KINEMATICS ANALYSIS ON HANDSPRING SIDEWAYS STRETCHED SIDEWARD SOMERSAULT WITH 1 3/4 TURNS IN HORSE-VAULTING OF ZEPENG LUO

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By using the 3D video analysis method, we have tested on the handspring sideways stretched side-ward somersault with 1 3/4 turns in Horse-vaulting (also known as Kasamatsu 360°) of Chinese elite athletes Zepeng Luo at the game site; obtain the relevant kinematics' parameters through analysis on the complete movement. The results show that: Zepeng Luo completed this action with high quality and advanced technology, but at the first flight, his legs were not fully close together.

KEYWORDS: horse-vaulting, Kasamatsu 360°, kinematics analysis.

INTRODUCTION: Horse-vaulting is one of advantage projects of China men's gymnastics team. The paper aims to use the three-dimension video to analyse the technology of Zepeng Luo at the game site of the 12th national games in 2013, and then get the kinematics parameters and summarize his skill features, so as to provide reference for the technical training of coaches and athletes.

METHODS: The main method is three-dimension video analyse. The whole process of the competition was recorded by two JVC cameras at 50 Hz from different angles (the angle of the two cameras was about 90°) (Figure1). And shooting frequency is 50 frames per second. The record analysis used 3-D SignalTec system and series analysis. We use Japanese Songjingxiuzhi phantom as the anthropometric dummy (22 articulation points, 16 segments). It passed the original data filter and the cut off frequency is 8 Hz. .

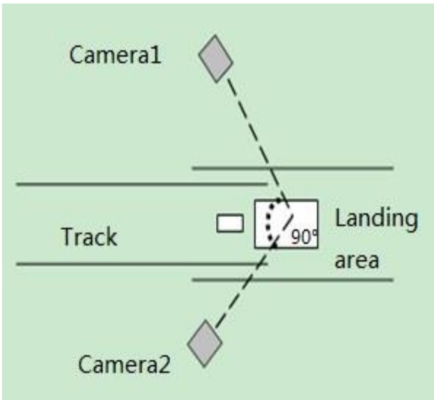

Figure1: Schematic diagram of cameras

Figure2: Game site photo

RESULTS AND DISCUSSION: In order to facilitate the analysis of the data, we divided the whole movement into four stages.
The run-up and pedal stage: In the run-up process (before feet touch the pedal) ,the flight height is 13cm, the maximum instantaneous horizontal velocity is 6.93 m/s, which can completely satisfy the needed to complete the action.

Table1
Pedal stage kinematics parameters

	Touch pedal moment	Leave pedal moment
horizontal velocity of cg（m/s）	6.01	4.42
vertical velocity of cg（m/s）	-0.52	3.13
shoulder Angle（°）	99	137
Hip angle（°）	119	146
knee angle（°）	153	175
ankle angle（°）	115	114
Pedal angle（°）	64	80

*cg: Body centre of gravity
Pedal angle: centre of gravity and foot-touching point connection with the horizontal angle

Pedal makes full preparations to get enough energy and it is the key technologies to complete the movement in the first flight (Wen, 2012). The jumping time is very short as 0.08 s. As seen from Table 1, during the pedal stage, horizontal velocity of cg decreased, but vertical velocity of cg increased significantly .this is because it is a brake take-off. This ensures the body to continue to move forward, and obtained a certain turnover speed.
The first flight and push hands stage: First flight time is 0.11s, horizontal velocity of cg is 3.97s, and vertical velocity of cg is 3.35s. Zepeng Luo’s adnominal muscle tensioned, hip bent slightly before food leave the pedal. This will not only avoid reducing force transfer and can stretch the back muscles to help accelerate the legs swing. When he touching the horse, his left foot speed reached 8.37 m / s, right foot speed reached 10.57m/s. foot speed is not the same, indicates that the air control is not very good, his legs are not closed together. This is not allowed.

Table2
Push hands stage kinematics parameters

	Touch vaulting horse moment	Leave vaulting horse moment
horizontal velocity of cg（m/s）	3.75	3.18
vertical velocity of cg（m/s）	3.20	3.01
shoulder angle(°)	123	155
elbow angle（°）	100	160
hip angle（°）	140	162
foot speed(m/s)	8.58	11.34
horse angle（°）	43	80

*horse angle: Center of gravity and hand-touching point connection with the horizontal angle

After entering the first flight, it needs to turn 90° as quickly as possible. When the first hand touches the horse, elbow bend, this is the technical requirements of the operation.
The main purpose is to speed up the body's turn (Wen, 1989). The time of push hands stage is 0.23s, horse angle is 43°. The height of the centre of gravity from the vaulting horse is 50 cm. According to the mechanics principle, the higher the position of the centre of gravity is the better for hand pushing and second flight. Form Table 2, horizontal velocity of cg decreased, but vertical velocity of cg increased, the same as the first stage, it is a brake take-off.

The Second flight stage:

Table 3
Second flight kinematics parameters

The highest point of the centre of gravity				Flight time (s)	horizontal axis flip angular velocity (m/s)	Vertical axis flip angular velocity (m/s)
horizontal velocity (m/s)	vertical velocity (m/s)	distance from ground (m)	distance from vaulting horse (m)			
3.02	0.11	2.81	1.39	0.98	7.99	14.36

Table 3 shows the highest point of the centre of gravity distance from ground is 2.81m.Flight time is 0.98 s. All of these made a good preparation for landing stage.
Zepeng Luo turned left immediately after pushing away the horse, swivel power depends mainly on the head, shoulders, and arms hold flexing, driven to the chest to reduce the body vertical axis radius. According to the momentum conservation theorem ($K=mr^2\omega$). Radius is inversely proportional to the rotating angular velocity (Wen, & Li, 2004).
Near turn over 630 degrees, the hip angle reduces gradually, the arms move to the side of the body, The purposes have 3: one is to increase body vertical axis radius, reduce the rotating angular velocity; second is to reduce the horizontal axis rotation radius, to speed up the turnover velocity of the body; tree is to be prepared for the landing.
Landing stage: Landing is quite steady. It is illustrated that the landing process in accordance with the laws of mechanics and basic requirements. The landing angle is 58°, if the landing angle too large or too small, it will make the rotating torque and braking torque out of balance, causing the landing instability. Fall to the ground instantly, knee and ankle joints extended as far as possible, this helped to prolong the buffer time and reduce the impact force (Xu, 2001).

CONCLUSION: Zepeng Luo completed this action with high quality and advanced technology, but at the first flight, his legs were not fully close together.
1. At the run-up and pedal stage, the flight height is 13cm; the maximum instantaneous horizontal velocity is 6.93 m/s, which can completely satisfy the needed to complete the action. Pedal makes full preparations to get enough energy and it is the key technologies to complete the movement in the first flight.
2. First flight time is 0.11s, horizontal velocity of cg is 3.97s, and vertical velocity of cg is 3.35s. After entering the first flight, it needs to turn 90 ° as quickly as possible. When he touching the horse, the left and right foot speed is not the same, indicates that the air control is not very good, his legs are not closed together. This is not allowed.
3. At the Second flight stage, highest point of the centre of gravity distance from ground is 2.81m.Flight time is 0.98 s. All of these made good preparations for landing stage.
4. Landing is quite steady. The landing angle is 58°. Fall to the ground instantly, knee and ankle joints extended as far as possible, this helped to prolong the buffer time and reduce the impact force.

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