THE KINEMATIC ANALYSIS OF GIANT SWING AND DISMOUNT OF DOUBLE SALTO BACKWARD STRETCHED WITH 720°TURNS ON HORIZONTAL BAR

Chin-Ku Chen and Yu Liu
Chinese Culture University, Taipei, Taiwan

The main purpose of this study was to analyze the kinematic characteristics of the Giant Swing Leg Beating Action on the horizontal bar and in addition, the movement of leaving bar during dismount of Double Salto Backward Stretched with 720°Turns. 3D kinematic data of one international top class (S1) and national level gymnasts (S2) were collected by using Peak Performance 3D Motion Analysis System. The data was obtained during final competition of the horizontal bar routine in 1998 International China Motor Cup Gymnastics Meeting. The results indicated that better performance was demonstrated if gymnasts could make use of the inflection of shoulders and hips to alternate the moment of inertia. This created the active moment that was required to accelerate body swing so that higher velocity can be gained when leaving the bar.

KEY WORDS: gymnastics, horizontal bar, leg beat action, kinematic

INTRODUCTION: Within the construction system of horizontal bar routine, each movement was correlated: the later movement was the result of the proceeding action and the proceeding was usually referred to initialization of the basic beginning. In a word, to complete these complicate movements, gymnasts had to own the basic and versed capacity of Giant Swing Leg Beat Action so that to accelerate body swing and to gain the elastic resumption which had body rapidly rotating and parabolic leaving from the bar.
The purpose of this study was to investigate the kinematic factors influencing: 1) the Leg Beat Action during Giant Swing Backward in Horizontal Bar and 2) the Dismount of Double Salto Backward Stretched with 720°Turns. A kinematic comparison has been made between international top class (S1) and national level (S2) gymnasts in order to get insights into the technical conditions and the develop directions of national gymnast.

METHODS: 3D kinematic data of international top class (S1) and national level gymnasts (S2) were collected during final competition of horizontal bar in 1997 International China Motor Cup Gymnastics Meeting by using 2 Panasonic video cameras at a rate of 60Hz with an electronic shutter of 1/1000s. One camera was placed at the side of the bar (the optical axes was parallel to the long axe of the bar) and another one was in front of the bar (the optical axes was perpendicular to the long axe of the bar). The object field was calibrated with a standard Peak Calibration Frame (25 point). The trials were analyzed using the Peak Performance Motion Analysis System. In each video field 17 body landmarks were digitized. The 3-D coordinates of the 17 body landmarks were reconstructed from the digitized data using the Direct Linear Transformation (DLT) technique. The raw position data were smoothed by a 4th-order Butterworth filter and optimal cut-off frequency was used. From the subjects' height and weight we applied the anthropometric data of Dempster (1955), modified by Winter (1990) to calculate the segment mass and inertia characteristics, as well as the position of the center of mass of the whole body and all the segment centers of mass.

RESULTS: The giant swing leg beat action on the bar. In this section, six positions (Figure 1) of The Giant Swing Leg Beat Action on the bar were adopted to discuss the correlated kinematic factors and the comparison has been made between these two gymnasts in each position.
Obviously difference change of hip and shoulder of S1 and S2 were performed in figure 1. As far as the position 3 was concerned, S1 was well prepared to adopt the technique of shoulder

and hip rapidly changed from flexion to extension that was subservient to accelerate the swing on the bar. From position 3 to 6, S1 took advantage of the inflection of hip, shoulder and leg to translate the elasticity which was stored by leg beating and shoulder-sinking action into active energy, however, S2 was not able to use the angle change well to complete the leg beat action.
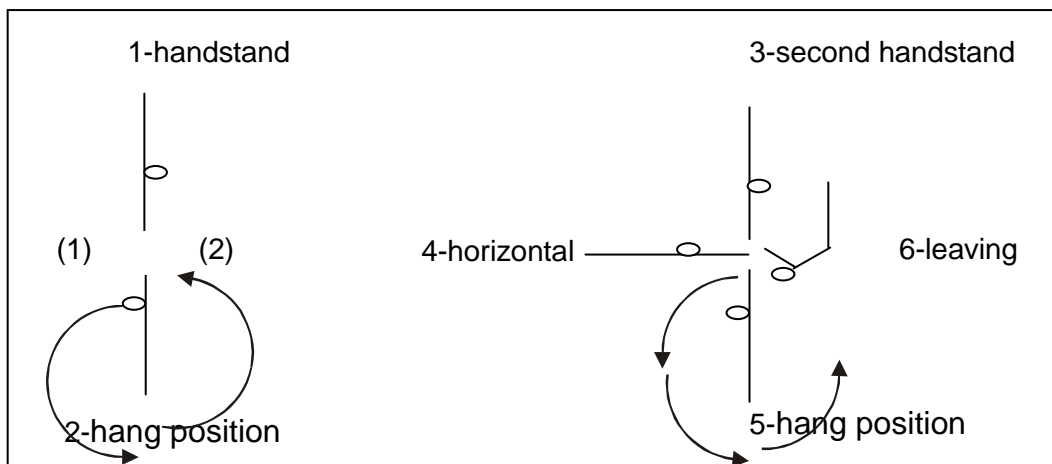

