APPENDICES

APPENDIX-A: Personal Data Sheet of the Subject
APPENDIX-B 1: Published Paper No. 1
APPENDIX-B 2: Published Paper No. 2
# APPENDIX- A

## Personal Data Sheet of the Subjects

<table>
<thead>
<tr>
<th>Sub No.</th>
<th>Name</th>
<th>Sex</th>
<th>Age (Yrs)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Level of achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>ANIMESH PANJA</td>
<td>Male</td>
<td>17</td>
<td>155</td>
<td>45</td>
<td>Represented India with National level medalist</td>
</tr>
<tr>
<td>02.</td>
<td>KARAM CHAND MURMU</td>
<td>Male</td>
<td>19</td>
<td>156</td>
<td>45</td>
<td>National level medalist</td>
</tr>
<tr>
<td>03.</td>
<td>PRASHANT SINGH</td>
<td>Male</td>
<td>17</td>
<td>165</td>
<td>54</td>
<td>National level medalist</td>
</tr>
<tr>
<td>04.</td>
<td>PULAK DAS</td>
<td>Male</td>
<td>20</td>
<td>165</td>
<td>54</td>
<td>National level medalist</td>
</tr>
<tr>
<td>05.</td>
<td>SUVANKAR DEY</td>
<td>Male</td>
<td>18</td>
<td>164</td>
<td>53</td>
<td>Represented India with National level medalist</td>
</tr>
<tr>
<td>06.</td>
<td>RAFIKUL ISLAM</td>
<td>Male</td>
<td>18</td>
<td>155</td>
<td>56</td>
<td>National level medalist</td>
</tr>
</tbody>
</table>
TAKE-OFF KINEMATICS OF BACKWARD SALTO IN 
FLOOR EXERCISE

Angsuman Banerjee* Sudarsan Bhowmick***

*Research scholar
***Professor, Department of Physical Education,
University of Kalyani, West Bengal, India

Abstract

Background: Backward take-off is one of the most important and frequently used components of Floor exercise routine in artistic gymnastics and can occur at any point of a routine.

Methodology: The purpose of the study was to investigate the biomechanical characteristics of dynamic take-off in backward salto performed by five male gymnasts in the floor exercise. Change of vertical and horizontal velocities during take-off and take-off angle were the selected kinematic parameters for analysis. The movement during take-off action was recorded by a videographic camera and the recorded movements were analyzed by using movement analysis software.

Result: Analysis of the data for male gymnasts revealed, that the mean vertical velocity of the body was 4.14 m/s (± 0.49) at active take-off and -1.26 m/s (± 1.36) at touch-down indicating a mean increase of 129%. The mean horizontal velocity of CM at touch-down was 1.44 m/s and horizontal velocity at take-off was zero. So, the mean decrease in horizontal velocity was 100% during take-off. The mean take-off angle was 71.6°.

Conclusion: Results of the study indicate that the take-off action of backward salto involved reduction in horizontal velocity and increase in vertical velocity.

Key words: Take-off kinematics, Backward salto, Floor exercise.

