International Journal of Physical Education, Sports and Health 2016; 3(2): 93-96

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 4.69
IJPESH 2016; 3(2): 93-96

www.kheljournal.com
Received: 22-01-2016
Accepted: 26-02-2016

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Kinematic analysis of angular velocity of take-off action between backward Salto in floor exercise and handspring vault in vaulting table in national level gymnasts

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Abstract
Angular velocity (AV), also called rotational velocity, is a quantitative expression of the amount of rotation that a rotating object undergoes per unit time. Here researchers wanted to find; by the performance of six national level gymnasts in the gymnasium of SAI at Salt Lake City, Kolkata; AV of Take-off action between Backward Salto in Floor Exercise and Handspring Vault in Vaulting Table used by Video camera and Silicon Coach Lite Live Software. It is to be seen that in this study, AV of the Main body at Push-off phase for Backward Salto (13.25 rad/s) was much greater than that of Handspring Vault (6.72 rad/s). Mean AV at Main body (Cg) at Push-off phase in Backward Salto and Handspring Vault shown significant statistical difference. Researcher can concluded by the result of this study that, changes of Angular Velocity of the body are faster in Backward Salto than Handspring Vault.

Keywords: Kinematic analysis, Angular velocity, Take-off action, Backward salto, Floor Exercise, Handspring Vault, Vaulting table.

Introduction
Angular velocity, also called rotational velocity, is a quantitative expression of the amount of rotation that a rotating object undergoes per unit time. It is a vector quantity, consisting of an angular speed component and either of two defined directions or senses. In this case Backward Salto in Floor Exercise and Handspring vault in Table Vaulting both were rotational movements in air born position in Men's Artistic Gymnastics and women's also so, the angular velocity was very much influenced by Push-off phase of the total take-off action.

Materials and methods
Six (6) male artistic gymnasts with average age of 18.17 years, average height of 160 cm and average body weight of 51.17 kg were selected as subjects for the present study. They were active gymnasts and were selected through "Talent search selection trial" by Sports Authority of India (SAI), Netaji Subhash Eastern Centre, Salt Lake City, Kolkata, West Bengal. They had been trained there as the trainee boarders for five years by qualified SAI coaches. They all had ten years of training experience. All of them had participated in the Men's senior level National Artistic Gymnastics competition as the members of West Bengal Gymnastics Team and won medals.
The purpose of this study was to analyze the take-off action for different gymnastics events on the basis of laws and principles of kinematics. Selected kinematic parameters for study and for analysis was "Angular velocity of the Main body (Cg) during Push-off phase of Take-off".
For collection and analysis of data the following instruments were used:

- A Video camera was used for recording movements. This camera was manufactured by Sony, Japan;
- The recorded movements were frame to frame analyzed by Silicon coach Lite Live online software and Adobe Premiere Pro CS3 (3.0.0) software;
- A double flexed standard Floor Exercise arena manufactured by Gymnova, USA was used for take-off of Backward Salto;

- A Springboard and Table Vault, both manufactured by Gymnova, USA were used for take-off of Handspring Vault;
- A Stadiometer was used for measuring height in meter.
- A Weighing machine was used for measuring weight in kg.
- Necessary materials and equipments were used like measuring scale, protector, pointer of joints, graph papers, one meter reference stick used as reference frame, running mats and 5 cm and 10 cm landing mats for Table Vault.

The subjects of the study were at first assembled in a hall and explained the purpose of the study. There anthropometric measurements were taken at first. Subsequently, the take-off actions of the subject were recorded using a Video camera. Finally, the recorded movement of the subjects were analyzed by using Silicon coach Lite Live online software and Adobe Premiere Pro CS3 (3.0.0) software.

Videographic technique was use to measure selected kinematic parameters. This was done in two successive phases. In first phase the recording of movement was done by a Video camera. This recording was done by following all the principles of scientific recording. The camera was placed on the left side of the subject. The lateral distances were 11 m for Floor Exercise and 6 m for Table Vault. Height of the camera lens was 1 m in both the axes. The camera axis was positioned at the perpendicular direction of the movement.

