text{Body density for men} = 1.1610 - 0.0632 \log \sum_4 \\
   \text{Body density for women} = 1.1581 - 0.0720 \log \sum_4 \\
   \text{Body density for boys} = 1.1533 - 0.0643 \log \sum_4 \\
   \text{Body density for girls} = 1.1369 - 0.0598 \log \sum_4
   \]

5. **Percent lean body mass**

   Procedure: percent lean body mass = 100 - percent body fat
6. **Humerus biepicondylar diameter**  
   Instrument used: Sliding caliper.  
   It measured the straight distance between the two outermost points on the condyles of lower end of humerus.  
   **Procedure**  
   The subject was asked to sit on a horizontal surface in erect posture with the arms bending at right angle. The two blunt arms of sliding caliper were allowed to touch across the outermost points on the condyles of the distal end of humerus. Results were recorded from the reading scale of the sliding caliper in cm.

7. **Femur biepicondylar diameter**  
   Instrument used: Sliding caliper.  
   It measured the straight distance between the two outermost points of the condyles on lower end of femur.  
   **Procedure**  
   The subject was asked to sit on a horizontal surface preferably on a flat stool, with knees bent at right angle. The two blunt arms of sliding caliper were allowed to touch across the outermost points on the condyles of the distal end of femur. Results were recorded from the reading scale of the sliding caliper in cm.

8. **Upper arm circumference**  
   Instrument used: Steel tape.  
   It measured the maximum circumference of the upper arm.  
   **Procedure**  
   The subject was asked to stand erect hanging the arm freely by the side. The measurement was taken at right angle to the axis of hanging arm where the biceps muscle was most developed. Results were recorded in cm.

9. **Chest circumference**  
   Instrument used: Steel tape.  
   It measured the circumference of chest of the subject when the subject is breathing normally:
**Materials and Methods**

**Procedure**

The subject was asked to stand erect on a horizontal plane keeping his/her feet close to each other with normal breathing normally. The arms of the subject were hanging freely by the side. The steel tape as applied at the level of nipples passing over the lower scapular angle. The results were recorded in cms.

10. **Hip circumference**

   Instrument used: Steel tape.

   It measured the maximum circumference of the hip.

**Procedure**

The subject was asked to stand erect on a horizontal plane keeping his/her feet close to each other. The steel tape was applied around the hip of the subject. Results were recorded in cm.

11. **Wrist circumference**

   Instrument used: steel tape

   It measured the least circumference of the forearm almost proximal to the styloid process.

**Procedure**

The subject is asked to stand erect on horizontal plane with arms hanging freely by the side. The steel tape is applied over the proximal to the styloid process around the wrist. Results were recorded in centimeter.

12. **Ankle circumference**

   Instrument used: steel tape

   It measured the circumference of the position proximal to the ankle bone.

**Procedure**

The subject is asked to sit on a horizontal plane, bending the knee at right angle and hanging the lower leg freely. The steel tape is applied around the ankle of the
subject above the malleolus i.e. least circumference of the lower leg. Results were recorded in centimeter from the scale of the steel tape.

13. **Shoulder width**

Instrument used: First segment of anthropometer rod or rod compass.

It measured the straight distance between the two acromial.

**Procedure**

The subject is asked to stand erect so that two acromia lie in the horizontal plane. The subject should keep his/her shoulders straight. The landmarks i.e. two acromia are located by the palpating with the finger while the other fingers hold the cross-bars are touched gently over the two acromian. Results were recorded from the reading scale of the anthropometer rod or rod compass in centimeter.

14. **Biceps skinfold**

Instrument used: Harpenden skinfold caliper.

It measured the skinfold thickness on the mid upper arm over the biceps muscle.

**Procedure**

The subject was asked to stand erect hanging the arms freely by the side. On the right arm, skin and subcutaneous tissue fold over the biceps muscle was picked up and the jaws of the caliper applied on the fold. Results were recorded from the circular reading scale of the skinfold caliper in millimeter.

15. **Triceps skinfold**

Instrument used: Harpenden skinfold caliper.

It measured the skinfold thickness on the mid upper arm over the triceps muscle.

**Procedure**

The subject was asked to stand erect hanging the arms freely by the side. On the right arm, skin and subcutaneous fold over the triceps muscle was picked up and the
jaws of the caliper applied on the fold. Results were recorded from the circular reading scale of the skinfold caliper in millimeter.

16. **Subscapular skinfold**

   Instrument used: Harpenden skinfold caliper.

   It measured the skinfold thickness below the inferior angle of scapula.

   **Procedure**

   The subject was asked to stand erect hanging the arms freely by the side. The subscapular skinfold was picked below the inferior angle of scapula and the jaws of the caliper applied on the fold. Results were recorded from the circular reading scale of the skinfold caliper in millimeter.

17. **Suprailiac skinfold**

   Instrument used: Harpenden skinfold caliper.

   It measured the skinfold thickness about 1 cm above and 2 cm medial to anterior superior iliac spine.