Introduction

In analyzing the back salto following a tumbling series, biomechanical considerations of the center of mass must be made to produce an efficient performance. Variables such as angle of attack (the angle at which the gymnast is at take-off with respect to the horizontal) and velocities at take-off must be calculated to provide an understanding of proper performance. The purpose of the take-off of the back salto is to project the gymnast to a maximum vertical height and allow the completion of one revolution about the mediolateral axis (Cornelius, 1996). Given this factor, one would expect to see a sizeable angle of attack,
high vertical velocities, and low horizontal velocities. According to Sands (1999), gymnastics
skills revolve around Newton's third law, the action-reaction principle. As is true in the back
salto, forceful blocking (e.g., little time on the ground and complete extension at take-off) off
the ground prior to flight would allow for maximum vertical height in the skill. However, it
has been shown that many gymnasts do not take advantage of this principle, tending to
show incomplete extension of their bodies during the take-off phase of many jumps and
skills (Sands, 1999). The vertical velocity achieved at take-off, along with how much time
the gymnast spends on the ground during the take-off phase, are important variables in the
amount of vertical height achieved by the gymnast. Greater lift is achieved with shorter take-
off times, although mathematically this would not seem to be the case, since the vertical lift is
expressed as vertical force multiplied by time (George, 1980; Schmidt, 1980). George
(1980) explains this paradox stating that the magnitude of vertical forces increases at a
proportionally greater rate as the time decreases. Accordingly, the position the gymnast is in
at take-off also relates to how high the gymnast will be projected, and at what angle. When
the feet come into contact with the ground at the end of the preceding skill the feet should be
behind the line of gravity so a backward rotation can ensue once the gymnast is off the
ground (George, 1980; Schmidt, 1980). Bowers, Fie, and Schmid (1981) support the idea
of pushing downward and forward on the ground in the opposite direction of intended
rotation to attain the desired skill. Angle of attack is mentioned as being less than 90° (Bowers,
et al., 1981; George, 1980); Hay (1993) states approximately 70° as optimal. The purpose
of this paper is to provide biomechanical information related to the take-off of a back salto
immediately after a round off has been performed.

Methodology

Five National level male Gymnasts with age ranged from 18-20 years, (average
weight 55.25kg and average height 163cm) were selected as subjects for the present study.
They had ten years training experience with the performance of senior national level.

In the present study the main task was to biomechanically analyze the take-off
action of forward salto where velocity, take-off angle and path of CM (Centre of Mass)
were considered as measuring criteria.

The subjects of the study were assembled in a hall and explained the purpose
of the study. Their anthropometric measurements viz. age, height, and weight were measured.
Subsequently, the take-off actions of the subjects were recorded using a video camera. This
recording was done observing all the principles of scientific filming. The camera was placed
on the left side of the subject. The lateral distance was 18.80 meters and the height of the camera was 1 meter. The camera axis was positioned at the perpendicular direction of the movement. The camera frequency was 30 fps. Finally, the recorded movements of the subjects were analyzed by using appropriate software.

The data were collected in two phases. In first phase the selected anthropometric measurements such as age, height, and weight were taken in a rest condition and in the second phase mechanical parameters such as horizontal velocity during take-off, vertical velocity during take-off, angle of take-off foot and trunk at touchdown, angle of take-off foot and trunk at take-off, and movement of CM in horizontal and vertical direction during take-off were measured during jumping.

Results and Discussion

Velocity of take-off was measured both in horizontal as well as vertical directions for both touchdown as well as active stretching phases of total movement structure of take-off.

Table-I show the values of horizontal velocity at touch down and take-off of the subjects of the group along with mean and SD values.

**Table-1 : Horizontal Velocity of CM during Take-off of backward salto**

<table>
<thead>
<tr>
<th>Sub. No.</th>
<th>Horizontal Velocity(m/s)</th>
<th>Decrease in velocity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Touch-down</td>
<td>Take-off</td>
</tr>
<tr>
<td>1</td>
<td>0.9</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>0.9</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>2.7</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>1.8</td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
<td>0.0</td>
</tr>
<tr>
<td>Mean</td>
<td>1.44</td>
<td>0.0</td>
</tr>
<tr>
<td>SD</td>
<td>± 0.80</td>
<td>±0.0</td>
</tr>
</tbody>
</table>

Results revealed from Table-I that the Horizontal Velocity at touch-down of CM for backward salto is 1.44 m/s (±0.80). The Horizontal Velocity at take-off of CG for backward salto is 0.00 m/s (±0.00). The Horizontal Velocity at take-off decreases by 100%.

