Chapter III

PROCEDURE

In this chapter the procedure adopted for the selection of subjects, selection of variables, reliability of data, experimental protocol, cinematographic data, analytical procedure, justification of two dimensional method used criterion, measures, collection of data and the statistical techniques for analysing the data are described.

Subjects

In this study twenty eight national level Judo players who were well skilled and trained at the N.S.N.I.S., Patiala, were selected as subjects for the study. Most of them were black belt and remaining were brown belt holders. Rest of them were regular participants and medal winners in National level Judo Championships. The age of the subjects ranged between 18 to 30 years. The subjects were well trained with both the techniques i.e., One arm shoulder throw (ISN) and Both arm shoulder throw (MSN). (Fig. 1 and 2)

Selection of Variables

The research scholar gone through the available literature in detail pertaining to the sport of judo. Keeping the feasibility criteria in mind, especially, the availability of
Fig. 1 - SHOTEI (ONE HAND) (One of the 18 Formal Sets)

1) Sharp impact to neck (preparatory phase)
2) Switch from a) locomotorization phase
Fig. 7 - MASTER SEKI HAGE (Both Arm Shoulder Throw)

1) Sketch Second to Third—preparatory phase.
2) Sketch Fourth to Seventh—execution phase.
instruments, the following biomechanical, anthropometric, flexibility and motor performance variables were chosen.

Biomechanical (Kinematic and Kinetic) Variables

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<th>S.NO.</th>
<th>Variables</th>
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<td>1.</td>
<td>Angle of inclination from horizontal (H) of the line joining right</td>
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<td>shoulder (rt.sh) and centre of foot (CF) when knee flexed (KF),</td>
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<td>2.</td>
<td>Angle of inclination from H of the line joining left shoulder (lt.sh)</td>
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<td>and CF when KF.</td>
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<td>3.</td>
<td>Angle of inclination from H of the line joining right hip (rt.hip)</td>
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<td>and CF when KF.</td>
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<td>4.</td>
<td>Angle of inclination from H of the line joining left hip (lt.hip)</td>
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<td>and CF when KF.</td>
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<td>5.</td>
<td>Angle of inclination from H of the line joining right knee (rt.knee)</td>
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<td>and CF when KF.</td>
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<td>6.</td>
<td>Angle of inclination from H of the line joining left knee (lt.knee)</td>
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<td>and CF when KF.</td>
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<td>7.</td>
<td>Angle of inclination from H of the line joining right ankle (rt.ank)</td>
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<td>and CF when KF.</td>
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<td>8.</td>
<td>Angle of inclination from H of the line joining left ankle (lt.ank)</td>
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<td></td>
<td>and CF when KF.</td>
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<td>9.</td>
<td>Angle of inclination from H of the line joining right centre of</td>
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<td></td>
<td>gravity (C.G) and CF when KF.</td>
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<tr>
<td>10.</td>
<td>Angle of inclination from H of the line joining lt.C.G</td>
<td>i10</td>
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50. DAI between KEHF at lt.C.G

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132. Angle at KJ formed by lt. thigh differences between KEHF position

133. Angle at rt. KJ total differences between KEHF position

134. Angle at lt. KJ total differences between KEHF position

135. Angle at HJ formed by rt. thigh differences between KEHF position

136. Angle at HJ formed by lt. thigh differences between KEHF position

137. Angle at HJ formed by rt. shin differences between KEHF position

138. Angle at HJ formed by lt. shin differences between KEHF position

139. Angle at rt. HJ total differences between KEHF position

140. Angle at lt. HJ total differences between KEHF position

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142. AV at AJ formed by lt. shin when KEKF

143. AV at AJ formed by rt. foot when KEKF

144. AV at AJ formed by lt. foot when KEKF

145. AV at rt. AJ total when KEKF
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<td>AV at rt. HJ total when KEKF</td>
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<td>AV at AJ formed by rt. foot when HFKE</td>
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<td>162</td>
<td>AV at AJ formed by lt. foot when HFKE</td>
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<td>AV at rt. AJ total when HFKE</td>
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<td>AV at lt. AJ total when HFKE</td>
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<td>AV at knee joint formed by rt.lower leg when HFKE</td>
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<td>AV at KJ formed by lt.lower leg when HFKE</td>
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<td>AV at KJ formed by rt.thigh when HFKE</td>
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<td>AV at KJ formed by lt.thigh when HFKE</td>
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<td>169</td>
<td>AV at rt. KJ total when HFKE</td>
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</table>
170. AV at lt. KJ total when HFKE

171. AV at hip joint formed by rt. thigh when HFKE

172. AV at HJ formed by lt. thigh when HFKE

173. AV at HJ formed by rt. shin when HFKE

174. AV at HJ formed by lt. shin when HFKE

175. AV at rt. HJ total when HFKE

176. AV at lt. HJ total when HFKE

177. Total time taken to execute the throw(TT)

178. Execution time that is time of main phase(ET)

179. Time of freely falling body from highest Y Coordinate(TFF)

180. Ratio of ET and TFF

181. Resultant velocity of freely falling body(RVFF)

182. Time of knee fl. from start of throwing(TKNFL)

183. TKNFL to Foot detachment of receiver(FD)

184. TKNFL to Leg ext.

185. TKNFL to Belt in vertical line of receiver(BVL)

186. Time of FD to Leg ext.

187. Time of FD to BVL

188. Time of Leg ext. to BVL

189. Displacement(Dis) of thrower(TH) at X coordinate

190. Displacement of thrower at Y coordinate

191. Displacement resultant of thrower

192. Dis of receiver(RE) at X coordinate

193. Dis of RE at Y coordinate

194. Dis resultant of RE
195. Final velocity of RE when contacts the mat (FVR)
196. Final acceleration of RE when contacts the mat (FAR)
197. Final force of contact of RE when contacts the mat (FFCR)

Anthropometric variables

1. Total body weight (kg)
2. Stature (cm)
3. Acromion height (cm)
4. Sitting height (cm)
5. Trunk length (cm)
6. Upper arm length (cm)
7. Fore arm length (cm)
8. Sum of upper and fore arm length (cm)
9. Trochanterion-Tibiae externum length (Thigh length)
10. Lower leg length (cm)
11. Sum of Thigh and lower leg length (cm)
12. Foot length (cm)
13. Biacromial diameter (cm)
14. Crural index (cm)
15. Trunk leg length ratio (cm)
16. Upper fore arm length ratio (cm)
17. Ponderal index.
Flexibility and Motor Performance Variables

1. Right grip strength (Isometric) in kg.
2. Left grip strength (Isometric) in kg.
3. Leg extension strength (isometric) in kg.
4. Back extension strength (isometric) in kg.
5. Bench press for maximum strength of arm extension (Isotonic) in kg.
6. Dips test for maximum arm and shoulder strength in kg.
7. Sit up for abdomen (Isotonic max. strength) in kg.
8. Bench squat for legs and back isotonic max. strength in kg.
9. Vertical Arm Pull (Explosive strength) for upper extremity in cm.
10. Vertical jump (Explosive strength) for lower extremity in cm.
11. Reaction and speed of movement (cm)
12. Planter flexion in degree
15. Wrist flexion in degree.
16. Wrist extension in degree.
17. Elbow flexion in degree.
18. Shoulder flexibility in cm.
19. Sit and reach Test (hip-Back flexion and hamstring extension) in cm.

