Chapter -III

Methodology
CHAPTER-III

METHODOLOGY

Description of the experimental equipment and procedures used during this investigation are contained in this chapter. The procedures used in the investigation are organized in this chapter as follows:

Subjects

In order to do comprehensive analyses of biomechanical factors of Fosbury-flop high jump technique fifty (50) elite male high jumpers were selected as the subject for the study. The demographic information and training age of the selected subjects is present in the following table.

**Anthropometric Description of the Subjects**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>23.32</td>
<td>1.36</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>65.73</td>
<td>2.00</td>
</tr>
<tr>
<td>Height (cms)</td>
<td>179.44</td>
<td>2.20</td>
</tr>
<tr>
<td>Arm Length (cms)</td>
<td>79.98</td>
<td>1.61</td>
</tr>
<tr>
<td>Leg Length (cms)</td>
<td>92.28</td>
<td>2.47</td>
</tr>
<tr>
<td>Training Age (Years)</td>
<td>5.38</td>
<td>1.31</td>
</tr>
</tbody>
</table>
Selection of Subjects

The subjects for the study were selected from the 70th All India Intervarsity Athletic Championship held at Chennai, 2010 and 71st All India Intervarsity Athletic Championship held at Guntur, Andhra Pradesh, 2011. As delimited only those jumpers were selected who performed the Fosbury-flop high jump technique during the competitions. The random sampling technique was applied for selection of the subjects. All the selected subjects were right-handed Fosbury-flop jumpers. The subjects were initiated through concerned coaches, organizing secretary of the competitions and later direct contacts were made to obtain the relevant data.

Criterion Measures

In the Fosbury-flop high jump technique different parameters play a great role for success in the performance like psychology, physiology and anthropometry of the player, etc. but here researcher selected only the biomechanical parameters, and worked on it and try to find out the effect of selected biomechanical parameters on the success of high jump performance. The selected biomechanical variables in the study were as:

In Approach Run Phase

- Ankle angle
- Knee angle
Chapter-III: Methodology

- Hip angle
- Shoulder angle
- Elbow angle
- Linear velocity

In Take-off Preparation Phase

- Ankle angle
- Knee angle
- Hip angle
- Shoulder angle
- Elbow angle
- Last stride length

In Take-off phase

- Ankle angle
- Knee angle
- Hip angle
- Shoulder angle
- Elbow angle
- Linear velocity
- Angular velocity

In Flight phase

- Ankle angle
- Knee angle
• Hip angle
• Shoulder angle
• Elbow angle
• Linear velocity
• Angular velocity

In L-position phase
• Ankle angle
• Knee angle
• Hip angle
• Shoulder angle
• Elbow angle
• Linear velocity
• Angular velocity

In Landing phase
• Ankle angle
• Knee angle
• Hip angle
• Shoulder angle
• Elbow angle
• Linear velocity
• Angular velocity
Figure I: Elgon of Subject’s Fosbury-flop Technique in different Phases
Figure II: The Fosbury-flop high jump technique has many characteristics: approach-run, take-off preparation, take-off, flight, L-position and landing in respect to ankle joint linear velocity.
Chapter III: Methodology

Figure III: The Fosbury-flop high jump technique has many characteristics: approach-run, take-off preparation, take-off, flight, L-position and landing in respect to knee joint linear velocity.
Chapter-III: Methodology

Figure IV: The Fosbury-flop high jump technique has many characteristics: approach-run, take-off preparation, take-off, flight, L-position and landing in respect to hip joint linear velocity.
Figure V: The Fosbury-flop high jump technique has many characteristics: approach-run, take-off preparation, take-off, flight, L-position and landing in respect to shoulder joint linear velocity.
Figure VI: The Fosbury-flop high jump technique has many characteristics: approach-run, take-off preparation, take-off, flight, L-position and landing in respect to elbow joint linear velocity.
Figure VII: A strong pronation of the ankle joint at the take-off in high jump
Figure 8: Rotations of the body during take-off

Vertical Axis (Twist rotation)

Horizontal Axis (Forward somersault)

Frontal Axis (Lateral somersault)
Chapter-III: Methodology

Apparatus and Software Used

Data collection and biomechanical analysis demand specific tools and equipments to capture and analyze the data. The experimental apparatus used in this research work were as follows:

**Video Recording Camera and tripod**

For the purpose of this study two Sony DCR SX40E high speed video recording cameras operating at 1/2000Hz with a frame rate of 60 frames per second were used. The tripods were used to place the cameras on it.