Table-2 shows the values of Vertical velocity at touch down and take-off of the subjects of the group along with mean and SD values.
Table-2 : Vertical Velocity of CM during Take-off of backward salto

<table>
<thead>
<tr>
<th>Sub. No.</th>
<th>Vertical Velocity(m/s)</th>
<th>Increase in velocity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Touch-down</td>
<td>Take-off</td>
</tr>
<tr>
<td>1</td>
<td>-2.7</td>
<td>4.5</td>
</tr>
<tr>
<td>2</td>
<td>0.0</td>
<td>4.5</td>
</tr>
<tr>
<td>3</td>
<td>-2.7</td>
<td>4.5</td>
</tr>
<tr>
<td>4</td>
<td>-0.9</td>
<td>3.6</td>
</tr>
<tr>
<td>5</td>
<td>0.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Mean</td>
<td>-1.26</td>
<td>4.14</td>
</tr>
<tr>
<td>SD</td>
<td>± 1.36</td>
<td>± 0.49</td>
</tr>
</tbody>
</table>

In the respect of Vertical Velocity at touch-down of CM for backward salto is -1.26 m/s (±0.136). The Vertical Velocity at take-off of CG for forward salto is 4.14 m/s (±0.49). The Vertical Velocity at take-off increases by 129%.

Table III shows the take-off angles of all the subjects of the groups.

Table-3 : Angle of Take-off of backward salto

<table>
<thead>
<tr>
<th>Group</th>
<th>Forward salto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub. No.</td>
<td>1</td>
</tr>
<tr>
<td>Take-off angle in degrees</td>
<td>71°</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
</tr>
</tbody>
</table>

The take off angle of backward salto followed by round-off in male artistic gymnastics is 72°

Conclusion

Results of the study indicate that the take-off action of backward salto involved reduction in horizontal velocity and increase in vertical velocity. This may be due to the fact that the purpose of take-off is to convert the horizontal velocity to the vertical velocity for lifting the body to a considerable height so that the gymnast can get required time to execute
the skill during airborne position. Comparing to the take-off for long jump it is seen that the percentage of conversion in this case is much higher for vertical velocity and considerably lower for horizontal velocity to meet the specific demand of the situation.

References


APPENDIX-B: 2
Published Paper No. 2

UNMESH

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A COMPARATIVE STUDY ON BIOMECHANICAL ANALYSIS OF TAKE-OFF TECHNIQUE IN FORWARD SALTO AND LONG JUMP

*Angsuman Banerjee  **Sauvik Ghosh  ***Sudarsan Bhowmick

ABSTRACT

Take-off action in Forward Salto differs from Long Jump in many respects. A good number of studies have been attempted for biomechanical analysis of movements of take-off action of Long Jumping. But there has been a very little attention for the comparative analysis of movements of take-off action of Forward Salto with Long Jump. Present study was conducted to compare kinematic parameters of the Take-off action of Forward Salto and Long Jump. The action of the Forward Salto and Long Jump of four male Sub Junior National Level Gymnasts and Sub Junior National Level Athletes were recorded by a Video Camera using the basic principles of scientific photography. Analysis of movements was done by freeze frame technique. Duration of take-off, change of Vertical and Horizontal Velocities during take-off and Angle of take-off were the selected mechanical parameters for analysis. Results revealed that the Horizontal Velocity at touch-down of Cg for forward salto is 2.90 m/s (±0.13) and long jump is 9.78 m/s (±0.32). The Horizontal Velocity at take-off of Cg for forward salto is 1.88 m/s (±0.17) and for long jump is 8.82 m/s (±0.49). The Horizontal Velocity at take-off decreases by 35.03% for forward salto and that of for long jump decreases by 9.82%. So, the reduction in Horizontal Velocity during take-off in forward salto is 25.21% more than that of long jump. In the respect of Vertical Velocity at touch-down of Cg for forward salto is -0.98 m/s (±0.46) and long jump is -1.08m/s (±0.31). The Vertical Velocity at take-off of Cg for forward salto is 1.59m/s (±0.86) and long jump is 2.37m/s (±0.12). The Vertical Velocity at take-off increases by 287.83% for forward salto and that of for long jump increases by 336.30%. The Vertical Velocity at take-off in long jump is 48.47% more than that of forward salto. The take off angle of forward salto in gymnastics is 62.25° and the take off angle of long jump in athletics is 56.50° with respect to horizontal. Therefore the take off angle in forward salto is 5.75° more than that in long jump. It was concluded that, during take-off horizontal velocity decreases and vertical velocity increases for both forward salto and long jump, decrease in horizontal velocity for forward salto is more than long jump and take-off angle for forward salto is more than that of long jump.