20. Trunk and Neck extension in cm.

21. Right grip strength per kg. body weight

22. Left grip strength per kg body weight

23. Leg extension strength per kg. body weight

24. Bench press strength per kg. body weight

25. Bench squat strength per kg. body weight.

Reliability of Data

All the instruments and equipments were taken from N.S.N.I.S., Patiala, Research Faculty, which were supplied by standard agencies and companies and their accuracy was ensured by the suppliers. So the data collected by using these instruments and equipments were considered reliable for the purpose of this study.

Experimental Protocol

A 16 mm. movie camera (bio-mechanics-500 photosonic IPL) loaded with 16 mm. high speed reversal movie film (ORWO) fixed at a distance of 11-25 meters from the centre of the throwing (performance) area was used for filming. The throwing area was 3.60 meters by 2.70 meters, covered with 'Tatami' the specialized
mat used for judo practice. The camera was mounted on a tripod and positioned at right angle to the (sagittal plane of performer) plane of movement. Fixed bodies were placed in the field of camera. These served as reference axes. (Fig. - 3). A two meters bar was also filmed in the plane of motion and was used for calibration purpose. (Fig. - 4).

The camera was operated at 100 frames per second. The speed of the camera was calibrated with internal light flashing with a frequency of 100 pulses per second. The film after processing was analysed on a film motion analyser (Nac 76-1) in the bio-mechanics laboratory of N.S.N.I.S., Patiala (Fig. - 5).

The conduct of the study was based on experimental method, in prearranged and controlled conditions. The performers were well informed, motivated and were well prepared for the experiment. Trial practice of each throw was given. One of the performer acted as receiver in all the throws for both the techniques. This ensured the uniformity in data collection. All the throwers were wearing shorts only, whereas the receiver was wearing the full judo dress as per regulation of judo.

To record each judo throw the camera was started a little earlier, then the thrower initiated his throwing action and continued till the completion of the throw. Each judo throw was recorded on the film individually.
Fig. 9 - Filling of the Technique.
Fig. 7 - Filming at the "No Entry Bar for the Usurpers"
Analytical Procedure

After the processing of the film, the film analysis was carried out on a film motion analyser.

Determination of Conversion Factor

The two meter rod, which was filmed for calibration was used to determine conversion factor by using the following formula:

\[
\text{C.F.} = \frac{L}{X_1 - X_2}
\]

C.F. = Conversion factor
L. = Original length of the rod
\( X_1 \) = 1st 'X' coordinate value of the rod
\( X_2 \) = 2nd 'X' coordinate value of the rod

The calculated conversion factor equaled 19 cms.

Determination of Centre of Gravity

To determine the path of C.G. in case of receiver and thrower individually, the following steps were followed as
described by Hochmuth\textsuperscript{1}.

'X' and 'Y' coordinates of each joint i.e., shoulder, hip, knee, ankle, elbow, wrist, the centre of head, centre of hands and centre of feet were read on the analyser using joint point method (Appendix-1).

The corresponding coordinates were multiplied by partial masses i.e., relative weights of human body parts (Total body 100 percent) related to the centre points of the joints according to Dickwach\textsuperscript{2}. (Appendix-1)

Finally with the help of formulas of Xcg and Ycg coordinates of C.G. of the body position of each frame was determined.

\[
\begin{align*}
X_{cg} &= \frac{\sum GTi \cdot xi}{100} \\
Y_{cg} &= \frac{\sum GTi \cdot yi}{100}
\end{align*}
\]

where,

\begin{align*}
GTi &= \text{Relative Weight} \\
100 &= \text{Constant} \\
xi &= 'X' \text{ coordinate of the frame} \\
yi &= 'Y' \text{ coordinate of the frame}
\end{align*}

\textsuperscript{1} G. Hochmuth, \textit{Biomechanics of Athletic Movement} (Berlin: Sport Verlag, 1984), pp. 96-97.

\textsuperscript{2} Ibid.
Determination of the Path of C.G.

The path of the C.G. was plotted on a linear graph paper from the computed C.G. in different frames of the thrower and receiver respectively. For both the techniques i.e. in ISN as well as, in MSN.

Determination of Time

Total time taken to perform the skill, time taken for the preparation phase, and time taken for the execution phase was determined from the number of frames in seconds or from the frame frequency.

Determination of Distance

To determine horizontal distance covered by the C.G. of thrower and receiver; vertical distance covered by the C.G. of thrower; maximum height gained by the C.G. of thrower and receiver; and minimum height gained by the C.G. of thrower in centimeters, research scholar made use of the \( X \) and \( Y \) coordinate values of thrower and receiver respectively in Ippon Seoi Nage and Morote Seoi Nage. To determine distance, the following formula based upon Pythagoras theorem was applied.
\[ d = \sqrt{\left( \frac{X - X'}{2} \right)^2 + \left( \frac{Y - Y'}{2} \right)^2} \]

\[ D = d \times C.F. \]

where,

\[ d = \text{Distance} \]
\[ X = 'X' \text{ coordinate} \]
\[ Y = 'Y' \text{ coordinate} \]

C.F. = Conversion factor, and

\[ D = \text{Actual distance.} \]

**JUSTIFICATION FOR THE USE OF TWO DIMENSIONAL CINEMATOGRAPHIC METHOD**

Two cameras or three dimensional cinematographic methods are always suggestible for high level of accuracy in motion analysis but three dimensional method is comparatively costly and complicated. It has been found that two dimensional or one camera methods are sufficiently accurate for certain type of movements which follow either of the following conditions. (i) The displacement of the body segments or centre of gravity, must be in one plane. (ii) Uniform, displacement in every trial of a performer or a group of performers. Thus, these two conditions are required to be tested in Seoi-Nage respectively for thrower and receiver at three predetermined stage (fig. 6) that are (i) The displacement from zero frame to knee completely flexed (ii)
Fig 6.1 Knee Completely Flexed of Thrower while Executing Seoi Nage

Fig. 6.2 Knee completely extended of Thrower While Executing Seoi Nage

Fig. 6.3 Hip Completely flexed of Thrower or Hip of Receiver Touches The Mat.

Fig. 6 Predetermined three stages of Seoi Nage in respect to Thrower
The displacement from knee flex to knee completely extended and
(iii) The displacement from knee completely extended to hip of
the thrower completely flexed or touching of receiver's hip with
the mat that is the end of execution.

