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A Kinematic Study of Back Tuck Somersault Take off Following Round off on the Floor Exercise

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Abstract
Introduction: Backward take-off is one of the most important and frequently used components of a floor exercise routine in artistic gymnastics and can occur at any point of a routine.**Methods**: The purpose of the study was to investigate the biomechanical characteristics of dynamic take-off in backward salto performed by the five Indian Senior National Level male artistic gymnasts on the floor at the practice session in Sports Authority of India Training Centre, Salt Lake, Kolkata. **Results and Discussions**: Data was captured at 24 frames /sec by two video cameras which permitted the calculation of kinematic data. Analysis of the data for male gymnasts revealed, that the most important performance factor determining salto height was the mean vertical velocity of the CG, at 4.11m/s at take-off. The mean horizontal velocity at touch-down was 6.92m/s and decreased to 2.61m/s at take-off and the mean take-off period was 0.14 sec. The mean touch-down angles and mean take-off angles of the CG to ground contact and the horizontal were 14.2˚±5.89 and 83.2˚±5.49. **Conclusion**: The study indicates that the take-off action of backward salto involved reduction in horizontal velocity and increase in vertical velocity which is due to the conversion of horizontal velocity to vertical velocity for lifting the body to a considerable height so that the gymnast can execute the skill during air borne position.
Keywords: Kinematic analysis, backward salto, Take-off, Floor exercise, CG.

Introduction

The most difficult acrobatic movements on floor depend upon the efficient execution of the transition skills, the round-off which acts as accelerators prior to take-off. The backward take-off initiates the linear and rotational impulses for salto with various body positions. The aim of the take-off for salto in the backward direction on floor is the optimization of take-off velocities by attaining a large amount of kinetic energy necessary to achieve a large magnitude of angular momentum. By and far the most comprehensive studies on backward take-off on Floor have been provided by Brueggemann (1983, 1987 and 1994), Knoll and Krug (1989) and Hwang et al. (1990). One of the purposes of Brueggemann's investigations was to determine the contributions of the arms, the trunk and the legs to total angular and linear momentum of the body. He also employed force platforms to record ground reaction forces (GRF) during the support phase (touch-down to take-off). The legs and trunk were responsible for the majority of the impulse exerted against the ground during take-off. The contribution of the legs, which was approximately twice that of the trunk, was due to their large mass. Therefore the accurate positioning of the legs at touch-down was of considerable importance in order to control the angular velocity of the body. Knoll and Krug, (1989) reported results from selected acrobatic series performed by male and female gymnasts during the gymnastics world championships in Stuttgart 1989. They concluded, that the most important factors at take-off for a successful salto were jumping height and angular momentum. In all cases the legs played the dominant role in contributing to the total angular momentum during take-off. Newton et al. (1993) reported on selected biomechanical data of the triple back salto on a single acrobat, gathered as part of an ongoing study in automated 3-D analysis. Their findings showed a 29% increase in vertical velocity at take-off over that reported for double back giving a 57% increase in height reached by the centre of gravity. For the above reason present study was planned to analyze the take-off action of backward Salto with respect of selected mechanical parameters.

Methodology

Sample

Five National level male Gymnasts with average age of 18 years, average weight of 51.17 kg and average height of 160 cm were selected as subjects for the present study. They had ten years of training experience of

participation at Indian senior national level gymnastics championship.

Procedure

In the present study the main task was to kinematically analyze the take-off action of backward salto where velocity, take-off angle and path of Centre of Mass (CM) or Cg were considered as measuring criteria. The subjects of the study were first assembled in their practice 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 11mt. and the height of the camera was 1mt. The camera axis was positioned at the perpendicular direction of the movement. The camera frequency was 24 frames /sec. Finally, the recorded movements of the subjects were analyzed by using Adobe Premiere Pro CS3 (Version 3.0.0) 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 and touch-down, vertical velocity during take-off and touch-down, angle of Cg during take-off and touch-down were measured during jumping.

Statistical Treatment

Only mean and standard deviation were computed to analyze the data.

