Chapter - III

PROCEDURE

In this chapter selection of subjects, selection of variables, criterion measure, reliability of data, collection of data, analysis of $F_{ILM}$ and the analysis of the data are being presented.

Selection of Subjects

For the purpose of this study 100 javelin throwers of different universities, who participated in All India Inter University Athletic Championship were selected as subjects. The subjects were fifty male and fifty female Javelin throwers who have attained the performance level of 45 meters and 30 meters respectively.

Selection of Variables

From the scholar's own understanding of the problem, on the basis of discussion with experts and as gleaned through the literature, the following physical and kinematical (Linear and Angular) variables were selected:
Physical Variables

1. Age
2. Height
3. Weight

Linear Kinematical Variables

1. Length of third stride
2. Length of impulse stride
3. Length of final stance
4. Length of Reverse stride
5. Height of Center of Gravity of the body in final stance
6. Height of Center of Gravity of the body at moment release
7. Height of Release

Angular Kinematical Variables

1. Angular kinematical variables were the angles at various joints of the body of throwers at moment final stance and at release.
   i. Ankle joint
      a. Angle of Right ankle joint
      b. Angle of Left ankle joint
ii. Knee joint
   a. Angle of Right knee joint
   c. Angle of Left knee joint
iii. Angle of Right Hip Joint
iv. Trunk Inclination
v. Angle of Right Elbow Joint (Throwing arm)

2. Angular kinematical variables at moment release
   i. Ankle joint
      a. Angle of Right ankle joint
      b. Angle of Left ankle joint
   ii. Knee joint
      a. Angle of Right Knee joint
      b. Angle of Left Knee joint
   iii. Angle of Right Hip Joint
   iv. Trunk Inclination
   v. Angle of Right Elbow Joint (Throwing arm)

**Criterion Measure**

The performance of the subjects in the Javelin throw, recorded in meters was the criterion measure of the study.
Reliability of Data

The reliability of the data was ensured by establishing the instrument reliability and tester's reliability.

Instrument Reliability

The instruments used for the study were calibrated and tested prior to the collection of data. Thus, they were considered reliable enough for the purpose of this study.

Tester's Reliability

The tester's reliability was established with the help of test re-test method, the performances of thirty subjects, selected at random on the selected variables were recorded twice under identical conditions by the research scholar. Pearson's product moment correlations were computed between the two measures of physical variables, the reliability coefficients have shown quite high values, which established the tester's reliability. The values of coefficients are given in table -1.
### TABLE-1

**RELIABILITY COEFFICIENT OF TEST, RETEST SCORES**  
**\(N=50\)**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Test (Unit)</th>
<th>Coefficient of Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Weight (Kg.)</td>
<td>.993</td>
</tr>
<tr>
<td>2.</td>
<td>Height (cm.)</td>
<td>.998</td>
</tr>
</tbody>
</table>

Since, in order to obtain the values of selected kinematical variables, the data were obtained from the analyzing of film using standard procedure. Hence, the measurements were considered reliable enough.

**Collection of Data**

The data pertaining to selected physical and kinematical variables were obtained by administering the following procedures.

**Physical Variables**

Selected physical variables were age, standing height and body weight.

**Age:**

The age of the subjects were recorded in completed years on the day of competition.
Standing Height:

Subjects were made to stand erect without shoes against the marked scale on the wall. The heels, buttocks and back were touching the wall. The subjects were instructed to keep heels together, head without tilt and to take and hold full breath while measurement was taken. A stiff hard board was held horizontally on the head touching the scale marked on the wall. The subject was asked to step out and the reading indicated by the hard board was recorded to the nearest half of a centimeter.\(^1\)

Body Weight:

The weight of the subject was taken by a weighing machine. The subject wearing minimum of clothing, stood on the weighing machine and weight was recorded to the nearest half of a kilogram.

Kinematical Variables

In order to obtain selected kinematical variables subjects were filmed by using photographic techniques. A video VHS National Panasonic camera was used for the purpose. The moment were filmed in sagittal plane only. The camera was placed on a tripod at a distance of 13.50 mts.

and the height of lens was 1.43 mts. from the ground. The subjects competed in competition without being disturbed. The selected linear kinematic variables i.e. the length of third stride, impulse stride, final stance, reverse, height of release of the Javelin, and center of gravity of thrower body in final stance and moment release were recorded on the film. Prior to the film, the object of known height and length was film in order to get a reference for horizontal and vertical measurement. A filming zone of 10 mts. was marked on the ground camera was started before the thrower entered the filming zone and stopped after the completion of the throw (release).

**Analysis of Film**

In order to obtain the angles of various joints and other selected variables, the film was analyzed. A square centimeter graph on a glass sheet was fixed infront of the television screen. The stick figures were prepared from the screen by joining the different land marks\(^2\) on the body of the subjects at "Final stance " and at "Moment Release" The angles of various joints were recorded by using a protractor and center of gravity of the body at moment final stance and release were calculated with the help of segmentation method.\(^3\)

\(^3\)Ibid., p. 138
Figure 1: Technique of Javelin Throw
Other kinematical variable i.e. length of third stride, length of impulsive stride, length of final stance, length of reverse stride and height of release were recorded with the help of scale which were then converted into actual distance by the multiplier.

**Linear Kinematical Variables**

**Length of Stride:**

Length of Third Stride, Impulse Stride, Final Stance, and Reverse Stride were measured from front edge of the rear foot to the front edge of front foot (toe to toe distance).

**Height of Release:**

Height of release was recorded as vertical distance from the ground to center of gravity of Javelin (cord) at moment release.