Key Words: Take-off, Forward Salto, Long Jump, Biomechanical analysis, Cg.
INTRODUCTION

Movement analysis of an activity is an important aspect of biochemical research. This approach has been widely used in the field of gymnastics also.

The great majority of floor exercises in gymnastics consist of jumping/rotating elements interconnected by simpler transitional skills. Understandably then, most research in floor exercises examines the take-off and (on occasion) landing characteristics of various types of somersaults. Thus for example, Hwang, Seo and Liu (1990) investigated take-off mechanics of three different types of forward somersaults performed at the 1988 Seoul Olympic Games including the contribution of the different body parts to the total angular momentum for the required spin. It was found that, in all cases, the legs’ contribution to the total angular momentum was dominant. Similar take-off mechanics was studied by Kerwin, Webb & Yeadon (1998) who investigated the production of angular momentum in forward somersaults performed during the 1996 Olympics. Angular momentum and center of mass (CM) or centres of gravity (Cg), kinematics of single and double forward somersaults were investigated by Brüggemann (1983). Most recently, take-off and landing characteristics of double forward somersaults on the floor performed at the 1994 World gymnastics championship were studied by Geiblinger, Morrison and McLaughlin (1995a; 1995b); the results presented were in agreement with previous literature. For scientific investigation Forward somersaults have received much attention. Russian once favored by the majority of gymnasts, has been studied by Knight, Wilson and Hay (1978) who concentrated mainly on the action of the arms. Ground reaction forces for the Russian type of somersaults were also examined by Miller and Nissinen (1987) in order to investigate their characteristics in relation to performance. In summary, there is a wealth of information and good understanding of somersault’ take-off requirements.

The total structure of movement of Forward Salto has four distinctive phases: approach; take-off, execution and landing. Though execution is the main part of the technique, it is agreed that the performance of execution is largely dependent on take-off.

Take off is also an important phase of running broad jump, an important event in Track & Field athletics. The purpose here is to generate more vertical velocity keeping the loss of horizontal velocity as low as possible.

As the take-off is a common phase for both the events, it appears to be an interesting topic to study the difference between both the situations in respect of mechanical parameters. Present study was planned to analyze the take-off action of Forward Salto and Long Jump in respect of selected mechanical parameters.
METHODOLOGY

Four Sub Junior National level male Gymnasts with average age of 13.25 years, weight of 35.25kg and height of 147cm respectively and four Sub Junior National level male Long Jumpers with average age of 13.75 years, weight of 38 kg and height of 149.75cm respectively, were selected as subjects for the present study. They had five years training experience with the performance of own specialized subject area. The selected mechanical parameters for analysis in present study were velocity and angle take-off and the path of Cg during take-off action.

The take-off actions of the subjects were recorded using a video camera. This recording was done observing all the principles of scientific filming. The camera was placed on the left side of the subject. The lateral distance was 4.57 meters and the height of the camera was 106 centimeters. The camera axis was positioned at the perpendicular direction of the movement. The camera frequency was 24 fps. Finally, the recorded movements of the subjects were analyzed by using Adobe Premiere Pro CS3 (Version 3.0.0) software.

Selected mechanical parameters were velocities both in horizontal and vertical directions, and take-off angle of Cg.

FIGURE - 1

TAKE-OFF ACTION OF FORWARD SALTO

[Diagram with labels: 1 = Touch Down, 2 = Ammortization, 3 = Take off]
Fig-1 and Fig-2 denotes the angle at touch-down and the angle of take off action of Forward salto and Long jump respectively.

RESULTS & DISCUSSION

Table-I and Table-II show the values of horizontal velocity at touch down and take-off of the subjects of both the groups along with mean and SD values. Table -III shows the differences in horizontal velocity of Cg during Take-off between Forward salto and Long jump.