**Analytic Software**

To analyze the recorded videos following software were use.

a) Silicon Coach Pro-7

b) STHVCD55 Software

c) SPSS 18
a) **Silicon Coach Pro-7:**

The Silicon Coach Pro-7 software for taking measurements from digital video and bitmap images. This software is intended for biomechanics or ergonomics; however, it may be useful for anyone in the fields of clinical use. Here are some of the features:

- Capture from two Mini DV cameras at the same time
- Supports multi-video formats: Including high speed video files, MPEG 2, MPEG 4 and AVCHD
Chapter-III: Methodology

- License Management System: Move your license from one PC to another PC

- Create presentations: Use simple-to-use templates and export as a high or low quality wmv, composited avi, to CD ROM, VCD (for playback on a DVD player), in Silicon coach player.

- Drawing Tools: By calibrating the video, drawing tool to use a range of angle and measurement tools.

- Analysis Tools: Use a range of angle and measurement tools to with various drawing and measurement tools available.
• Compare multiple videos: Synchronise multiple video clips for side-by-side or overlaid comparison (Compare up to 4 videos at the same time)

• Record verbal and visual feedback: over the top of a video.

• Screenshot, capture your onscreen analysis: and save as a jpeg that can be used in reports.

• Step through a video frame by frame.

• Calculate joint angles, linear and angular velocity

• Superimpose a grid over the image.

• Load MPEG, AVI, or QuickTime video files.

• Create a video snapshot of key frames.

• Print still images or copy the image into another program.
b) **STHVCD55 Software:**

This software was used to edit the recorded video clips.

c) **SPSS 18:**

SPSS 18 Software was used to calculate multiple linear regression to determine which variables were the best predictor of bar height, angle of segments during take-off preparation phase, take-off phase, flight phase, L position phase and landing phase and their velocity (linear and angular).

**Computer System**

Video recording camera was used to capture the movement of the selected athlete’s performance for further evaluation and analysis. The captured movement of the subjects was stored in computer for the review, identification and analyses with software. The captured performance and movements in the field setting directly downloaded into computer for further data analyses.

**Procedure of Biomechanical Analysis**

The investigator gleaned through both critical as well as allied literature related to the problem. Keep in mind the feasibility criteria, the facilities and equipments available in the Department of Physical Health and Sports Education, Aligarh Muslim University, Aligarh, for the analysis. The videography technique was adapted to biomechanical
analysis of Fosbury-flop high jump technique. This is probably the most adaptable method to analyze the kinematics variables.

**Preliminary Investigation**

Prior to the actual data collection a preliminary investigation conducted in order to tackle the possible hindrance concerning the experimental set-up. Applying the cameras positions and focuses setting. One high jumper was filmed while performing the Fosbury-flop high jump technique during the preliminary investigation.

**Experimental set-up**

One camera was placed at the tripod right side to the runway at the distance of ten meters, and filmed the whole of the steps of the approach. Another camera was placed at a distance of six meters perpendicular to the cross-bar, and filmed the jumpers from the last steps to landing. The camcorders mounted at a height of five feet from the ground and tilted down in order to get the image of the subject as large as possible while that all points of interested remained totally within movement.
Chapter-III: Methodology

Camera Speed

The cameras were set at sports mode and the sampling rates of the video cameras were sixty (60) frames per second. The shutter speed of the cameras were fixed at fast speed (1/2000 fast shutter speed allow fast-moving subject to capture one frame at a time vividly) in order to eliminate the blur while video recording. A fast shutter speed can freeze the motion of a fast-moving subject and a slow shutter speed can blur the subject to give the impression of the motion.