**Angular Kinematical Variables**

**Angle of Ankle Joint:**

To measure the angle of ankle joint different land marks i.e. tibiale, sphysion and acropodion were marked on the graph sheet. All the points
were joined together with the help of a scale and angle of ankle joint was measured in degree.

**Angle of Knee Joint:**

To measure the angle of knee joint three different points, points of greater trochanter, points of tibiale and points of sphysion were marked at the maximum knee flexion which were then joined with the help of a scale and measured in degree.

**Angle of Hip Joint:**

To measure the angle of hip joint three different landmark acromiale, point of greater trochanter and point of tibiale were marked on the graph sheet. All the three points were joined with the help of scale and measured in degree.

**Trunk Inclination:**

The angle of trunk inclination in the final and release position of the subjects of Javelin throws were obtained by calculating the center of gravity separately for both the positions. A horizontal line parallel to the running surface were drawn, passing through the center of gravity and a

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5 Ibid, p. 103-113
medial line passing through the vertebral column were drawn and angle were recorded in degrees with the help of protector\textsuperscript{7}.

**Angle of Elbow Joint:**

To measure the angle of elbow joint three different landmarks i. e. acromiale, radiale and stylion were marked on the graph sheet which were then joined with the help of scale and measured in degrees\textsuperscript{8}.

**Center of Gravity**

The center of gravity was calculated with the help of segmentation method. The steps taken were as follows:

1) The reference points (table 2) associated with each segment were marked on the photograph.

2) A stick – figure were constructed as representation of the subject by ruling straight lines between appropriate reference points. (The trunk line was obtained by joining the midpoint of the line between the right and left hip joint to the midpoints of the trunk at the level of the suprasternal notch.

\textsuperscript{7} Hay, "The Biomechanics of Sports Technique", 412.
\textsuperscript{8} Ibid, p. 103-113.
3) Length of each segment line was measured, and divided these various length in the appropriate ratio as indicated in table 2. Mark the points of division (that is, the centers of gravity of the segment) on their respective line.

4) Two arbitrary axes (O Y and O X), one to the left and one below the stick-figure were ruled.

5) A form was prepared such as, shown in table 3 and in column 1. The weight of the segments were entered.

6) For each segment, the perpendicular distance were measured from the center of gravity to the line O Y and entered this distance in the appropriate place on the form (table 3, column 2)

7) In order to find the moments about O Y, the weight of each segment were multiplied by the distance of its center of gravity from the line, and these were entered on the form (table 3, column 3)

8) The sum of the moments about O Y by adding the contents of column 3 on the form. Was calculated (this was equal to X).

9) A line O Y was ruled parallel to O Y and a distance of X. The center of gravity of the subject lies on this line.

10) Steps 5 to 9 were repeated, taking moments about O X instead of O Y. The center of gravity of the subject lies on the line O' X'. And in these two lines one point was common (the point where they intersect), it was the center of gravity of the subject.
TABLE-2
LOCATION OF CENTERS OF GRAVITY OF BODY SEGMENTS

<table>
<thead>
<tr>
<th>SEGMENT</th>
<th>CENTER OF GRAVITY LOCATION EXPRESSED AS, PERCENTAGE OF TOTAL DISTANCE BETWEEN REFERENCE POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>46.4 % to Vertex; 53.6% to Chin –Neck Intersect</td>
</tr>
<tr>
<td>Trunk</td>
<td>43.8 % to Suprasternal Notch; 56.2 % to hip axis</td>
</tr>
<tr>
<td>Upper Arm</td>
<td>49.1 % to shoulder axis; 50.9 % to elbow axis</td>
</tr>
<tr>
<td>Fore Arm</td>
<td>41.8 % to elbow axis; 58.2 % to wrist axis</td>
</tr>
<tr>
<td>Hand</td>
<td>82.0 % to wrist axis; 18.0 % to knuckle III</td>
</tr>
<tr>
<td>Thigh</td>
<td>40.0 % to hip axis; 60.0 % to Knee axis</td>
</tr>
<tr>
<td>Calf</td>
<td>41.8 % to knee axis; 58.2 % to ankle axis</td>
</tr>
<tr>
<td>Foot</td>
<td>44.9% to heel; 55.1% to tip of longest toe</td>
</tr>
</tbody>
</table>
**TABLE - 3**

FORM FOR COMPUTATION OF CENTER OF GRAVITY COORDINATES

<table>
<thead>
<tr>
<th>Segment</th>
<th>Column 1 Segment Weight</th>
<th>Column 2 Distance to oy (cm.)</th>
<th>Column 3 Moments about oy</th>
<th>Column 4 Distance to ox (cm.)</th>
<th>Column 5 Moments about ox</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEAD</td>
<td>0.073</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRUNK</td>
<td>0.507</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT UPPER ARM</td>
<td>0.026</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT FORE ARM</td>
<td>0.016</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT HAND</td>
<td>0.007</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEFT UPPER ARM</td>
<td>0.026</td>
<td></td>
<td></td>
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<td>0.016</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEFT HAND</td>
<td>0.007</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT THIGH</td>
<td>0.103</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT CALF</td>
<td>0.043</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RIGHT FOOT</td>
<td>0.015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEFT THIGH</td>
<td>0.103</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total** 1.000
Analysis of Data

The data obtained for selected physical and kinematic variables were analyzed by using the following statistical techniques:

1) Mean
2) Standard Deviation
3) Coefficient of correlation

For testing the hypothesis, the level of significance was 0.05.