TABLE -1

CHANGE OF HORIZONTAL VELOCITY OF CG DURING TAKE-OFF OF FORWARD SALTO

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FORWARD SALTO</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SUB NO.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>MEAN</td>
<td>SD</td>
</tr>
<tr>
<td>T. D. Velocity (m/s)</td>
<td>3.02</td>
<td>3.02</td>
<td>2.68</td>
<td>2.88</td>
<td>2.90</td>
<td>±0.13</td>
</tr>
<tr>
<td>T. O. Velocity (m/s)</td>
<td>2.01</td>
<td>1.68</td>
<td>1.68</td>
<td>2.16</td>
<td>1.88</td>
<td>±0.17</td>
</tr>
<tr>
<td>Decrease in Velocity (%)</td>
<td>33.44</td>
<td>44.37</td>
<td>37.31</td>
<td>25.0</td>
<td>35.03</td>
<td></td>
</tr>
</tbody>
</table>

Results revealed from Table-I that the mean & S.D. of Horizontal Velocity at touch-down and at take-off of Cg for forward salto was 2.90 m/s (±0.13) and 1.88 m/s (±0.17) respectively. The mean Horizontal Velocity at take-off decreased by 35.03% for forward salto.
TABLE - 2
HORIZONTAL VELOCITY OF CG DURING TAKE-OFF OF LONG JUMP

<table>
<thead>
<tr>
<th>GROUP</th>
<th>SUB NO.</th>
<th>LONG JUMP</th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>T. D. Velocity (m/s)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>9.87</td>
<td>9.73</td>
<td>10.16</td>
<td>9.38</td>
</tr>
<tr>
<td>T. O. Velocity (m/s)</td>
<td>8.4</td>
<td>8.46</td>
<td>9.46</td>
<td>8.96</td>
</tr>
<tr>
<td>Decrease in Velocity (%)</td>
<td>14.89</td>
<td>13.05</td>
<td>6.89</td>
<td>4.47</td>
</tr>
</tbody>
</table>

Results revealed from Table-II that the mean & S.D. of Horizontal Velocity at touch-down and at take-off of Cg for long jump is 9.78 m/s (±0.32) and 8.82 m/s (±0.49) respectively. The mean Horizontal Velocity at take-off decreased by 9.82% for long jump.

TABLE - 3
DIFFERENCE IN HORIZONTAL VELOCITY OF CG DURING TAKE-OFF BETWEEN FORWARD SALTO

<table>
<thead>
<tr>
<th>FORWARD SALTO</th>
<th>LONG JUMP</th>
<th>DIFFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.03 %</td>
<td>9.82 %</td>
<td>25.21 %</td>
</tr>
</tbody>
</table>

Results revealed from Table- III that the reduction in mean Horizontal Velocity during take-off in forward salto is 25.21% more than that of long jump.

Table-IV and Table-V show the values of Vertical velocity at touch down and take-off of the subjects of both the groups along with mean and SD values. Table -VI show the differences in Vertical Velocity of Cg during Take-off between Forward salto and Long jump.
### TABLE - 4

VERTICAL VELOCITY OF CG DURING TAKE-OFF OF FORWARD SALTO

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FORWARD SALTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUB NO.</td>
<td>1</td>
</tr>
<tr>
<td>T. D. Velocity (m/s)</td>
<td>1.08</td>
</tr>
<tr>
<td>T. O. Velocity (m/s)</td>
<td>1.34</td>
</tr>
<tr>
<td>Total T. O. Velocity (m/s)</td>
<td>2.42</td>
</tr>
<tr>
<td>Increase in Velocity (%)</td>
<td>224.07</td>
</tr>
</tbody>
</table>

Results revealed from Table-IV that, mean & S.D. of Vertical Velocity at touch-down and take-off of Cg for forward salto is -0.98 m/s (±0.46) and 1.59 m/s (±0.86) respectively. However, the mean and S.D. of total Take off velocity were 2.57 m/s and ±1.23 respectively. The mean Vertical Velocity at take-off increases by 287.83% for forward salto.