Data Acquisition

After the field setting the film recording process (data acquisition) started. The process conducted on the ground in a sunny day and the weather was clear and pleasant. All the subjects were wear a specific kit in order to perform Fosbury-flop high jump technique as per the requirement of the study. The data was recorded form movement onset to
the landing phase. Prior to data acquisition subjects asked to go for
general warm-up followed by specific warm-up i.e. different jumps trials.
When subjects warmed-up completely they again asked to go for
Fosbury-flop jump for three times on a set height. All attempts of the
subjects were recorded when they cleared the bar on a particular height
that was taken as successful jump and when they were unable to clear the
bar at the same height was considered as unsuccessful jump.

Subject and Trial Identifications

To identification the subject in the video graph, each subject was
given with a chest number, which were given by the all India intervarsity
organizing committee as to distinguish in the data recorded. For
identification purposes of a best jump, the trial viewed on the computer
system on the subject remarked the trial for the data acquisition. The
best jumps were spotted and edited for analysis.

Data Reduction and Analysis

After video recording sessions were over, the recorded videos were
loaded in to the researcher’s personal computer for trial identification.
The identified trials were played with the help of software STHVCD 55
to make separate clips of each player. The separate clips were then
opened on to the Silicon Coach Pro-7 (SCP-7) software. This software
provides to identify the angles, velocity, displacement, time and number of frames. The sequence of procedures that were followed:

**Analysis of Kinematical Variables via (Silicon Coach Pro-7 Motion Analysis) Software:**

**Determination of Shoulder Joint Angle**

To determine the shoulder joint angle recorded clips played in the software. The software has a provision to determine the angle of the body segment. First the angle tool was taken then the curser was click on the hip joint to the shoulder joint after that the curser was click on elbow joint. The software automatically generates the angle of shoulder joint.

**Determination Elbow Joint Angle**

To determine the elbow joint angle recorded clips played in the software. The identified clips of the selected subject were loaded onto the Silicon Coach Pro-7 software. To acquire data of elbow joint angle the anatomical lines drawn with the curser from shoulder joint to the elbow joint and after that the curser was click on the wrist joint then software automatically generate the angle of elbow joint.

**Determination of Hip Joint Angle**

Hip joint angle has been measured between anatomical line of femur and line drawing between shoulders joint to the hip joint. To
determine the shoulder joint angle recorded clips played in the software. To acquire data of hip joint angle lines were drawn with the curser from shoulder joint (over the head of humerus) to hip joint and after that the curser was click on the knee joint so we found the hip joint angle.

**Determination of Knee Joint Angle**

Knee joint permits only two movements, flexion and extension. Knee joint angle was measured between anatomical lines of the femur and tibia.

The identified clips of the selected subject were loaded onto the Silicon Coach Pro-7 motion analysis software. To acquire data of knee joint angle the anatomical lines were drawn with the curser from hip joint (over the greater trochanter of femur) to the knee joint (over lateral condyle of tibia) and then to the ankle joint over the lateral malleolus of fibula. So that the software generates the knee joint angle.

**Determination of Ankle Joint Angle**

Ankle joint permits two movements, dorsi flexion and planter flexion. When the ankle joint extend, causing the top of the foot draw away from the tibia bone, it is planter flexion.

The identified clips from of the selected subject were played into the Silicon Coach Pro-7 software. To acquire data of ankle joint angle lines were drawn with the curser from knee joint to the ankle joint over
the lateral malleolus of fibula and after that the cursor was put on to tip of the longest toe then we found an angle that is the ankle angle.

**Analysis of Linear Velocity via Software**

**Determination of Shoulder Joint Linear Velocity**

The linear velocity of the joints angle defines as the rate of change of displacement of joints from one phase to another phase. To calculate the linear velocity of shoulder joint from take-off preparation phase to take-off phase, take-off phase to flight phase, flight phase to L-position phase and L-position phase to landing phase was measured with respect to the shoulder joint displacement between these different phases; it comprised the change of position from start to the finish.