Eight national level male Judoka were filmed from the
anterior posterior dimension (right angle to the frontal plane of
performer) of the movement, while performing Seoi-Nage following
identical experimental protocol used for main data collection,
except the direction of placement of camera (fig.7), then
analysed in respect to centre of head, right and left shoulder
joint, right and left elbow joint, right and left wrist, right
and left centre of hand, right and left hip joint, right and left
knee joint, right and left ankle joint, right and left foot and
centre of gravity. Coefficient of variance (CV) computed (Table
and 2) for each body parts centre of gravity by the following
formula.

\[
C.V. = \frac{100 \times T}{M}
\]

Where,

\[
M = \text{Mean}
\]

\[
T = \text{Standard Deviation}
\]
CAMERA 'B'
Used For Justification Of One Camera Method In Present Context

CAMERA 'A'
Used For Main Filming

---Frontal Plane
---Transverse Plane
---Sagittal Plane

Fig. 7 - Filming Dimensions


<table>
<thead>
<tr>
<th>S.No</th>
<th>Body Part</th>
<th>Coeff. of variance at 'Z' Coordinate displacement</th>
<th>Coeff. of variance at 'Y' Coordinate displacement</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>When knee flexed</td>
<td>When knee Ext.</td>
</tr>
<tr>
<td>1</td>
<td>Head</td>
<td>2.01</td>
<td>3.13</td>
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<tr>
<td>2</td>
<td>Rt. Shoulder</td>
<td>2.13</td>
<td>2.57</td>
</tr>
<tr>
<td>3</td>
<td>Lt. Shoulder</td>
<td>1.95</td>
<td>3.35</td>
</tr>
<tr>
<td>4</td>
<td>Rt. Elbow</td>
<td>2.53</td>
<td>3.46</td>
</tr>
<tr>
<td>5</td>
<td>Lt. Elbow</td>
<td>1.74</td>
<td>3.81</td>
</tr>
<tr>
<td>6</td>
<td>Rt. Wrist</td>
<td>3.33</td>
<td>5.36</td>
</tr>
<tr>
<td>7</td>
<td>Lt. Wrist</td>
<td>1.73</td>
<td>3.43</td>
</tr>
<tr>
<td>8</td>
<td>Rt. Hand</td>
<td>3.16</td>
<td>4.64</td>
</tr>
<tr>
<td>9</td>
<td>Lt. Hand</td>
<td>1.86</td>
<td>3.34</td>
</tr>
<tr>
<td>10</td>
<td>Rt. Hip</td>
<td>1.10</td>
<td>2.01</td>
</tr>
<tr>
<td>11</td>
<td>Lt. Hip</td>
<td>2.10</td>
<td>3.08</td>
</tr>
<tr>
<td>12</td>
<td>Rt. Knee</td>
<td>2.97</td>
<td>2.27</td>
</tr>
<tr>
<td>13</td>
<td>Lt. Knee</td>
<td>3.22</td>
<td>1.46</td>
</tr>
<tr>
<td>14</td>
<td>Rt. Ankle</td>
<td>2.89</td>
<td>2.21</td>
</tr>
<tr>
<td>15</td>
<td>Lt. Ankle</td>
<td>2.55</td>
<td>1.64</td>
</tr>
<tr>
<td>16</td>
<td>Rt. Foot</td>
<td>3.11</td>
<td>2.62</td>
</tr>
</tbody>
</table>
TABLE 1 (Continued)

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>17.</td>
<td>Lt. Foot</td>
<td>2.57</td>
<td>1.64</td>
<td>3.91</td>
<td>2.54</td>
</tr>
<tr>
<td>18.</td>
<td>C.S.</td>
<td>4.64</td>
<td>2.82</td>
<td>2.24</td>
<td>1.92</td>
</tr>
</tbody>
</table>

TABLE 2

Variance of Receiver at 'Z' and 'Y' Dimension at Three Predetermined Stages of Seoi Nage

<table>
<thead>
<tr>
<th>S.No</th>
<th>Body Part</th>
<th>Coeff. of variance at 'Z' coordinate displacement</th>
<th>Coeff. of variance at 'Y' Coordinate displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>When knee flexed</td>
<td>When knee receiver&quot; flexed</td>
<td>When Ext.</td>
</tr>
<tr>
<td>1.</td>
<td>Head</td>
<td>1.51</td>
<td>3.46</td>
</tr>
<tr>
<td>2.</td>
<td>Rt. Shoulder</td>
<td>1.49</td>
<td>3.81</td>
</tr>
<tr>
<td>3.</td>
<td>Lt. Shoulder</td>
<td>1.73</td>
<td>5.87</td>
</tr>
<tr>
<td>4.</td>
<td>Rt. Elbow</td>
<td>1.55</td>
<td>3.96</td>
</tr>
<tr>
<td>5.</td>
<td>Lt. Elbow</td>
<td>3.29</td>
<td>4.68</td>
</tr>
<tr>
<td>7.</td>
<td>Lt. Wrist</td>
<td>4.88</td>
<td>1.58</td>
</tr>
<tr>
<td>8.</td>
<td>Rt. Hand</td>
<td>8.33</td>
<td>1.51</td>
</tr>
<tr>
<td>9.</td>
<td>Lt. Hand</td>
<td>2.52</td>
<td>1.58</td>
</tr>
<tr>
<td>10.</td>
<td>Rt. Hip</td>
<td>4.47</td>
<td>3.68</td>
</tr>
<tr>
<td>11.</td>
<td>Lt. Hip</td>
<td>1.75</td>
<td>2.45</td>
</tr>
<tr>
<td>13.</td>
<td>Lt. Knee</td>
<td>1.63</td>
<td>2.58</td>
</tr>
</tbody>
</table>
The findings presented in table 1 and table 2 clearly indicates that all the throwers receivers having homogeneity in their 'Z' and 'Y' coordinates displacement (Frontal plane) in the three predetermined stages in respect to their 17 body parts and centre of gravity. As the obtained coefficient of variance are ranging from 3.95 to 5.36 in the case of throw and from 0.77 to 16.34 in the case of receiver in Seoi-Nage. Thus, thrower of Seoi-Nage were bearing greater homogeneity than that of receiver. It is convention that below 20 C.V. value of any variable is considered to be homogeneous and the C.V. values are less than 20. It is interesting to note that C.V. value of throwers are ranging from 1.10 to 5.36 and in the case of receivers from 1.03 to 7.43 at the 'Z' coordinate. These low C.V. values at 'Z' coordinates suggest that one camera method or two dimensional cinematographic method that are 'X' and 'Y' coordinate (sagittal plane of the performer) motion analysis bears sufficient accuracy for Seoi-Nage, hence, it may be considered for the present study for final filming.
CRITERION MEASURES

The sixteen male national level Judo players who were filmed, by following same experimental protocol and analytical procedure, simultaneously, players were ranked by Sh.J.G. Sharma, Sh.T Lee and Dhananjoy Shaw separately for developing criterion or feasible and objective criteria at the initial stage.

The ranking of three experts were averaged out to obtain over all expert ranking, which was correlated with the number of probable objective criteria based upon exiting literature and IJF contest rules by using rank difference method of correlation.

Table 3

OBJECTIVITY OF EXPERT RATING AND OVER ALL JUDO PERFORMANCE

<table>
<thead>
<tr>
<th>S.NO</th>
<th>VARIABLES</th>
<th>COEFFICIENT OF CORRELATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Expert One VS Expert Two</td>
<td>0.80</td>
</tr>
<tr>
<td>2.</td>
<td>Expert Two Vs Expert Three</td>
<td>0.86</td>
</tr>
</tbody>
</table>

TABLE 3 (Continued)

3. Expert One VS Expert Three 0.88
4. Over all Judo Performance as rated by expert. 0.86

Findings of presented table 3 indicated that experts were consistent in their rating based on the given conditions that is effectiveness of Seoi-Nage execution.

