

**KINEMATICS ANALYSIS OF CHINESE VAULTING HORSE ATHLETE YANG YAHONG'S
ACTION OF "HANDSPRING WITH 90°-180°-LAYOUT BACK DOUBLE TWIST"
- LAYOUT BACK DOUBLE TWIST"**

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"Handspring with 90°-180°-layout back double twists" is the new developed kind of action in the women gymnastics championship in recent years. Yang Yahong is the only one that can complete this action. With the method of sports biomechanics, the kinematics characteristic of her action will be analyzed and her advantage and disadvantage will be exposed. The finding shows that her running up is fast, the angle speed of the handspring in the second flight is swift and the pose in space is excellent. However, the amount of time of pushing horse is over long and the height of the handspring in the second flight is not enough.

KEY WORDS: vaulting horse; technique; biomechanics

INTRODUCTION: In the newly issued "The Rules of International Women Gymnastics, 2005-2008", the action of "Handspring with 90°-180°-layout back double twists" in E group level difficulty is modified with the start marking score to 10.0 point. The relevant references show that some excellent athletes can perform this action such as in Rumania, France, Russia, Canada, Spain and so on. The women gymnastics team of China is far behind the world level with only Yang Yahong having the ability to do that. There is no essays on the action of "handspring with 90°-180°-layout back double twists" in China and a little in the world, so the kinematics study on this action is very important and it will provide newer and more scientific referable arguments for the development of the internal women vaulting horse in the aspect of difficult and new action.

METHOD AND ANALYSIS METHODS: Using two Japanese JVC-9800 high speed videos, we videoed Yang Yahong's movement (Using two videos A and B. A is shooting the front of horse with the light axis 25 m away from the center of the horse. B forms 70-degreee anger with A and also is 25 m away form the center of the horse. The two videos are 1.6 m in height and have a high shooting speed of 100 f/s and a shutter speed of 1/250 s). We analyze these single frame pictures using the TJ-V3.0 3D sport analysis software to gain the physical parameters of athlete's technical action. Smoothing the collected data with method of low filtrating waves, cut-off frequency being 5, we analyze, select and arrange the received data, then conduct it in conventional statistic procession, combining P4 computer Microsoft Excel system.

RESULTS:

Table1 Horizontal velocity and Vertical velocity of each stage v (m/s).

Contents	Run-up to be off the ground	Getting on the board	Leaving the board	Touching the horse	Leaving the horse
Horizontal velocity	8.11	6.71	3.65	3.64	3.15
Vertical velocity	1.38	-0.72	4.59	3.45	2.49

Table 2 Angle parameters of each stage.

Steps	contents	Parameters
Getting on the board moment	Angle of getting on the board(°)	67.4
	Angle of knee(°)	173.2
	Angle of coxa(°)	129.9
Beating the board moment	Angle of take-off(°)	99.4
Propping on horse moment	Angle of propping on horse(°)	25.4
Pushing hands moment	Angle of push-off(°)	73.2
	Angle of dismount(°)	60.3
Dismount moment	Stability state	Walk a little pace after dismount

Notes: angle of getting on the board is the back angle between the line, linking center of gravity with the point of feet straining, and the horizon line; angle of knee is the back angle between the line, linking ankle joint center with knee joint center, and the line, linking knee joint center and coxa joint center; angle of take-off is the back angle between the line, linking gravity center with the point of feet straining, and horizon line; angle of propping on horse is the back angle between the line, linking center of gravity with the point of hands straining, and the horizon line; angle of push-off is the back angle between the line, linking center of gravity and the point of hands straining, and the horizon line; angle of dismount is the back angle between the line, linking center of gravity and the point of feet straining, and horizon line.

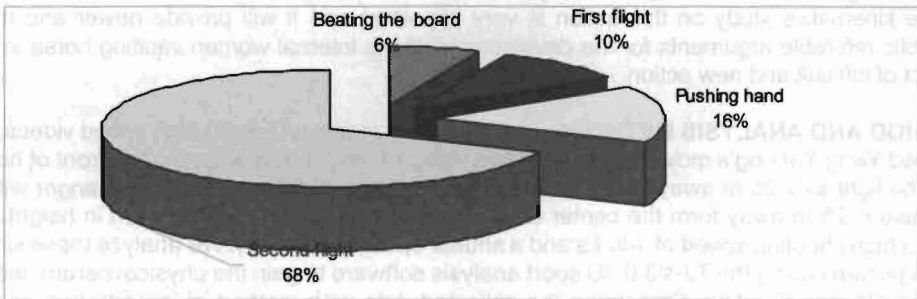


Figure 1 Time percentage of each stage.

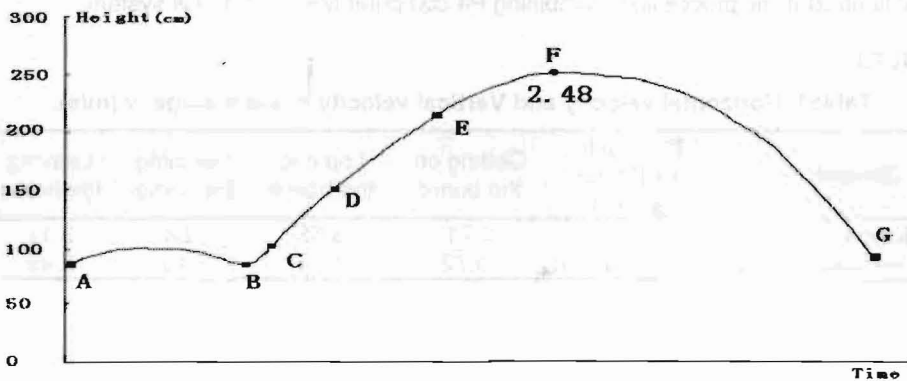


Figure 2 Track of body center of gravity.

