

## **A COMPREHENSIVE STUDY ON THE STRAIGHT BODY DISMOUNT WITH 3 ROTATIONS ON THE HORIZONTAL BAR**

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### Introduction

The movement on the horizontal bar is a most breathtaking and graceful one, with the rotation (turn) movement being one of the most important indicators to judge for difficulty level on the horizontal bar. In the past few years the body straightened dismount with 2 turns has been used on the horizontal bar in world gymnastics competitions. However the 3 turn has not been reported and quantitatively analysed. In order to explore the technical movement mechanism, the objective of the movement is to raise the technical level of gymnasts.

### Subject and Method

**Subject:** Xie Bo, male, elite gymnast in Shandong, China, was born in August 1977. His body height is 1.60m and body weight is 48kg. He began to exercise the body straightened dismount with 3 turns under the guidance of his coach at the beginning of 1991 and perfected the movement in 1992. He was awarded the first prize for "New Movement" in the National Gymnastics Championship in September 1992.

**Method:** The measurement method used high-speed photography. The model LBS-500 35mm high speed camera, manufactured by Xian Optical Precision Instrument Research Institute attached to China Academy of Sciences, was used for designated scanning. Shooting time: July, 1993; camera height: 1.56m; shooting frequency: 100 pcs/s; shooting times: 3 times. The best and worst movements were selected for the analysis. The high speed photography analytical software was manufactured by the Department of Biomechanics of National Research Institute of Sports Science. A low-pass filter was used for smoothing with a cut off of 7.

### RESULT AND ANALYSIS

The block diagram of the whole movement process is shown in Fig. 1.

For convenience's sake, we divided the whole movement into two parts: giant circle on horizontal bar flight and landing.

**Giant circle:** the giant circle is the movement basis to complete the body straightened dismount with 3 turns. The giant circle is the preparation for hand release and speed. Xie Bo's giant circle lasts 2 turns and the body center orbit of the 2nd turn for the first and second movements is shown in Fig. 2.

As shown in Fig. 2, the first turn belongs to the preparatory swing. The body straightens and the center orbit tends to circle. The second turn covers the movements of the so called covering wave, vibrating wave, sinking shoulder and wrapped-up leg. The center orbit tends to ellipse.

The concrete process is as follows:

On the basis of the first giant circle, the second circle accelerated the swing. The gymnast's body center was near the horizontal bar to reduce the shoulder angle and hip

angle. This movement was pulled by a full stretched of the body away from the horizontal bar. This made the center radius enlarge so as to increase the speed through angular momentum. When the body swung near the horizontal plane of the bar, the limbs and trunk stretch presented the greatest back arch. In the process of forming the back arch, the legs opposed the arms producing a contrary movement to offset the increased speed. But the lost mechanical energy in the form of elastic energy storage in the muscle created greater power. The wrapped leg is the important link to increase speed. When the body center swings through 30 degrees below the horizontal bar, the power is developed by the feet which are stretched swiftly and violently. The speed of the body center at the moment of hand release is slower than the maximum speed of the center during rotation.

The shoulder and hip angle of the body for two movements and the changed phenomenon of the center speed as shown in Table 1.

As shown in Table 1, the process of the covering wave, the corresponding time phase of the shoulder and hip angles for the second movement is smaller than that of the first one. This made the covering wave deeper and the effect better. Because of the better effect of the second covering wave, the loss rate of hand release is lower. So the condition of hand release for the second movement is better than that of the first one. See Table 2.

As shown in Table 2, after the wrapped-up leg for the second movement,  $V_{c2}$  and  $V_{\text{ankle } 2}$  are larger than those of the first movement and the lost rate of center speed for the second movement is also smaller than of the first one ( $12.71\% < 13.65\%$ ). At the moment of hand release, the speed of the right ankle joint  $V_{\text{ankle } 2}$  is much faster than  $V_{\text{ankle } 1}$  ( $6.38 > 3.81\text{m/s}$ ). The movement is fast and the time used is short. The swing effect of the giant circle for the second time is good and the condition of hand release is better. This supplied an advantageous condition to increase flight height and the moment of momentum for the somersault.

### Flight Turn and Landing

Hand release flight is followed by the giant circle. Table 3 shows the two hand releases and their relative parameters.

As shown in Table 3, because there are different effects in the two movements of the giant circle, the initial condition for two movements of hand release flight is different, and the parameters of flight height and time are also different. The key factor to influence the flight height is initial velocity of flight and flight angle. The initial velocity of the second movement ( $5.56\text{m/s}$ ) is faster than that of the first one ( $5.06\text{m/s}$ ). If initial velocity is high the flight angle should be increased as much as possible and to increase that, the key is to increase initial vertical velocity. In the process of body turn at the moment of hand release, the turned kinetic energy changed into potential energy. If the rotation speed is given, it is very important for the center flight angle. It has been found that when the center flight angle is 81 to 83 degrees the lost rate of speed is smaller. When the flight height is higher, the horizontal speed is greater and this is the best opportunity for hand release.

After hand release the body's movement is tilted upward opposite reference (ground), on the other hand. The body rotates twice. The unchanged condition of total momentum, rotating about two body axis changes through movement in the air. The proper movement in the air is the important condition to complete the somersault.