The ranking of Seoi-Nage and ranking of over all Judo performance by the experts bears high correlation, thus, undertaking the present study based upon Seoi-Nage was worth while.

Table 4

VALIDITY OF CRITERION WHEN CORRELATED WITH AVERAGED SUBJECTIVE RANKING OF IPPON SEOI NAGE AND MOROTE SEOI NAGE

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>CRITERION IN</th>
<th>COEFF. OF CORR 'e' WITH ISN</th>
<th>COEFF. OF CORR 'e' WITH MSN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ratio of Execution time and time of free fall from highest 'Y' coordinates of that throw (receiver) All Ist trial's ET/TFF</td>
<td>0.647**</td>
<td>0.530*</td>
</tr>
<tr>
<td>2.</td>
<td>Execution time</td>
<td>0.615*</td>
<td>0.210</td>
</tr>
<tr>
<td></td>
<td>All Ist trial's ET</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>3. Time of free fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All 1st trial's of TFF</td>
<td>0.088</td>
<td>0.367</td>
<td></td>
</tr>
<tr>
<td>4. Total time (Best of two trial) = TT</td>
<td>0.578*</td>
<td>0.499*</td>
<td></td>
</tr>
<tr>
<td>5. Total time (only 1st trial) = TT</td>
<td>0.490</td>
<td>0.414</td>
<td></td>
</tr>
<tr>
<td>6. Ratio of total and execution time when given highest ratio as 1st position &amp; so on. TT/ET</td>
<td>0.09</td>
<td>0.145</td>
<td></td>
</tr>
<tr>
<td>7. Average velocity i.e. Total distance/Total time (Best of two trials)</td>
<td>0.244</td>
<td>0.297</td>
<td></td>
</tr>
<tr>
<td>8. Final velocity of receiver while falling on the mat (FVR)</td>
<td>0.105</td>
<td>0.541</td>
<td></td>
</tr>
<tr>
<td>9. Final force of falling on the mat of receiver FFFR highest (cm)</td>
<td>0.515*</td>
<td>0.274*</td>
<td></td>
</tr>
<tr>
<td>10. Height (cm)</td>
<td>0.407</td>
<td>0.371</td>
<td></td>
</tr>
<tr>
<td>11. Height of thrower when knee flexed (HTLF)*</td>
<td>0.185</td>
<td>0.177</td>
<td></td>
</tr>
<tr>
<td>12. Weight (kg)</td>
<td>-0.128</td>
<td>-0.128</td>
<td></td>
</tr>
<tr>
<td>13. Height difference between thrower and receiver (Ht dif.)</td>
<td>-0.035</td>
<td>0.304</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at .05 level.  **Significant at .01 level
r.05 (14) = 0.497,  r.01 (14) = 0.623
N = 16
The finding of table 4 shows that ET/TFF and TT criterion having significant correlation with averaged expert ranking into care of both the variation of Seoi nage, hence, it may be considered as criterion measure, on the other hand, some criteria were not found significantly correlated to any of the variation and some of the criterion were only related to any one among two variations of Seoi Nage.

**Table 5**

**CORRELATION MATRIX AMONG THE SELECTED CRITERION VARIABLES OF ONE ARM SHOULDER THROW**

<table>
<thead>
<tr>
<th></th>
<th>EXP</th>
<th>ET</th>
<th>TT</th>
<th>HT</th>
<th>FT</th>
<th>WT</th>
<th>TFF</th>
<th>HT</th>
<th>DIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP</td>
<td>.647*</td>
<td>.578*</td>
<td>.407</td>
<td>.185</td>
<td>-.129</td>
<td>.088</td>
<td>-.043</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>0.904*</td>
<td>0.043</td>
<td>0.176</td>
<td>-.365</td>
<td>-.335</td>
<td>-.073</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TT</td>
<td>0.092</td>
<td>0.176</td>
<td>-.254</td>
<td>-.136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HT</td>
<td>0.542*</td>
<td>0.613*</td>
<td>0.695*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mt. Fl.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.507*</td>
<td>0.334</td>
</tr>
<tr>
<td>Wt.</td>
<td>0.507*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.542*</td>
<td>0.501*</td>
</tr>
<tr>
<td>TFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.360</td>
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<tr>
<td>Ht</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level
** Significant at .01 level
### TABLE 6

**CORRELATION MATRIX AMONG THE SELECTED CRITERION VARIABLES OF BOTH ARM SHOULDER THROW**

<table>
<thead>
<tr>
<th></th>
<th>EXPERT</th>
<th>ET/ TFF</th>
<th>TT</th>
<th>HT.</th>
<th>HT. FL</th>
<th>WT.</th>
<th>TFF</th>
<th>HT</th>
<th>DIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>RANKING</td>
<td>0.530*</td>
<td>0.499*</td>
<td>0.371</td>
<td>0.179</td>
<td>-0.128</td>
<td>0.403</td>
<td>0.304</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td></td>
<td></td>
<td>0.676**</td>
<td>0.087</td>
<td>0.316</td>
<td>-0.288</td>
<td>-0.130</td>
<td>0.325</td>
<td></td>
</tr>
<tr>
<td>TFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.076</td>
<td>0.325</td>
<td>-0.279</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>0.059</td>
<td>0.079</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.529*</td>
<td>0.687**</td>
<td>0.649**</td>
</tr>
<tr>
<td>HT. FL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.378</td>
<td>0.503*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.725**</td>
<td>0.510*</td>
</tr>
<tr>
<td>TFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.643**</td>
</tr>
<tr>
<td>HI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIFF</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level
** Significant at .01 level

According to the table 5 and 6, it is clearly evident that expert rankings are significantly related to ET/TFF and total time and at the same time ET/TFF and TT were significantly related to each other. Hence, it may be concluded that either of these two criteria may be considered as criterion or both for the present study. Expert ranking is not significantly related to time of free fall (TFF), on the other hand ET/TFF having highest
correlation with expert ranking, hence justified the criterion for consideration. Height (thrower) is significantly related to HT flexed (thrower), weight, time of free fall (TFF) and height differences (HT DIFF) suggesting that height having its own influences on the parabola of receiver i.e. TFF, thus ET/HT may be a replacement to ET/TFF.

Application of Criterion Measures—

To evaluate and to develop feasible criterion applicable to the coaching in the field. Thirty five Judo players performed ISN and MSN respectively on a common receiver which were rated by three Judo experts on the bases of given consideration and also clocked for total time and execution time with the help of three bionic 1/100 sec. electronic stop watches simultaneously. Height of the Judoka were also measured in centimeter with the help of anthropometric rod.