In second phase recorded movement was displayed by a laptop. Silicon coach Lite Live online software and Adobe Premiere Pro CS3 (3.0.0) software were used to observe the display from frame to frame. Kinegram of each execution was developed by Silicon coach Lite Live online software and by Adobe Premiere Pro CS3 (3.0.0) software.

Obtained data were analyzed using Microsoft Office Excel 2007 for statistical procedure. The mean and Standard deviation were calculated as the measure of Central tendency and Variability respectively and 't' test was calculated as the measure of Difference between two mean.

Results & Discussion

The Angular velocity at Main body (Cg) at Push-off (P.O.) phase of total take-off in Backward Salto has been shown in Fig. 1.

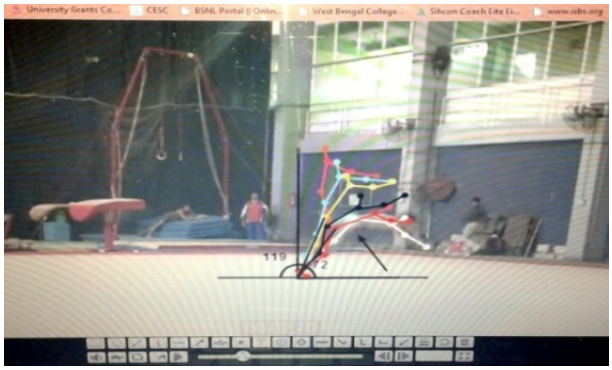

Fig 1: Angular velocity of the Main body (Cg) in Push-off phase in Backward Salto

This figure indicates the different angular positions of Angular velocity of Main body (Cg) for Push-off phase of Backward Salto and the direction of movement have been pointed by a black arrow mark.

The data of Angular Velocity of the Main body (Cg) during Push-off phase for all the subjects for Backward Salto have been presented in Table 1.

Table 1: Angular Velocity at Main body (Cg) at Push-off phase in Backward Salto

Name	Angular Velocity (rad)
Subject 1	9.70
Subject 2	7.71
Subject 3	10.64
Subject 4	19.55
Subject 5	15.90
Subject 6	16.00
Mean	13.25
S. D.	±4.56

It is seen from the table that the Angular Velocity at Main body (Cg) at Push-off phase for these subjects varied from 19.55 rad/s to 7.71 rad/s. The mean value of Angular Velocity at Main body (Cg) at Push-off phase was 13.25 rad/s with the S.D. of ± 4.56 rad/s. According to Cuk *et al* (2000) and Heinen *et al* (2011) the mean value of Angular Velocity were 35.7 rad/s and 36.17rad/s respectively. It is clear from the results that the Subject No. 4 was quickest in Angular Velocity at Main body (Cg) at Push-off phase with Velocity of 19.55 rad/s and Subject No. 2 was the slowest in Angular Velocity at Main body (Cg) at Push-off phase with Velocity of 7.71 rad/s.

The Angular velocity at Main body (Cg) at Push-off (P.O.) phase of total take-off in Handspring Vault has been shown in Fig. 2.

Fig 2: Angular velocity of the Main body (Cg) in Push-off phase in Handspring Vault

Above figure indicates the different angular positions of Angular velocity of Main body (Cg) for Push-off phase of Handspring Vault and the direction of movement have been pointed by a black arrow mark.

The Angular Velocity at Main body (Cg) at Push-off phase for all the subjects for Handspring Vault, has been presented in Table 2.