**Determination of Elbow Joint Linear Velocity**

The linear velocity of the joints angle defines as the rate of change of displacement of joints from one phase to another phase. To calculate the linear velocity of elbow joint from take-off preparation phase to take-off phase, take-off phase to flight phase, flight phase to L-position phase and L-position phase to landing phase was measured with respect to the elbow joint displacement between these different phases; it comprised the change of position from start to the finish.
Determination of Hip Joint Linear Velocity

The linear velocity of the joints angle defines as the rate of change of displacement of joints from one phase to another phase. To calculate the linear velocity of hip joint from take-off preparation phase to take-off phase, take-off phase to flight phase, flight phase to L-position phase and L-position phase to landing phase was measured with respect to the hip joint displacement between these different phases; it comprised the change of position from start to the finish.

Determination of Knee Joint Linear Velocity

The linear velocity of the joints angle defines as the rate of change of displacement of joints from one phase to another phase. To calculate the linear velocity of knee joint from take-off preparation phase to take-off phase, take-off phase to flight phase, flight phase to L-position phase and L-position phase to landing phase was measured with respect to the knee joint displacement between these different phases; it comprised the change of position from start to the finish.

Determination of Ankle Joint Linear Velocity

The linear velocity of the joints angle defines as the rate of change of displacement of joints from one phase to another phase. To calculate the linear velocity of ankle joint from take-off preparation phase to take-off phase, take-off phase to flight phase, flight phase to L-position phase
and L-position phase to landing phase was measured with respect to the ankle joint displacement between these different phases; it comprised the change of position from start to the finish.

**Analysis of Angular Velocity via Software**

**Determination of Shoulder Joint Angular Velocity**

The angular velocity of shoulder joint was calculated as: firstly the shoulder joint angles during take-off preparation, take-off, flight, L-position and landing phases were determined with the help of Silicon Coach Pro-7 motion analysis software. The changes in the angles from initial phase to the take-off phase and then between the other phases were calculated from the values generated by the software. Then determined angular velocity’s value of shoulder joint was divided by the time taken.

**Determination of Elbow Joint Angular Velocity**

The angular velocity of elbow joint was calculated as: firstly the shoulder joint angles during take-off preparation, take-off, flight, L-position and landing phases were determined with the help of Silicon Coach Pro-7 motion analysis software. The changes in the angles from initial phase to the take-off phase and then between the other phases were calculated from the values generated by the software. Then determined angular velocity’s value of elbow joint was divided by the time taken.
Determination of Hip Joint Angular Velocity

The hip joint angular velocity was calculated as: firstly the shoulder joint angles during take-off preparation, take-off, flight, L-position and landing phases were determined with the help of Silicon Coach Pro-7 motion analysis software. The changes in the angles from initial phase to the take-off phase and then between the other phases were calculated from the values generated by the software. Then determined angular velocity’s value of hip joint was divided by the time taken.

Determination of Knee Joint Angular Velocity

The angular velocity of knee joint was calculated as: firstly the shoulder joint angles during take-off preparation, take-off, flight, L-position and landing phases were determined with the help of Silicon Coach Pro-7 motion analysis software. The changes in the angles from initial phase to the take-off phase and then between the other phases were calculated from the values generated by the software. Then determined angular velocity’s value of knee joint was divided by the time taken.

Determination of Ankle Joint Angular Velocity

The angular velocity of ankle joint was calculated as: firstly the shoulder joint angles during take-off preparation, take-off, flight, L-position and landing phases were determined with the help of Silicon Coach Pro-7 motion analysis software. The changes in the angles from
initial phase to the take-off phase and then between the other phases were calculated from the values generated by the software. Then determined angular velocity’s value of ankle joint was divided by the time taken.

**Statistical Procedure**

Whenever a research conducted to ascertain something, to know the worthy result of that investigation, it is required to give an appropriate statistical treatment to the acquired data. In this study, the basic statistical parameters of all variables were computed in the first phase of data analysis. In the second part Multiple Linear Regression was applied to know this existing relationship. All statistical functions were performed with the SPSS (v.18) software. In all statistical analyses, the significance threshold was set at $p < 0.05$ with 48 degree of freedom.