Table 7

OBJECTIVITY OF EXPERT RATING

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>One Vs Two</td>
<td>0.741**</td>
<td></td>
<td></td>
<td>0.69**</td>
</tr>
<tr>
<td>2.</td>
<td>Two Vs Three</td>
<td>0.728**</td>
<td></td>
<td></td>
<td>0.807**</td>
</tr>
<tr>
<td>3.</td>
<td>One Vs three</td>
<td>0.867**</td>
<td></td>
<td></td>
<td>0.846**</td>
</tr>
</tbody>
</table>

**Significant at .01 level.
The findings placed in table 7 indicated that experts were consistent in their rating based on the given conditions for Ippon Seoi Nage and Morote Seoi Nage.

Table 8

VALIDITY OF CRITERION MEASURES WHILE IMPLEMENTED WITH THE HELP OF STOP WATCH

<table>
<thead>
<tr>
<th>S.No</th>
<th>Criterion Measures</th>
<th>Ippon seoi nage expert rating</th>
<th>Morote seoi nage expert rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total time</td>
<td>0.774**</td>
<td>0.642**</td>
</tr>
<tr>
<td>2.</td>
<td>Execution time</td>
<td>0.613**</td>
<td>0.317**</td>
</tr>
<tr>
<td>3.</td>
<td>Execution time &amp; height of the thrower (Ratio)</td>
<td>0.948**</td>
<td>0.866**</td>
</tr>
</tbody>
</table>

**Significantly correlated at .01 level.

N = 35

The findings in table 8 revealed that the total time, and ratio of execution time and height of the Judoka (thrower) were significantly correlated to expert rating in ISN and MSN, which confirms the criterion as objective measure for evaluation of ISN and MSN for effectiveness. Where as execution time were not found to be statistically significant in morote seoi nage that is not consistent evaluating criterion for both the
variation of Sei Nage thus rejected to be considered as criterion.

Ratio of execution time and time of free fall is replaced by ratio of execution time and height of the thrower to have a feasible criteria for coaches to be used in practice and to avoid complications of cinematographic method that is computation of path of C.G. and then the maximum height of parabola to compute time of free fall. Similar trend have been confirmed with the findings shown in table 3 and 4 evident considerably high coefficient of correlation between height of the thrower and time of free fall in both of the variations of Sei Nage.

TESTER COMPETENCY AND RELIABILITY OF ANTHROPOMETRIC MEASUREMENTS

The testers competency was evaluated together with the reliability of the test. To determine the reliability of test the selected variables the measurements were recorded five times under identical conditions by the scholar. Person's product moment correlation was computed between the two measures of each variable and these reliability Co-efficients are shown in table
### Table 9

**RELIABILITY OF ANTHROPOMETRIC MEASUREMENTS**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Measurement</th>
<th>Co-efficient of reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body weight (grams)</td>
<td>0.99</td>
</tr>
<tr>
<td>2.</td>
<td>Stature (cm)</td>
<td>0.99</td>
</tr>
<tr>
<td>3.</td>
<td>Acromion height (cm)</td>
<td>0.98</td>
</tr>
<tr>
<td>4.</td>
<td>Sitting height (cm)</td>
<td>0.98</td>
</tr>
<tr>
<td>5.</td>
<td>Trunk length (cm)</td>
<td>0.98</td>
</tr>
<tr>
<td>6.</td>
<td>Upper arm length (cm)</td>
<td>0.96</td>
</tr>
<tr>
<td>7.</td>
<td>Forearm length (cm)</td>
<td>0.96</td>
</tr>
<tr>
<td>8.</td>
<td>Sum of upper and forearm length (cm)</td>
<td>0.96</td>
</tr>
<tr>
<td>9.</td>
<td>Trochanterion - tibiale externum length (Thigh length) (cm)</td>
<td>0.96</td>
</tr>
<tr>
<td>10.</td>
<td>Lower leg length (cm)</td>
<td>0.96</td>
</tr>
<tr>
<td>11.</td>
<td>Sum of thigh and lower leg length (cm)</td>
<td>0.96</td>
</tr>
<tr>
<td>12.</td>
<td>Foot length (cm)</td>
<td>0.99</td>
</tr>
<tr>
<td>13.</td>
<td>Biacromial diameter (cm)</td>
<td>0.96</td>
</tr>
<tr>
<td>14.</td>
<td>Crural index</td>
<td>0.96</td>
</tr>
<tr>
<td>15.</td>
<td>Trunk-leg length ratio</td>
<td>0.97</td>
</tr>
<tr>
<td>16.</td>
<td>Upper-forearm length ratio</td>
<td>0.96</td>
</tr>
<tr>
<td>17.</td>
<td>Ponderal index</td>
<td>0.99</td>
</tr>
</tbody>
</table>
From the test rates Co-efficient of correlation (table 11) it was obvious that the tester's reliability was significantly high, as establishing the competency of the scholar to administer the tests.

PROCEDURE FOR COLLECTION OF DATA

The values of Biomechanical variables 'X' and 'Y' coordinates of each joint e.g. shoulder, hip, knee, ankle, centre of head, centre of feet and centre of gravity were obtained from the (Nac.76-1) film. Motion analyser were plotted on graph paper without any conversion to develop stick diagram of three predetermined phases of ippon seoi nage and morote seoi nage of thrower determine angle of inclination from the centre of feet in respect to the frontal horizontal imaginary line of centre of feet (fig, 8, 9, 10, 11 and 12) and angles at hip, knee and ankle joints in respect to imaginary horizontal line at respective joints and respective body segments of thrower in all the predetermined phases of Ippon Seoi Nage and Morote Seoi Nage (fig. 13) respectively, for right and left side by placing the protector accordingly.

VALIDITY OF STICK DIAGRAM

The obtained joint angles from stick diagram with the
Fig. 8 - Angle of Inclination of Centre of Gravity
Fig. 9 - Angle of Inclination of Shoulder Joint
Fig. 10 - Angle of Inclination of Hip Joint
Fig. 11 - Angle of Inclination of Knee Joint
Fig. 12 - Angle of Inclination of Ankle Joint
Fig. 13 - Angles at Hip, Knee & Ankle Joints
help of protractor were correlated with the angles of knee and hip joints for both the side, i.e., right and left sides were determined by tracing the paper from screen of the analyser. After tracing the paper in respect to lateral condyloid of knee joints and greater tuberosity of hip joints as well as mid line of the subjects respective body segments, the angles were determined with the help of a protractor in degrees by using product moment correlation respectively for ISN and MSN.

Table 10

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>Techniques</th>
<th>Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Right Knee</td>
</tr>
<tr>
<td>1.</td>
<td>Ippon seoi nage</td>
<td>0.759*</td>
</tr>
<tr>
<td></td>
<td>N = 62</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Morote seoi nage</td>
<td>0.68*</td>
</tr>
<tr>
<td></td>
<td>N = 60</td>
<td></td>
</tr>
</tbody>
</table>

Significant at 0.01 level
It is evident from the data, presented in table 10 that coefficient of correlation between stick diagram and tracking method for both the techniques at knee and hip joints respectively for right and left side were found to be statistically significant at 0.01 level. Hence stick diagram method seems to be valid for the present study.

