

A KINEMATICS ANALYSIS OF GIANT SWING BACKWARD AND DOUBLE SALTO BACKWARD STRETCHED DISMOUNT IN JINNAN YAO 'S UNEVEN BARS

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Using 3D camera analytic method, the paper tests Jinnan Yao's (who won the gold medal in the female uneven bars final of the 45th World Gymnastics Championship in October 11th, 2014) technical movements of giant swing backward and double salto backward stretched dismount and make a kinematics analysis of the complete movements. The purpose of this study was to reveal the kinematic rules and technical features of the movements, in order to provide references of technical training for athletes. The results indicated that better performance was demonstrated if gymnast could increase the height of salto suspension, so that increase the flight time, in order to prepare landing.

KEY WORDS: uneven bars, giant swing backward, double salto backward stretched dismount, kinematic analysis.

INTRODUCTION: The movements named giant swing backward and double salto backward stretched dismount is one of the most frequently used dismounts through worldly outstanding gymnasts nowadays. It belongs to group D dismount action in the rule of international gymnastics. As it were, the key to win the competitions is not finishing that movements whether or not but how to complete the movements with high quality. This paper reveals the kinematics rules and technical feature of giant swing backward and double salto backward stretched dismount in uneven bars performed by Jinnan Yao through the sport biomechanics analysis, which conducts a kinematics analysis on the dismount by her, and further more obtains the kinematics characteristics of Jinnan Yao's dismount. All of that are in order to provide references of technical training for athletes.

METHODS: The main method is three-dimension camera analyze. We used two JVC9800 Synchronized cameras at the right side and back side of the game site. The shooting frequency is 50 frames per second. The record analysis used 3-DSignalTec system and series analysis. The anthropometric dummy is Japanese Songjingxiuzhi phantom (21 articulation points, 16 segments). It passed the original data filter and the cut off frequency is 8Hz.

RESULTS AND DISCUSSION: The actions of giant swing backward and double salto backward stretched dismount can divide into two phases, the first phase is to giant swing backward which starts with handstand statically, then turns to do giant swing backward, and ends with let go her hold from the high bar. According to the action feature of giant swing backward, it can divide into three processes including two circles giant swing acceleration process, giant swing continuing downswing process and giant swing continuing upswing process. The second phase starts within moments of letting go her finished hold from the high bar, and ends with having double salto backward somersault body straight until the buffering when falling to the ground and then stop. According the feature of the action, it can divide into two processes including double salto backward stretched process and landing and buffering process. Please see below, the technological analysis of the action structure's two phases.

Athletes starts with handstand statically and then turns to do giant swing backward, end with completed two circumference giant swing backward acceleration process. This process is prepared

for obtaining greater speed in the third circumference swing.

In the moment of from handstand statically to doing giant swing backward, the vertical distance of the center of gravity and the high bar surface is 0.90m. When the first circumference swing is over, which means the handstand on the bar of the third circumference swing moment, the resultant velocity of center of gravity is 2.6m/s after the acceleration of the two circles giant swing.

The process named giant swing continuing downswing process which means athletes starts with the third circumference handstand downswing backward and ends with being the sagging face of the bar. That is the motor process when the body center of gravity turns the highest to the lowest point. In this process, the potential energy of human body will transform to the kinetic energy, which is the energy for backward somersault.

With the body downswing, the whole body should unbend, and the head should be lower down, shoulder fully unfolded, to increase the gravity torques. The greater the gravity torques is, the greater the angular momentum will be and the strength to finish a wreath will be much greater. The round bar loopback ability is one of the main powers to complete the action. In the process of Jinnan Yao's body downswing, the humeral angle and the hip angle will decrease a few. But the two angles starts to increase again on the horizontal plane of the high bar. At this moment, the left and right humeral angles are 167° and 169°, and the hip angles are 173° and 175°. Besides, the center of gravity acceleration is 4.90m/s, which is profit from the backward vertical speed. By now, human body can obtain the greater moment of momentum, which is good for the action behind.

Human body will continue downswing at the moment passing the horizontal plane of the high bar, the humeral angle will increase, the shoulder joint will subsidence and the hip angle will increase obviously at that moment. When the body continues downswing reach to vertical position, the humeral angles increase to 198° and 201° and the hip angles increase to 168° and 170°, the center of gravity resultant velocity is 6.13m/s. The purpose of lowering the shoulders is to let the high bar become shape change, which is prepared for utilizing the elastic potential energy of high bar fully while finishing next process actions. Visibility, Jinnan Yao completes that process preferably.

The giant swing continuing upswing process starts with the upswing on the vertical plane under the bar, and ends with the releasing grip the bar moment. This process is for decreasing the loss of flip angle's speed and increasing the height of release grip.

When body has passed the vertical place under the bar, two legs must kick up energetically to create favourable muscle operating conditions. In order to finish this in the upswing process, the speed of left and right legs respectively accelerate obviously. At the same time that two legs upswing, the shoulder joint must keep down the stalk head and avoid lifting shoulders and head. Otherwise it will affect the speed at the top of the shoulder is rather small. In the moment, the humeral angle and the hip angle decrease obviously, which shortens the radius between the body center of gravity and bar axis to decrease the loss of palstance while body center of gravity rising.