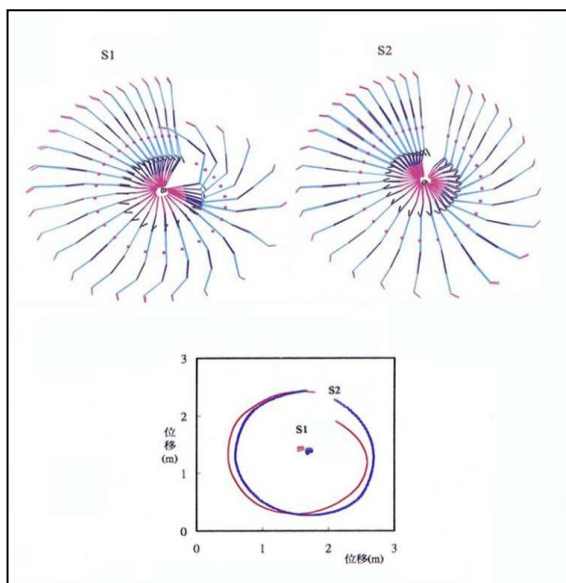**Figure 1 - Six positions of giant swing leg beat action.**
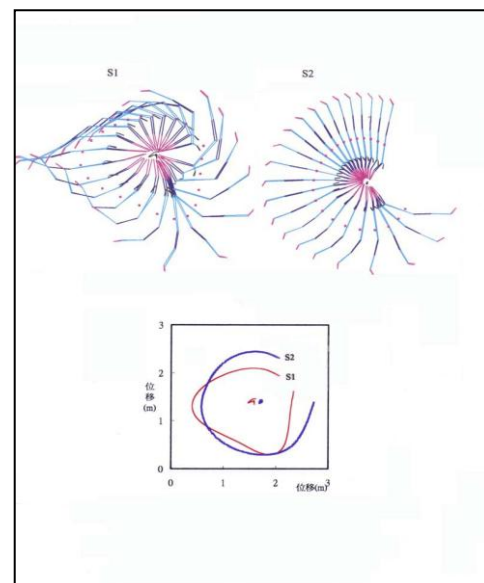

Figure 2 - The trajectory of C.M.

Figure 3 - The trajectory of C.M.

Through Figure 2 and 3, the trajectory of c.m. of S1 and S2 were similar during the first circle, but significant rhythm changes of c.m. radius were occurred upon S1 by the angle various change while the second circle beginning, the main reason was S1 changed his hip and shoulder angle reasonably (see Table 1), and S2 was merely like that of ordinary Giant Swing. To sum up, at the first phase (from handstand position to hang-up position at vertical line in first circle), international top class and national level gymnasts were similar. But the shoulder and hip angle as well as the radius of c.m. circling the bar of S1 is smaller than that of S2 at position

3 due to S1 have done the movement of shoulder and hip flexed to be preparing for beating. The major difference between S1 and S2 is the movement performed during the movement process of position 3, 4 and 5 (see Table 1). S1 was well prepared to adopt body straightening, back bowing, shoulder sinking and leg beat action. Unfortunately, S2 did not present those skills and failed to show the rhythm of beat action.

Table 1   The Angle of Shoulder and Hip in Each Position

	Position	(1)	(2)	(3)	(4)	(5)	(6)
S1	Left Shoulder	143.4°	188.0°	108.7°	164.4°	198.3°	111.0°
	Right Shoulder	141.0°	189.5°	109.1°	155.3°	192.8°	107.9°
	Left Hip	155.3°	207.0°	123.1°	151.0°	205.7°	138.9°
	Right Hip	173.6°	197.0°	123.7°	152.4°	197.6°	136.5°
S2	Left Shoulder	161.6°	168.2°	148.9°	176.9°	187.4°	127.7°
	Right Shoulder	165.8°	172.7°	141.2°	165.5°	183.8°	130.3°
	Left Hip	182.1°	187.3°	186.5°	176.8°	206.1°	149.1°
	Right Hip	185.8°	186.1°	189.2°	176.7°	212.3°	176.3°