RELIABILITY OF STICK DIAGRAM METHOD FOR ANGLES MEASUREMENTS IN SEDI NAGE

To determine the reliability of the stick diagram method, the stick diagram were developed twice on the graph paper separately with the help of same 'X' and 'Y' co-ordinate values obtained from motion analyser of the particular frames. Pearson's product moment correlation was computed between the two stick diagram's at various joints with its horizontal line and of indication. These reliability co-efficients are shown in table 11.

Table 11

RELIABILITY CO-EFFICIENTS OF TEST RETEST STICK DIAGRAM METHOD

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Measures</th>
<th>Co-efficient of reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Angle of inclination from centre of foot, N = 30</td>
<td>0.996*</td>
</tr>
<tr>
<td>2.</td>
<td>Segmental joint angles N = 162</td>
<td>0.995*</td>
</tr>
</tbody>
</table>

*Significant at 0.01 level.
It was obvious from the data arranged in table 11 that the stick diagram method for measuring angles and tester reliability was highly significant, hence it may be considered suitable for this study.

**DIFERENCE OF ANGLES OR ANGULAR DISTANCE**

The difference of angles were computed by subtracting the angle values of knee extended stage from the angle values of knee extended stage as well as by subtracting the angle values of knee extended stage from the values hip touch stage for obtaining differences of angle of inclination and body segment angles respectively.

**ANGULAR VELOCITY**

To determine the angular velocity of specific body segment obtained angular distance of that specific body segment was divided by time taken to reach one stage to other stage.

Formula:-

\[
LV = \frac{LD}{T}
\]

Where,

\(LV = \text{Angular velocity}\)

\(LD = \text{Angular distance}\)

\(T = \text{Time taken to reach one stage to other stage}\)
TOTAL TIME AND EXECUTION TIME

The total time taken to perform the techniques, time taken for the preparation phase, and time taken for the execution phase was determined from the number of frames in seconds or from the frame frequency respectively for ippon seoi nage and morote seoi nage.

TFF

Time of freely falling body from the highest 'Y' coordinate value of the receiver for each throw was obtained from the highest point of C.G. at 'Y' coordinate by using the following formula.

\[
T = \frac{\sqrt{2h}}{g}
\]

Where,

\[T = \text{Time}\]

\[h = \text{Height of parabola and}\]

\[g = \text{Acceleration due to gravity}\]

RATIO OF EXECUTION TIME AND TIME OF FREE FALL

Execution time was divided by TFF of the respective throw that is ippon seoi nage and morote seoi nage.
RESULTANT VELOCITY OF FREELY FALLING BODY (RVFF)

RVFF was computed by using the following:

\[ \frac{h}{RVFF} = \frac{1}{TFF} \]

Where,

- \( h \) = Highest point of parabola and
- \( TFF \) = Time of free fall.

TIME OF KNEE FLEXION FROM START OF THrowing (TKNFL)

TKNFL was obtained from the frame frequency of the camera, which was operated at 100 fms/sec. TKNFL is the time taken from starting of the throw till thrower reach to his maximum knee flexed position while executing ippon seoi Nage or morote seoi nage.

TKNFL TO FOOT DETACHMENT OF THROWER (FD)

It is the time taken from completely flexed knee to the thrower to detachment of the test of receiver that is to be pair born obtained from the frame frequency.

TKNFL TO LEG EXTENSION

It is the time taken from completely knee flexed position to reach completely knee extended position of thrower.
which was obtained from the frame frequency.

**TKNFL TO BELT IN VERTICAL LINE OF RECEIVER (BVL)**

It is the time taken from the completely knee flexed position of the thrower to reach the waist belt in vertical line that is belt parallel to vertical line of receiver which was obtained from the frame frequency.

**TIME OF FD TO LEG EXTENSION**

It is the time taken from the foot detachment of receiver to the knee completely extended position of throw which was obtained from the frame frequency.

**TIME OF FD TO BVL**

It is the time taken from the foot detachment to reach the waist belt in vertical line that is belt parallel to vertical line of receiver, which was obtained from the frame frequency.

**DISPLACEMENT**

As per the method for determination of distance mentioned in experimental design.

**VELOCITY**

Determination of the following velocities in meter-
per second in respect to their C.G. (a) velocity of the U.G. of thrower at the beginning of execution phase (b) velocity of the C.G. of thrower at the end of by extension in execution phase, and velocity of C.G. of receiving at the end of leg extension of thrower (c) velocity of receiver's C.G. at the moment, falls on the mat were obtained by averaging out the distance in consecutive three frames and time taken with the help of following formula.

\[
V = \frac{d}{t}
\]

where,

\[V\] = Average velocity
\[d\] = Distance
\[t\] = Time

**ACCELERATION**

Acceleration in meter per second whereas in case of leg extension of thrower's C.G. and the receiver's C.G. at the moment receiver falls on the mat were determined by applying the following formula.

---

5 Ibid; P.19.
\[ a = \frac{v_f - v_i}{t} \]

Where,

\( a \) = The average acceleration  
\( v_f \) = The final velocity  
\( v_i \) = The initial velocity  
\( t \) = The elapsed time

**FORCE OF IMPACT**

Determination of force of impact in kilogram / meter per second of receiver’s C.G. at the moment he falls on the mat was calculated through direct method by using the following formula.

\[ F = ma \]

Where,

\( F \) = Force of impact  
\( m \) = Mass of the receiver, and  
\( a \) = Acceleration of the receiver

---

The data pertaining to biomechanical variables of ISN and MSN are presented in appendices 2 and 3.

ANTHROPOMETRIC MEASUREMENTS

BODY WEIGHT

The body weight of the subjects were taken on weighing machine. The subjects were bare footed wearing nothing (nude) stood at the centre of the weighing machine. The weight was recorded to quarter of a kilogram.

STATURE (cm) (Anthropometer)

The subject stood erect on a horizontal surface, and was instructed to stretch as much as possible and an extra care was taken that the heels must touched each other at the horizontal surface. Slight upward pressure was applied below the mastoid processes in order to help in stretching to the fullest. The head was held at frankfort plane. Anthropometer rod was held vertically and the horizontal arm was brought down so that it touched the highest point on the head in the mid sagittal plane and height was recorded in 1/10 of centimetre.
ACROMION HEIGHT (cm) (Anthropometre)

At the superior and external border of the acromion process of the right side of the subject stood erect and shoulder relaxed. Measured vertically with the help of anthropometer rod at 1/10 of centimeter.

SITTING HEIGHT (Anthropometer)

The subject sat on a table's top, and the legs were hung down freely, the back of the subject was stretched. The head was held at the frankfort plane and gentle upward pressure was applied to the mastoid processes. The muscles of the thigh and buttocks contracted, so the help in fullest stretching. The horizontal bar of the anthropometer rod was brought down so that it touched the highest point of the head and value was recorded upto 1/10 of a centimeter.

TRUNK LENGTH (Anthropometer)

Measured vertically from the midgluteus horizontal line to horizontal line drawn tangentially to the top of the shoulder at the base of the neck.

9 Singh and Malhotra, Kinanthropometry, P.7-17.
UPPER ARM LENGTH (Anthropometer)

The distance between the interior border of the acromion process and the external superior border of the head of radius was taken. The arm was hung down normally. The palm of the hand was directed towards the thigh. The two above mentioned points was marked and the distance between them was measured in 1/10 th of centimetre with the help of the anthropometer.