### TABLE - 5

VERTICAL VELOCITY OF CG DURING TAKE-OFF OF LONG JUMP

<table>
<thead>
<tr>
<th>GROUP</th>
<th>LONG JUMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUB NO.</td>
<td>1</td>
</tr>
<tr>
<td>T. D. Velocity (m/s)</td>
<td>−1.31</td>
</tr>
<tr>
<td>T. O. Velocity (m/s)</td>
<td>2.40</td>
</tr>
<tr>
<td>Total T. O. Velocity (m/s)</td>
<td>3.71</td>
</tr>
<tr>
<td>Increase in Velocity (%)</td>
<td>283.70</td>
</tr>
</tbody>
</table>

Results revealed from Table-V that, mean and S.D. of Vertical Velocity at touch-down and take-off of Cg for long jump is -1.08 m/s (±0.31) and 2.37 m/s (±0.12) respectively. However, the mean and S.D. of total Take off velocity were 3.46 m/s and ±0.23 respectively. The mean Vertical Velocity at take-off increases by 336.30% for long jump.
### TABLE - 6
DIFFERENCE IN VERTICAL VELOCITY OF CG DURING TAKE-OFF BETWEEN FORWARD SALTO & LONG JUMP

<table>
<thead>
<tr>
<th>LONG JUMP</th>
<th>FORWARD SALTO</th>
<th>DIFFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>336.30 %</td>
<td>287.83 %</td>
<td>48.47 %</td>
</tr>
</tbody>
</table>

Results revealed from Table-VI that, the mean Vertical Velocity at take-off increases by 287.83% for forward salto and that of for long jump increases by 336.30%. The Vertical Velocity at take-off in long jump is 48.47% more than that of forward salto.

### TABLE - 7
DIFFERENCE BETWEEN ANGLE OF TAKE-OFF OF FORWARD SALTO AND LONG JUMP

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FORWARD SALTO</th>
<th>LONG JUMP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>TAKE-OFF ANGLE IN DEGREES</td>
<td>55° 72° 62° 60°</td>
<td>60° 54° 55° 57°</td>
</tr>
<tr>
<td>MEAN</td>
<td>62.25°</td>
<td>56.50°</td>
</tr>
<tr>
<td>DIFFERENCE</td>
<td></td>
<td>5.75°</td>
</tr>
</tbody>
</table>

The mean take off angle of forward salto in gymnastics is 62.25° (Fig-1) and the mean take off angle of long jump for athletes was 56.50° (Fig-2) with respect to horizontal. Therefore, the take off angle for forward salto was 5.75° more than that of long jump.

Analysis of the data revealed that the important factor determining the height of long jump and forward salto was the increase in vertical velocity of the CG which at take-off was 336.30% and 287.83% (Table-VI) respectively. The Vertical Velocity at take-off in long jump is 48.47% more than that of forward salto (Table-VI).

This difference was produced because forward salto has a skillful aesthetic value and after that it has to land on both legs. But in long jump, the main purpose is how to cover the more distance. The vertical velocity value for the gymnasts was lower than the jumpers in this study might be due to completion of the selected element taken for this study.
The mean Horizontal Velocity at take-off decreased by 35.03% for forward salto and 9.82% in long jump respectively. So, the reduction in Horizontal Velocity during take-off in forward salto was 25.21% more than that of long jump. It shows a typical characteristic of Take off for forward salto in gymnastics does not require higher velocity like long jump. A controlled and balanced take-off may help to achieve optimal height of particular movement with both feet landing.

The mean take off angle of Cg for forward salto was 5.75° more than that of long jump, because forward salto does not require to achieve more horizontal distance but to gain vertical height.

**CONCLUSION**

On the basis of the results of the present investigation, the following conclusions were drawn:

(i) During take-off horizontal velocity decreases and vertical velocity increases for both forward salto and long jump;

(ii) Decrease in horizontal velocity for forward salto is more than long jump;

(iii) Increase in vertical velocity for long jump is more than forward salto;

(iv) Take-off angle for forward salto is more than that of long jump.

(v) In general the horizontal and vertical velocity of Long jump is more than Forward salto in gymnastics.

**REFERENCE**


Appendix 120

- Huang, Chen-fu and Hsu, Gm-Shu. Biomechanical analysis of gymnastic back handspring.