Results

The "take-off phase" is defined as the elapsed time from touch-down (from round-off or first frame of foot contact) to take-off (first frame of ground contact). Table-1 and Table-2 show the values of horizontal velocity at touch down and take-off and vertical velocity at touch down and take-off of the subjects along with mean, SD and percentage of decrease or increase values. And Table–3 shows the touch-down and take-off angles of Cg during Take-off of backward salto.

Results revealed from Table-1 that the mean & S.D. of Horizontal Velocity at touch-down and at take-off of Cg for Backward salto was 6.92 m/s (±1.82) and 2.61 m/s (±2.91) respectively. The mean Horizontal Velocity at take-off decreased by 62.28% for backward salto.

Results revealed from Table-2 that the mean & S.D. of Vertical Velocity at touch-down and at take-off of Cg for Backward salto was -3.92 m/s (±1.22) and 4.11 m/s (±1.82) respectively. The mean Vertical Velocity at take-off increased by 204.84% for backward salto.

Results revealed from Table-3 that the mean height of the Cg at touch-down and take-off during backward salto was 0.78mt. and 1.05mt. in Backward salto take-off.

Results revealed from Table-4 that the angle formed by the Cg to ground contact (toes) and the horizontal was measured at touch-down and take-off and referred to as touch-down and take-off angle. The mean and SD of touch-down and take-off angle of Backward salto in gymnastics is 14.2˚ (±5.89) and 83.2˚ (±5.49) respectively. And the mean duration of the take-off phase was 0.14 sec. in backward salto.

Discussion and Conclusion

Analysis of the data revealed, that the most important performance factor determining salto height was the mean and SD of vertical velocity of the Cg which at take-off was 4.11m/s ± 1.82. This was apparent in the maximum Cg height during the salto and was measured at 1.37m/s ± 0.15. The higher values of mean maximum Cg height during the salto for males was due to a combination of several performance factors such as angle of Cg to ground contact and horizontal, and faster leg extension. The vertical velocity value for the male gymnasts (4.2 m/s ± 0.46) was lower, compared to previously reported studies by Brueggemann (1983) of 4.57 m/s, Hwang et al., (1990) 4.46 m/s and Newton et al., (1993) 5.8 m/s. This was most likely due to localized leg muscle fatigue as the analyzed take-off in this study were performed as the finishing acrobatic series. Brueggemann (1983, 1987) and Hwang et al., (1990) reported, that the leg muscles played the dominant role in take-off. The horizontal velocity at touch-down was 6.92 m/s ± 1.82 and decreased to 2.61 m/s ± 2.91 at take-off. The mean duration of the take-off phase was 0.14 sec. The touch-down and take-off angles of the Cg to ground contact and the horizontal were 14.2˚± 5.89 and 83.2˚± 5.49.

Results of the study indicate that the take-off action of backward salto involved reduction in horizontal velocity and increase in vertical velocity. This is due to the reason that the horizontal velocity has been converted to vertical velocity for lifting the body to a considerable height so that the gymnast can get required time to execute the skill during air borne position.

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Table-1
Change of Horizontal velocity of Cg during Take-off of backward salto

Take-off of Backward salto		
Horizontal velocity of Cg	**Mean**	**S.D.**
T.D. Velocity (m/s)	6.92	±1.82
T.O. Velocity (m/s)	2.61	±2.91
Decrease in Velocity (%)	62.28	

Table-2
Change of Vertical velocity of Cg during Take-off of backward salto

Take-off of Backward salto		
Vertical velocity of Cg	**Mean**	**S.D.**
T.D. Velocity (m/s)	-3.92	±1.22
T.O. Velocity (m/s)	4.11	±1.82
Increase in Velocity (%)	204.84	

Table-3
Mean height of Cg in mt. at Touch-down and Take-off during backward salto Take-off

Mean Cg height	
Touch-down	**Take-off**
0.78 m	1.05m

Table-4
Different angles at Touch-down & Take-off of Cg and Mean Take-off duration in sec.

	Touch-down	**Take-off**	**Take-off duration**
Mean	**14.2°**	**83.2°**	**0.14 sec.**
SD	±5.89	±5.49	

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