FORE ARM LENGTH (Anthropometer)

The superior border of the head of radius & the tip of the lateral styloid process was marked, the arm hung down and distance between the two points was measured with the help of anthropometer.

SUM OF UPPER AND FORE ARM LENGTH

The value of upper an fore arm length were summed together.

TROCHANTERION - TIBIALE EXTERNUM LENGTH (Thigh length)

The distance between the trochanterion on tibiale was measured vertically with the help or anthropometer.

Ibid

Ibid
LOWER LEG LENGTH (Anthropometer)

The tibiale and malleolus points was marked & distance between them measured.

SUM OF THIGH & LOWER LEG LENGTH

The thigh and lower leg length were summed together.

FOOT LENGTH (Sliding caliper)

The subject was sitting, sliding caliper was planed along the axis of the foot. One arm of the instrument was brought in contact with the centre of the heel and other with the longest toe.

BIACROMIAL DIAMETER OR SHOULDER WIDTH

The measurement was taken between the outside edges both the acromion processes, from the back side of the subject.

CRURAL INDEX

This ratio was computed by dividing the score of foreleg length by the corresponding score of thigh length & the obtained value was recorded correct to two decimals.

---

Ibid
TRUNK LEG LENGTH RATIO

To obtain the ratio of trunk & leg length the value of trunk length was divided by the leg length value.

UPPER FORE ARM LENGTH RATIO

This ratio was computed by dividing the score of upper arm length by the corresponding score of fore arm length & the obtained value was recorded to two decimals.

PONDERAL INDEX

Ponderal index was computed by using the following formula:

\[
P.I. = \frac{\text{Standing height}}{\sqrt[3]{\text{Weight}}}\]

This ratio for each subject was calculated by substituting the scores in the above shown formula, standing height in centimeter, nearest to half a centimeter and weight nearest to the half of a kilogram.

\[\text{13}\]

\[\text{Ibid.}\]
The data pertaining to anthropometric measurements has been presented in appendix-4.

FLEXIBILITY AND MOTOR PERFORMANCE VARIABLES

GRIP STRENGTH (Isometric)

EQUIPMENT: Dynamometer

Performers were asked to place dynamometer in the palm. The grip was adjusted so that the bottom of the dynamometer was resting against the base of the palm and fingers grasp the adjustable portion of the handle. The performer bent the elbow slightly and raised the arm. Subject moved the arm forward and downward gripping with maximum strength. The dynamometer scale was read in kilograms. Test was conducted then of right and left hand respectively. best of the two trials were recorded kilograms. (fig. 14)

LEG EXTENSION STRENGTH (Isometric)

EQUIPMENT: Leg dynamometer.

Subject was asked to stand on the leg dynamometer

flexed the knee at 123° angle then the chain of the dynamometer was so adjusted that handle of the dynamometer fixed across the upper edge of both thigh, held tightly against the lower abdomen with both of the hand and a belt round the waist from the handle was tight. (fig. 15)

Then the subject was asked to stand up with maximum effort & the score was recorded from the scale of dynamometer out of the two the best trial in kilograms.

BACK EXTENSION STRENGTH (Isometric)

EQUIPMENT: Leg Dynamometer.

Subject was asked to stand on dynamometer in fully erect position by putting the palms on the front thigh with their fullest reach then the handle of dynamometer was adjusted at the height of the tip of the middle finger of the subject. Then, the subject was asked to hold the handle with under hand grip and with one hand and overhand grip with the other hand. Then the subject was asked to extend his hip and the score was taken from the scale of dynamometer out of two best trials in kilograms.

Fig. 15 - Leg Lateralized Strength Test.
BENCH PRESS FOR MAXIMUM STRENGTH OF ARM EXTENSION

EQUIPMENT: Barbell and weight, flat bench (width of 25 & 30 centimeters)

The subject was asked to lay down in supine position with the head & trunk (including buttocks) extended on the bench and feet flat on the floor. Then the subject was asked to press the bar with maximum possible weight vertically to straight arm's length & hold it motionless for two second court. The hands were held at 81 centimeters apart. (fig. 16)

The best lift of three attempts was recorded as the score in kilogram.

IPS TEST FOR MAXIMUM ARM AND SHOULDER STRENGTH

EQUIPMENT: Two parallel bars weight plates straps and a chair.

After securing the derived amount of weight to the book of waist belt of the subject then the subject was asked to step upon the chair and to take secure grip on the parallel bars. As he assumed the straight arm support chair was removed & the subject was asked to lower himself downward until the elbows formed a right angle. The chair was replace under his feet when 17 asked to push up to straight arm support. (fig. 17)

16 Ibid.
17 Ibid.
Fig. 17: Exercise to increase arm and shoulder strength.
The best score of the two trials was recorded in terms of the amount of extra weight satisfactorily lifted in kilograms.

SIT UP FOR ABDOMEN (Isotonic Maximum Strength)

EQUIPMENT: Barbells of different weights

The subject was asked to lie down on his back with the knee bent. The angle at the knee was 90°. The subject was asked to hold barbell in a comfortable way at back of the head and neck and a partner was holding the feet of the subject. The subject was asked to bring the head and elbow forward during curl up and finally to touch the elbows to the knee only once. The best score if two trials was recorded in terms of the amount of extra weight satisfactorily lifted in kilogram. (fig. 18)

BENCH SQUAT FOR LEGS AND BACK

EQUIPMENT: Bench and barbells.

The bar with weight was placed upon the shoulder (behind the neck of the subject standing near the edge of the bench with feet comfortably placed at the shoulder side apart and firm grip of hand. Then student was asked to lower himself to an exact sitting position on the bench. Then without launching back and forth the subject was asked to return to the standing position. (fig. 19)
Fig. 2: Bench Squat Test. The Legs and Back Achieve Stiffness.
Satisfactorily lifted weight was recorded in kilogram.

**VERTICAL ARM PULL** (Explosive Strength)

**EQUIPMENT**: A bench, a rope, marking tape.

The subject was made to sit on the bench and asked to grasp the rope as high as possible without raising the buttocks from the bench, the marking tape was placed around the rope just above the uppermost hand of the subject. Then the subject was asked to pull the rope (without letting the feet touch the floor) and reach as high up the rope as possible and grasp and hold the rope (fig. 20).

The best pull of two trials was recorded in terms of 20 distance in centimeters.

**VERTICAL JUMP** (Explosive strength for lower extremity)

**EQUIPMENT**: Chalk and a smooth wall surface with adequate ceiling height.

The subject was made to stand with side towards the wall. Height was recorded from the highest vertical reach of the middle finger then, asked to swing arms and downward and backward, taking a crouched position with the knee bent about at right angle and leap as high as possible, swinging. The arms upward and put the mark with chalked finger on the wall. The maximum standing height was subtracted from maximum Jump Height.

The score of the best three trial was then recorded in 21 centimetre. (fig. 21)

REACTION AND SPEED OF MOVEMENT

EQUIPMENT: Tape and ruler.