Table 2: Angular Velocity at Main body (Cg) at Push-off phase in Handspring Vault

Name	Angular Velocity (rad)
Subject 1	6.78
Subject 2	6.66
Subject 3	8.10
Subject 4	8.00
Subject 5	3.71
Subject 6	7.08
Mean	6.72
S. D.	±1.59

It is seen from the table that the Angular Velocity at Main body (Cg) at Push-off phase for these subjects varied from 8.10 rad/s to 3.71 rad/s. The mean value of Angular Velocity at Main body (Cg) at Push-off phase was 6.72 rad/s with the S.D. of ± 1.59 rad/s. According to Chen *et al*. (2009) the mean value of Angular Velocity of Push-off phase was 1.62 rad/s. It is clear from the results that the Subject No. 3 was quickest in Angular Velocity of the Main body (Cg) at Push-off phase with Velocity of 8.10 rad/s and Subject No. 5 was the slowest in Angular Velocity of the Main body (Cg) at Push-off phase with Velocity of 3.71 rad/s.

The Angular Velocity at Main body (Cg) at Push-off phase for Backward Salto and Handspring Vault have been presented in Fig. 3.

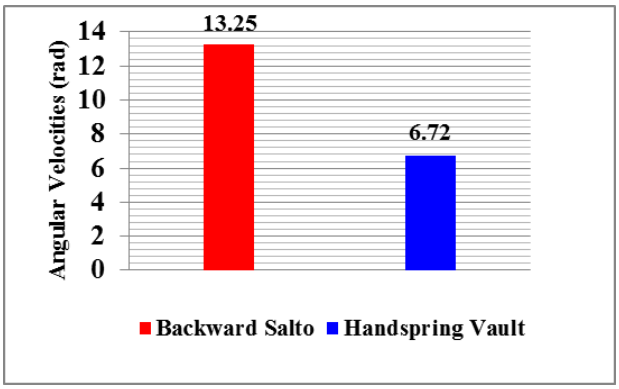

Fig 3: Mean angular Velocity at Main body (Cg) at Push-off phase in Backward Salto and Handspring Vault

It is to be noted that the mean Angular Velocity at Main body (Cg) at Push-off phase was much quicker in Backward Salto than Handspring Vault.

Table 3: Testing Statistical significance between mean value of selected kinematic parameters between Backward Salto (B S) and Handspring Vault (HPV)

Mean value of		Mean difference	't' value (df=10)	Significant at 0.01 level
B S	H P V	6.53	3.31	Significant
13.25	6.72			

Angular Velocity of the Main body at Push-off phase for Backward Salto (13.25 rad/s) was much greater than that of Handspring Vault (6.72 rad/s). Mean angular Velocity at Main body (Cg) at Push-off phase in Backward Salto and Handspring Vault shown significant statistical difference. According to Chen *et al.* (2009) the mean value of Angular Velocity of Push-off phase was 1.62 rad/s. Changes of Angular Velocity of the body are faster in Backward Salto than Handspring Vault.

Conclusions

The aim of the study was to compare the mechanical effects which was Angular velocity of two airborne rotations (Backward Salto and Handspring Vault) used in the take-off phase of two different Salto prior to the completion of the Backward Salto and Handspring Vault. It ultimately aimed to identify the connection that resulted in a more efficient performance of the skill. The angular velocity of Backward Salto allowed greater angular displacement and momentum, while the Handspring Vault allowed better vertical displacement and lower angular velocity. This difference in velocity could be related to the type of the Push-offs the gymnasts used in the total Take-off phase during the somersault. The direction of the reaction forces was different between the two Salto. Finally, the results of the present study may be intimated to the concerned Artistic gymnasts and their coaches as an effective feedback to understand the existing errors in the technique and to locate the possibility of improvement, however, each technique could provide specific benefits to the gymnasts: analysis of the results suggests that changes of Angular Velocity of the body are faster in Backward Salto than Handspring Vault.

Acknowledgments

The researcher feels immense pleasure to express his deepest sense of gratitude and regards to Dr. Sudarsan Bhowmick, Professor, Department of Physical Education, University of Kalyani for his affection, wise counseling, valuable advice in planning of the research paper, guidance and supervision throughout the study and preparation of the report.

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