When body is close to the horizontal plane of releases grip from the bar immediately and closes legs together, at that moment the angel means the included angle between the center of gravity to rod shaft and vertical plane down bar. At the moment while leaving the bar the kinematic velocity of two legs will decrease, that is the left and right kinematic velocity will decrease to 9.05m/s and 8.98m/s. Since two legs has braked before leaving the high bar and the shoulder joint is rushed forward, so it can avoid bumping bar by two legs in the double salto backward somersault body straight process after releasing grip. It takes 0.24s from vertical position under the bar to the moment while leaving the bar. Thus, too short time can lead to the lower center of gravity while leaving the bar. Whereas, Jinnan Yao's reversal palstance is about 3.26rad/s, and it is bigger than

other gymnasts, which is benefit for quickening the palstance while body overturning to backward after releasing grip from the high bar.

Beginning with the moment while leaving the bar, and ending with finishing backward somersault body straight for two circumferences, and that is double salto backward stretched process .In that process human body turns into without support condition and will be affected with the gravity mainly. Due to vertical velocity of gravity is far greater than horizontal velocity at the moment of away from the bar, the parabolic trajectory of body center of gravity is 0.001m/s^2 ---which is near zero when arriving at the highest center of gravity point. And then continuing arc backward by gravity .The vertical velocity of gravity accumulates slowly, and the moment legs landing it's 3.13m/s . Jinnan Yao's highest center of gravity point is 0.38m taller than asymmetrical bars' rod shaft, the vertical distance is 2.52m from the pad and the horizontal distance is 2.35m between the bar and the landing point. The flight time in the air is 1.24s from leaving the bar to landing. The basic condition of completing that action are height of arch, landing distance and flight time after leaving the bar .If the higher the height of arch, the father the landing distance and the longer the flight time will be ,the action can be better completed. However Jinnan Yao's center of gravity while leaving the bar is not that high, so it leads to the low height of arch.

To finish the backward somersault body straight for two circumferences must utilize not only the rotation angular velocity by body rolling the rod shaft while leaving the bar, but only the mechanics to change body's reversal radius so that it can quicken the reversal palstance while body rolling the horizontal axis. Therefore, make sure to brake legs immediately after leaving the bar, unbend the body, the upper body backward bending and head lifting, and the body is reverse-bow shape of a circle. At this moment, the lip angels increase obviously which are 215° and 218° when the center of gravity is in the highest. The upper arm will move from the upthrow position to the sides of body, the humeral angles decrease obviously. Thus, the radius of the whole body's longitudinal axis can decrease, it is benefit for increasing the reversal palstance while body rolling the horizontal axis. The reversal palstance of straight reversal for two circles is about 5.20rad/s . It's clear that her reversal palstance is kind of fast. When the reversal proceeds about $3/4$,the body start to unbend and the lip angels decrease step by step to prepare for landing .The left and right lip angels decrease to 128° and 130° while the moment legs landing.

The process, from the feet touch pads to landing buffer still, namely the landing buffer process, this process is to maintain the balance of the body.

Before landing legs stretched as far as possible to contact pads, thus create favorable buffering time and space for the landing buffer, after landing the knee and ankle bending buffer immediately retreat. If the moment when it land, the ground horizontal velocity of center of gravity is very big, the landing angle is also large, on the contrary, the gravity torque is smaller. Effect of heavy torque is insufficient to offset torque, the body will reach or was forced to change the original supporting point. When the gravity torque can make it brake in buffer process, which will waste forward or backward inertia torque, the focus now in support is arranged on the top of the stable boundary range, their vector and tends to zero or equal to zero, the body will stand still. However, the moment when Jinnan Yao landing on the ground, the horizontal velocity is 0.98m/s , the landing angle is 83° (the angle between the center of gravity of the body and landing instant connection with the formation of the ground).The body center of gravity toward the front side, the remaining of the horizontal velocity is also large, so Jinnan Yao landed a small step jump forward ,which indicated that the human body from high sky jumping and landing, not only the height determines the human body's impact force to the ground, the action of the sky jumping and landing also increase the impact force to the ground. If

the energy is not consumed before falling to the ground, the body will be hard to be balanced.

CONCLUSION: Through the kinematics analysis of double salto backward stretched dismount by Jinnan Yao ----the champion in the world, it is concluded that Jinnan Yao motion model is as follows: Giant swing backward phase: when the third circumference handstand downswing backward, the resultant velocity of center of gravity is 2.60m/s, and it is bigger than other gymnasts. Because Jinnan Yao took three circumferences giant swing backward. It takes 0.24s from vertical position under the bar to the moment while leaving the bar. Thus too short time can lead to the lower center of gravity while leaving the bar. Whereas, Jinnan Yao's reversal palstance is about 3.26rad/s, which is benefit for quickening the palstance while body overturning to backward after releasing grip from the high bar.

Double salto backward stretched dismount in uneven bars phase: time to let she go away from the poles, the flight time is 1.24s. The height of salto suspension is 0.38m, it is low. When body reach to the highest center of gravity point, the hip angles increase obviously and the humeral angles decrease obviously, the body is reverse-bow shape of a circle. Now the left and right humeral angles are 68° and 70° , the left and right hip angles are 215° and 218° . It is benefit for decrease the radius of the whole body's longitudinal axis, so that increasing the reversal palstance while body rolling the horizontal axis. The reversal palstance of straight reversal for two circles is 5.20rad/s. It's clear that her reversal palstance is kind of fast. When Jinnan Yao landing on the ground, the horizontal velocity is 0.98m/s. The body center of gravity toward the front side, the remaining of the horizontal velocity is also large, so Jinnan Yao landed a small step jump forward. Visibility, Jinnan Yao completed the double salto backward stretched dismount. But also can improve in the following aspects: to increase the height of salto suspension, so that increase the flight time, in order to prepare landing.

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