   **Procedure**

   The subject was asked to stand erect. The suprailiac skinfold on the anterior superior iliac spine was picked up and the jaws of the caliper applied on the fold. Results were recorded from the circular reading scale of the skinfold caliper in millimeter.

18. **Calf skinfold**

   Instrument used: Harpenden skinfold caliper.

   It measured the skinfold thickness on the medial side of the calf muscle where it was developed its maximum.

   **Procedure**

   The subject was asked to sit on a horizontal surface bending knees at right angle with the lower legs hanging freely. Skinfold on the medial calf muscle was picked up
and the jaws of the skinfold caliper were applied to the site. Results were recorded from the circular reading scale of the skinfold caliper in millimeter.

19. **Sit and reach test**

Sit and reach test was used to measure flexibility of lower back and hamstring muscle. The subject was made to sit with their feet approximately hip wide against the testing box with their knees extended and placed the right hand over the left, then asked the subject to slowly reached forward as far as they could by sliding their hands along the measuring board. The score was recorded to the nearest centimeter or half inch as the distance reached by the hand.

20. **Multi stage test**

It was used in aerobic fitness test. This test involves continuous running between two lines 20 m apart in time to record beeps. The test subject stands behind one of the line facing the second line and begins running when instructed. The subject continues running between two lines, turning when signals by the recorded beeps after about one minute a sound indicates an increase in speed and the beeps will be closer together. This continues each minute. If the line was not reached in time for each beep, the subject must run to the line turn and try to catch up the pace within two more beeps. The test was stopped if the subject fails to reach the line for two consecutive ends. The athlete’s score was the level and number of shuttles reached before they are unable to keel up with the recording.

3.3. **Statistical Analysis**

Data was analyzed using SPSS (Statistical Package for Social Science) version 17.0. Student’s t test was applied for the comparison of all the variables between different sets of populations, and ANOVA was also applied. Pearson correlation coefficients were carried out with the strength measurements, anthropometric variables and physical performance tests in the collegiate athletes of Delhi. A 5% level of probability was used to indicate statistical significance.
1. **Arithmetic Mean ( \( \bar{X} \))**

   Arithmetic mean gives the average of the whole range of the data given by adding together all the items and by dividing this total by number of items, and is given by the following formula:

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

   Where

   - \( X \) = arithmetic mean
   - \( \sum X \) = sum of all variables
   - \( N \) = total number of all variables

2. **Standard Error (S.E.)**

   It enables the measurements of magnitude of the sampling error. It is calculated by the following formula:

   \[
   S.E. = \frac{\sqrt{SD}}{N}
   \]

   Where

   - S.D. = Standard deviation
   - N = Total number of variables

3. **Standard Deviation (SD)**

   It gives the degree of deviation or dispersion of the recorded data from the mean. It is given by the formula:

   \[
   S.D. = \sqrt{\frac{\sum(X - \bar{X})^2}{N}}
   \]
Materials and Methods

Where

S.D. = Standard deviation

X = Individual variables

\( \overline{X} \) = Mean of variables

4. Students t-test

It gives the difference between the two independent random samples of size \( N_1 \) and \( N_2 \) with mean \( X_1 \) and \( X_2 \) and S.E. of \( X_1 \) and S.E. of \( X_2 \). It is calculated by the following formula:

\[
t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{(S.E.)^2 + (S.E.2)^2}}.
\]

Where

\( t \) = t test

\( \overline{X}_1 \) = Mean of 1st variable

\( \overline{X}_2 \) = Mean of variable

S.E.1 = Standard error of 1st variable

S.E.2 = Standard error of 2nd variable

5. One-way ANOVA TEST

One–way ANOVA for different subject design is used to compare results from 3 or more conditions, with different, unmatched subject groups in each condition. It only tells, if there are general non-specified differences in the results from the 3 conditions.

The following table is formed:

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Squares</th>
<th>‘f’ ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Conditions</td>
<td>SSbet</td>
<td>dfbet</td>
<td>MSbet</td>
<td>Fbet</td>
</tr>
<tr>
<td>Random error</td>
<td>SSerror</td>
<td>dferror</td>
<td>MSerror</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>SSTot</td>
<td>dfTot</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

66
6. Correlation

To understand the dimension of relationship of handgrip strength as dependent variable with set of anthropometric variables, Karl Pearson’s product moment correlation coefficients were calculated. The correlation coefficient is denoted by ‘r’ and is expressed as follows:

$$r = \frac{N \sum A \times B - \sum A \times \sum B}{\sqrt{(N \sum A^2 - (\sum A)^2)(N \sum B^2 - (\sum B)^2)}}$$

- $\sum A$ = Sum of variables A
- $\sum B$ = Sum of variables B
- DF = N-2

The p value for the corresponding r value was seen in the table using the degree of freedom. Level of significance was $p < 0.05$.

Interpretation of r

A value close to +1 indicates a perfect or near perfect positive relationship between two quantitative variables and a value closer to -1 indicates perfect negative relationship between them. A value close to zero indicates that the two quantitative variables are not linearly related.