The dismount of double salto backward stretched with 720°turns. Five positions of Double Salto Backward Stretched with 720°Turns were divided (Figure 4) to discuss the correlated kinematic factors and the comparison between S1 and S2 in each position by the difficulty class E of leaving bar.
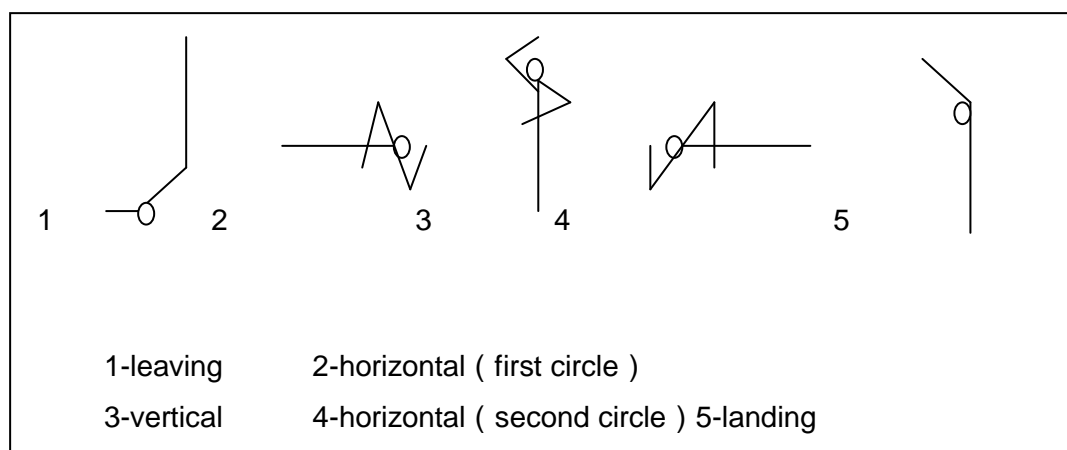

1-leaving   2-horizontal (first circle)
3-vertical   4-horizontal (second circle) 5-landing

Figure 4 - Positions of double Salto backward stretched with 720° turns.

Table 2 showed the angle change between the trunk and horizontal plane. S1's angle is entirely higher than S2 (54.0°: 30.5°). At leaving the bar, S1 tend to the vertical plane and S2 on the contrary tend to horizontal. S2's angle between the trunk and horizontal plane was 52.8 °while S1 finished the Dismount of Salto Double Backward Stretched with 720°Turns, S2 conducted this turning movement slowly behind S1 about one position; S2 only achieve the 18.2°while S1 had done the position 3; S2 achieve 77.2°while S1 finish the position 4.

Because the reason mentioned above, S2 was lack of enough time to process the properly landing and occurred the movement of flexed shoulder and hip (Figure 5).

Table 2   The Angle between Trunk and Horizontal of S1 and S2

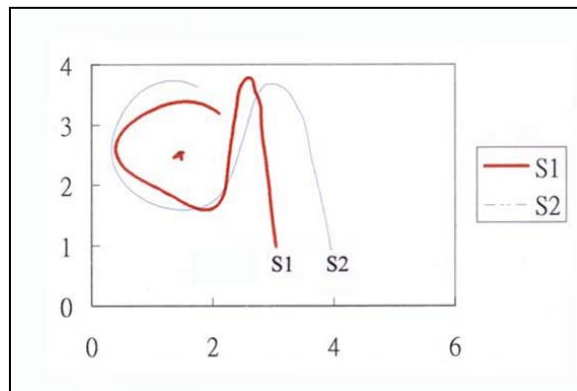| Position		1	2	3	4	5
Film No.	S1	1	15	28	38	75
	S2	1	23	36	47	74
S1 Subject		54.0°	10.3°	76.5°	1.6°	55.2°
S2 Subject		30.5°	52.8°	18.2°	77.2°	44.5°

Figure 5 - The movement of flexed shoulder and hip.

CONCLUSION: The giant swing leg beat action. The results reveal that the international level gymnast could use the angle changes of shoulder and hip to accelerate the swing of distal part of body and performed the body-straightening, back-bowing, shoulder sinking and free falling according timing to achieve leg beat action. But S2 did not present those skills and failed to show the smoothing of swing, and the radius track was circle, just like usual giant swing.

Dismount of double salto backward stretched with 720°turns. S1 released the bar quickly by flexed shoulder and hip with a greater angle of release in order to achieve a longer flight time to perform stable Salto and Turns landing, S2 was tend to leave the bar with a smaller angle of release and thus has inefficient flight duration to conduct the Double Salto Backward Turns.

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