The subject was asked to sit on the chair with his hands resting each other with the inside border of the little fingers along two lines which was on the edge of the table 30 cm. apart. Then the ruler was hanged between the palms with the base line of ruler on the upper borders of the subjects hand and asked to stop the ruler as quickly as possible by clapping the hands together while falling.

The score for the combined response movement was observed from the ruler at the point just above the upper edge of the hand after the catch. The average of the middle ten trials, after the slowest and fastest five trials have been discarded was 22 recorded in centimeters. (fig. 22)

PLANTER FLEXION IN DEGREE

EQUIPMENT: Universal goniometer.

The subject was made to sit by placing his leg as straight as possible. Then the mid point of the protractor of goniometer was placed on the lateral middle of the ankle joint.

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21 Ibid, PP. 201-203.
22 Ibid, PP. 248-249.
Fig. 21: Vertical Jump for Explosive Strength of Lower Extremity
Fig. 22. Test for revolution and speed of wave.
and arms of the goniometer along with the midline respective body segments. Then the subject was asked to extend the ankle. At the maximum EXTENSION the degree of extension was recorded from the goniometer. (fig. 23)

DORSI FLEXION IN DEGREE

EQUIPMENT : Goniometer

Identical procedure and scoring as planter flexion. Here the subject was asked to dorsiflex at ankle joint.

KNEE FLEXION IN DEGREE

EQUIPMENT : Goniometer

The subject was made to lie down in prone position (on stomach) with legs in extend position. The goniometer was placed at the latter middle side of the knee joint and the arms of the goniometer along with respective body segments and then subject was asked to flex the knee as much as possible. Then the maximum degree of flexion was recorded from the goniometer.

WRIST FLEXION IN DEGREE

EQUIPMENT : Goniometer

The subject was asked to sit on the chair and the put hand in fully extended supine position wrist at 180° on the table. Then the centre of goniometer was placed laterally on the wrist joint and subject was asked to flex the wrist as much as
Fig. 27 - Measurement of Plantar Flexion & Inversion.
possible. Then degree of flexion was recorded from the goniometer.

WRIST EXTENSION

EQUIPMENT: Goniometer

The subject was asked to put the hand in prone position on the table. Wrist at 180°, then mid point of goniometer was placed laterally on the wrist joint of the subject and asked to extend the wrist as much as possible. Then degree of extension of wrist joint was recorded from the goniometer.

ELBOW FLEXION

EQUIPMENT: Goniometer

The subject was asked to fully extend his hand and supine position at elbow 180° on the table. Then the mid point of goniometer was placed at the centre of lateral elbow joint. The subject was asked to flex the elbow to the maximum extend. The degree of flexion was recorded from the goniometer.

SHOULDER FLEXIBILITY

EQUIPMENT: 60 inches stick

The subject was asked to hold the stick with both the hands, few inches away from each other and extend both the arms in full length in front of the chest and rotate the stick over the head, and let the stick slide within the grip as meet with
resistance so that the arms could spread and allow to lower the stick until it was resting across the back. Then the stick between thumbs of the hands was measured in inches and recorded.

The best score of the three trials was recorded by subtracting the shoulder width in centimeters.

**SIT AND REACH TEST**

**EQUIPMENT**: Yard stick

The subject was asked to sit on the floor by fully extending both legs and heels not more than 5 inches apart. Then a stick was placed across the bottom of the heels of the subject and asked to slowly stretch forward and try to --- the stick to the maximum extend.

The measurement of reach was measured in centimeter from the inner edge of cross stick to middle finger tips.

**UNK AND NECK EXTENSION**

**EQUIPMENT**: Yard stick

The subject was asked to assume a prone position on the mat and hands resting on his back. Then the subject was asked to raise his trunk upward as high as possible from the floor and to touch the vertically placed yard stick with his tip of nose.

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Subtracting the best of three lifts from trunk and neck length, score of the subject was recorded in centimeters (Fig. 24).

**STRENGTH PER KILOGRAM BODY WEIGHT**

Right grip, left grip, leg extension, bench press and bench squat strength per Kg. body weight was determined, by dividing the respective maximum strength by body weight of the subject respectively.

The data pertaining to flexibility and motor fitness variables are presented in appendix 5.

**STATISTICAL PROCEDURE**

1. Mean and standard deviation were computed as descriptive statistics for all the dependent and independent biomechanical, anthropometric and motor performance variables respectively for Ippon Seoi Nage and Morote Seoi Nage.

2. The total time (TT) and ratio of execution time—Time of freefall (TFF) as criteria were correlated with all the biomechanical, anthropometric and motor performance variables respectively for Ippon Seoi Nage and Morote Seoi Nage by using product moment correlation.

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Fig. 24 - Pneumonitis of Lung and Neck Lymphatics.
3. Multiple correlation was computed to examine the combined effect of most contributing independent variables to the criteria separately in Ippon Seoi Nage and Morote Seoi Nage.

4. Stepwise method was used to find out the most contributing biomechanical, anthropometric and motor performance variables to the criteria of Ippon Seoi Nage and Morote Seoi Nage respectively.

The stepwise method is a modification of the forward selection technique and differs in that variables already in the model do not necessarily stay there as in the forward selection method variables are added one by one to the model and the $F$ statistic for a variable to be added must be significant at the slentry level. After a variable is added however, the stepwise method looks at all the variables already included in the model and deletes any variable that does not produce on $F$ statistic at the slentry $= \text{Level}$. Only after this check is made and necessary deletions accomplished can another variable be added to the model. The stepwise process ends when none of the variables outside the model has on $F$ statistic significant at the slentry level and every variable in the model is significant at the slentry level, or when the variable to be added to the model is just deleted from it.
5. Factor analysis technique was used as a tool to select biomechanical measure. Out of extract biomechanical variables from 197, biomechanical variables for Ippon Seoi Nage and Morote Seoi Nage independently. These extracted biomechanical variables through phase-wise adopted stepwise regression procedure, would serve as a comprehensive kinematic and kinetic measures of Ippon Seoi Nage and Morote Seoi Nage.

The method of principle components analysis with latent root greater than one method of factor analysis was selected out of five factor analysis methods i.e. Principle components analysis, Principle factor analysis, Age analysis, Alpha factor analysis and Reo’s canonical factor method.

The correlation matrix of inter correlation among the extracted biomechanical variables was obtained by applying the pearson product moment formula, the data were then subjected to factor analysis utilizing the principle axis form of preliminary rotation as suggested by H.H.Harnian, to obtain unrotated and rotated factors.

The rotated matrix was selected for interpretation as recommended by Comery.

For rotated factors Kaiser's varimax criterion was used.

The rotated factor loading was obtained from orthogonal rotation. The variable having more than +3 loading on the factors were picked up to be included in the factor for its recognition and subsequent interpretation of the variables in the factor.

All the significantly loaded variables in a particular factor were subjected to stepwise regression procedure by treating total time and ratio of execution time and time of free falling body in turn as dependent variables to select the most predictive variables in a specific biomechanical factor or specific set of underlying biomechanical variables in Ippon Seoi Nage and Morote Seoi Nage.

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