Landing is the end of the complete set movement. The steady landing form the

Table 1 the changed phenomenon of the shoulder and hip angle of the body, and the center speed for two movements

position	90°	45°	0°	-30°	-50°	-90°	rising rate			
No. of pict.	1	2	3	4	5	6	7	%		
right	# 1	140°	105°	110°	112°	135°				
shoulder										
angle	8.2	115°	95°	98°	112°	112°	94°			
right	8.3	102°	106°	110°	115°	110°	174°			
hip										
angle	8.4	117°	100°	100°	117°	105°	148°			
center	Vc1	3.08	3.01	3.04	3.16	3.33	3.40	3.48	3.90	21.02
speed	Vc2	3.75	3.76	3.64	3.58	3.67	3.80	3.85	3.97	5.54
(m/s)										

Table 2 the change of the center, shoulder, hip, and ankle speed from the maximum to the moment of the brake and the hand release for two movements

		the Max speed when mapped-up leg	when hand release	the loss of speed	time	
	No.	speed(m/s)	speed	[%]	(s)	
center	Vc1	26-29	5.86	5.06	13.65	0.13
	Vc2	27-29	6.37	5.56	12.71	0.10
right	V1	26-29	3.83	3.58	6.52	0.13
shoulder	V2	27-29	4.72	3.80	19.49	0.10
right	V1	26-29	7.22	5.81	20.10	0.13
hip	V2	27-29	7.98	7.11	10.10	0.10
right	V1	16-23	16.44	5.81	64.66	0.24
ankle	V2	18-23	18.35	6.81	62.89	0.15

Table 3 the relative parameters of the two times hand release

parameter	first			second		
total time(s)						
time for single	first	second	total	first	second	total
giant circle	1.40	1.46	2.86	1.40	1.98	2.48
straight distance from center to bar(m)	0.146 (under bar)			0.123 (over bar)		
at hand release						
distance from center to bar(m)	0.60			0.68		
at hand release						
hand release angle	10° (under bar)			9° (over bar)		
initial speed(m/s)	5.06			5.56		
at hand release						
speed at hand release(m/s)	5.81			6.81		
flight height of center(m)	1.26			1.50		
Max center height from the ground(m)	3.714			4.223		
the flight time(s)	1.04			1.38		

Fig. 1 the block diagram of the whole movement process  
 Fig. 2 the body center orbit of the 2 turn for two movements

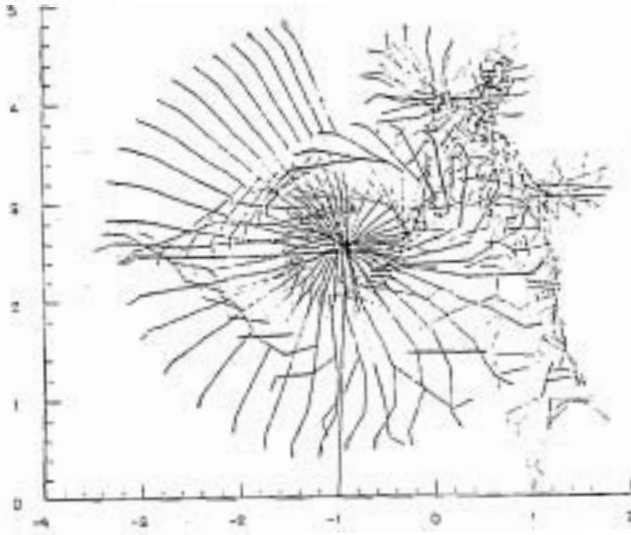
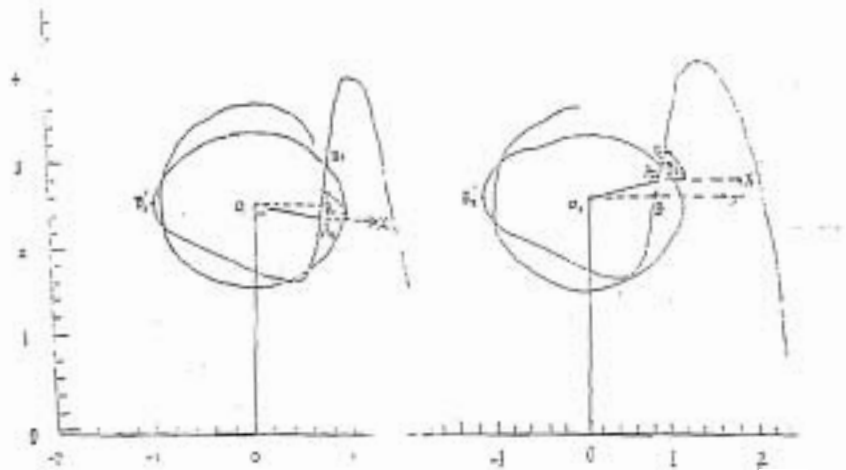


Fig. 1 the block diagram of the whole movement process



the first movement      the second movement

Fig. 2 the body center orbit of the 2 turn for two movements

turn movement is the important indicator to measure success. It depends mainly upon the somersault technique and flight time. At the same time, a certain height is needed after finishing the somersault so as to prepare for the landing. The flight height of the first movement by Xie Bo is low and the somersault is not adequate therefore the landing is not good. After the second turn is completed, the body center is 1.80m above the ground. When the feet touch the land, the line between the head and mass center is 17 degrees and the center is 0.8m above the floor.

#### Conclusion:

The technical key to complete the body straightened dismount with 3 turns on the horizontal bar is to link the covering wave, vibrating wave, wrapped-up leg and hand release of the giant circle. Xie Bo's technique is reasonable and the movement is completed affectively.

The initial velocity of hand release and its angle are the main factors influencing flight height. The flight of initial velocity is 5.56m/s and center flight angle is between 81 to 83 degrees.

After finishing the somersault with the height of the body center above 1.80m the gymnast can complete the landing better.

#### References

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