DISCUSSION:

1. Every stage's time distribution of Yahong Yang completing technical action "handspring with 90°-180°-layout back double twists".

We cut the process of Yahong Yang completing this action into four stages, which are touching board, first flight, pushing hands, second flight. They partly occupied 6%, 10%, 16%, and 68% of the whole time of the process (Figure 1). In period of touching board, her both legs are very powerful in very short duration, using only 0.08 seconds which is less than 0.12 s that is the average beating period of time performed by the world's excellent athletes in the relevant references. In period of first flight after finishing first movement, she is rapidly swinging her legs, immediately rotating body from head and shoulders by 90 degree. After first flight at the 0.12 second, she pushes horse positively and initially. The interval of both hands pushing horse successively is very short. During 0.03 s, arms straighten while pushing horse, body being back arch, gravity center higher than the level of shoulders, and body complete rotating body by 90 degrees, then both hands support shoulders and push hands powerfully in very short duration. But her duration is a bit longer, being 0.2 s. According to the recorded references, the average hands pushing duration of excellent athletes lasts about 0.18 s. Her second flight is a little longer, being 0.88 s (the average period of time of the second flight performed by the world's excellent athletes is 0.80 s), yet being beneficial to completing revolving in the air.

2. Velocity alters in periods of Yahong Yang completing technical action "handspring with 90°-180°-layout back double twists"

Run-up is the essential source of impetus to complete vaulting horse. The instant strength of Yahong Yang's lower limbs distinguishes among domestic athletes, being able to accelerate the speed in a twinkling. The average rate of her run-up off the ground is up to 8.11 m/s (Figure1). This running up speed is close to those of men. The technique of beating the board is mainly to gain the body a height to rise to the sky and a speed to rotate forward. It is a important process to alter the horizontal speed to vertical speed, and it is also another inevitable impetus for athletes to flight over machines and quicken body to rotate. Yahong Yang beats the board quick and powerful, with vertical speed being increased obviously, horizontal being decreased by a big range. The vertical average rate of gravity center rises from -0.72 m/s on board to 4.59 m/s off board, and the horizontal average rate of gravity center fall from 6.71 m/s on board to 3.65 m/s off board. We can see that the lash to board is so powerful while beating the board from the consumption of horizontal speed, that she gains a rather high vertical rate and body revolving angle rate. From take-off board to touching horse, the vertical rate of the first flight loses by 1.14 m/s; from touching horse to leaving horse, the horizontal rate loses 0.49 m/s and the vertical 0.96 m/s.

3. Angle transformation in periods of Yahong Yang completing technical action "handspring with 90°-180°-layout back double twists".

At the moment of Yahong Yang touching board, the angle of on board is 67.4°, on board angle of knee is 173.2°, and the angle of coxa is 129.9°. Stretch forward while take off immediately and powerfully, and begin to sidle body at the same time. At the period of beating the board, Yahong Yang's angle of take-off is 99.4°, which can not only increase the vaulting velocity of body forward, but also enlarge the vaulting moment of force, not only benefit to swinging legs efficiently, but also increase the forward vaulting velocity of body. After her action of beating the board, she swing legs immediately, and rotate her body by 90° from head and shoulders at the same time, then push horse positively and initially after the first flight at the 0.12 second. Angle of pushing horse is 25.4°, arms being straight, body being opposite arch, and center of gravity being higher than the horizontal line of shoulders. Hands push horse quickly one by one, angle of pushing off being 73.2°. She crooks her arm to chest and abdomen during her second flight, which decreases inertia in axis of ordinate and accelerates angular velocity. Her average angular velocity is rather high, being up to 13.92 rad/s, which make up the shortcoming of her second flight in height. Having finished the rotating by 450° - 500°, both arms begin to leave away from body, the radius of rotating in axis of ordinate enlarged and rotating velocity

reduced, which is benefited to doing well the action of dismount. The angle of dismount of her second flight is 60.3° .

4. Track trend of body center of gravity of Yahong Yang completing technical action "handspring with $90^\circ \sim 180^\circ$ -layout back double twists".

Figure 2 is the track trend of body center of gravity of Yahong Yang completing the action. Part AB is the parabola of on board and flight, which can show that the on board and flight is not high, on board action is low and quick, and the track of parabola of gravity center doesn't rise and fall in a large range; part BC is curve of intermediate state of beating the board period, in which the height of gravity center rises from 0.85 m to 1.02 m, the center of gravity raised by 0.17 m; part CD is the parabola of the duration of the first flight, the height of gravity center being 1.50 m while pushing horse, and the center of gravity raised by 0.48 m; Part DE is the curve of intermediate state of pushing hands, the height of gravity center being 2.13 m while pushing hands, the center of gravity raised by 0.63 m; after both hands pushing horse with force, her body pull up, up to point F, which is the highest point of the gravity center track the second flight, being 2.48 m. This height of flight is not ideal enough. Part EG is the parabola of the second flight, during which she maintains a height of 1.2 m when the rotating is over, and this enables her to have adequate time to adjust the position of dismount.

CONCLUSION: When performing the action of "Handspring with $90^\circ \sim 180^\circ$ -layout back double twists", Yahong Yang is running up fast, beating powerfully, rising up fast and the angle speed of the handspring in the second flight is swift and the pose in space is excellent. However the period of pushing horse is over long and the second flight is not enough high. So she would have the promising future in the world vaulting horse championship, if she could keep the fast running up, swift handspring and powerful breading up, standardize her pose in space, and conquer the over long period of hands pushing and the low height in the second flight.

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