BIOMECHANIC CHARACTERISTICS OF THE TECHNIQUES OF TOP STRIKERS' WHIP-LEG

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In this paper, the authors have obtained the technical photos of three top strikers under biomechanic research methods by means of 3-D photography, then they have analyzed these photos according to APAS photo analysis system for the purpose of providing theoretical basis for striking teaching, scientific training and competition. At the time of finishing whip-leg movements the knee joint of the motion leg should be bent so as to decrease the moment of inertia, increase the twist angular velocity. The strikers should emphasize the sudden stop of the near side joints and make the moment of momentum be passed to the far side joints in a proper way so as to improve the action speed and striking effect.

KEY WORDS: striking, whip-leg, movement, characteristics, biomechanics, striking effect

INTRODUCTION: Striking, which has rich contents and complicated movements and a high demand of human biological energy, is a competitive Wushu event containing kicking and fighting and wrestling. We all realize that if a striker wants to gain ideal training effect and wins an international contest, he has to be directed by the scientific research results obtained through the development of modern scientific technology. We find that the approach of leg kicking and whipping has become the main fighting technique through our years of observations. Leg techniques have been playing the main role in striking. Whip-leg is one of the threatening techniques of striking. It has the characteristics of bent kicking and sweeping, with a large range of attack and quick recovery. We try to build the complicated whip-leg movements on the basis of basic biomechanic laws to improve striking techniques and obtain the best training and competitive results.

SUBJECTS: Three top strikers from Shaanxi province and Xi'an Institute of Physical Education complete the whip-leg movements by using the right legs. Data see Table 1.

Table 1 Subjects.

item / striker	Height (cm)	Weight (kg)	Age (years)	Training (years)	Competitive results
1	185	91	24	5	International champion
2	177	74	22	3	National champion
3	183	85	24	5	International champion

METHODS: Two TM-7610 High-speed Photographers, one American APAS Motion Analyzer, two Kistler-9287B 3D-force Plates, one Engine support.
One 3D-force Plate is fixed on the support lest it swing as the strikers come into action and affect the test results. The surface of the 3D-force Plate is fixed by training target lest the strikers be injured and affect their performance. The height of the central point of the plate is 1.3 m. The other plate is put on the floor. It is moved according to the striker's position and is used to measure the force of the striker's supporting leg. One High-speed Photographer is fixed with an angle of 5 against the fixed plate; the other with an angle of 70 against the first one. The height of the two photographers is 1.2 m and they have a distance to the central point of the fixed plate of 15 m.
All experimental data are obtained by using APAS Motion Analyzer

RESULTS AND ANALYSIS:

Movement characteristics analysis: Time of the strikers' completion of whip-leg movement and the joints' characteristic angles of the supporting legs.

The time is from the instance a striker stretches his supporting leg (minimum knee joint angle) to the instance he reaches the maximum foot gravity velocity of the whiplash leg.

Table 2 Action time and the supporting legs' knee joint angles.

Item / striker	Minimum knee joint angle (^{0})	Maximum knee joint Angle (^{0})	Knee joint angle (^{0})	Action time (s)
1	132.4	158.8	143.0	0.48
2	134.7	150.8	147.3	0.52
3	126.7	153.6	139.7	0.51

We can see from Table 2 that striker one has the shortest action time of 0.48 s; striker two, the longest 0.52 s. When the strikers come into action, striker three has the minimum knee joint angle of 126.7^0; striker two, the maximum 134.7^0. Judging by the changes of the two norms of the knee joint angles (at the time of maximum knee joint angle and foot gravity velocity), when a striker finishes the movement of stretching his leg, the body gravity falls a little; thus, strengthens body stability and benefits the movement completion.

Table 3 Maximum velocity (m/s) of the strikers' right side limbs.

Item / striker	Elbow (m/s)	Wrist (m/s)	Hand (m/s)	Shoulder (m/s)	Hip (m/s)	Knee (m/s)	Ankle (m/s)	Foot Gravity (m/s)
1	4.62	6.23	7.88	2.67	1.98	7.59	12.36	17.27
2	4.22	5.61	6.83	2.14	2.08	6.83	12.97	16.59
3	4.62	5.93	6.74	2.67	2.63	6.79	12.28	17.25

The velocity changes of the right leg's and upper right body joints' show that the joint action chain is in accordance with joint action consequence principle, and the joints' potential is put to its full play. As far as the dissection structure of human body is concerned, the muscles of arms and legs become weaker from near side joints to far side ones. In the course of performance, strikers should strengthen the force of the joints to display their potentials fully. We can see that striker one has the highest foot gravity velocity of 17.27 m/s; striker three, 17.25 m/s; striker two, the lowest 16.59 m/s.

Table 4 Lower body joints' angles at the right legs' maximum gravity velocity.

Item / striker	left hip (^{0})	left knee (^{0})	left ankle (^{0})	right hip (^{0})	right knee (^{0})	right ankle (^{0})
1	128.13	143.00	106.02	110.07	153.47	161.11
2	133.75	147.30	107.49	109.96	149.29	167.83
3	126.10	139.70	105.82	108.27	152.86	167.20

We can see from Table 5 that the smallest knee joint angle of striker one is 76.64^0, his knee joint angular velocity is 16.60 rad/s.The knee joint angle of striker three is 76.94^0, and he has the biggest angular velocity of 16.63 rad/s. Striker two has the biggest knee joint angle of 84.32^0 and the smallest angular velocity 15.64 rad/s. The data further show that during action, the action leg is under tucked condition, which reduces the twist inertia and quickens the angular velocity of the knee joint and makes muscles of the action leg under the best action condition and improves the muscles' contracting speed.

Table 5 Minimum action leg (right) knee joint angle and maximum knee joint twist angular velocity.

item \ striker	1	2	3
Minimum angle (^{0})	76.64	84.32	76.94
Maximum velocity (rad/s)	16.60	15.64	16.63

In the course of doing whiplash movement, the turning angle along X, Y and Z axis of hipbone, shoulder and left hand could be seen in Table 6.

Table 6 The Turning Angle of Testee's Hip, Shoulder and Left Foot.

item	Hip (^{0})			Shoulder (^{0})			Left Foot (^{0})		
	X	Y	Z	X	Y	Z	X	Y	Z
1	94.18	115.34	106.26	56.78	168.56	114.03	61.47	75.79	74.54
2	101.45	106.01	118.34	70.41	150.36	116.22	43.62	67.21	68.49
3	98.51	103.18	105.23	67.52	171.34	112.37	56.18	67.29	66.82

From the data of Table 6, we could easily see that when doing whiplash movement, twisting body trunk positively and actively can help the testee to achieve the technology requirement, which enlarges the elastic energy of contracting muscles to lengthen the distance of muscles' working. Moreover, the turning of support legs and feet helps the testee to speed his body trunk and hip turning.

Mechanic principles of whip leg movement: Whiplash movement could make terminal link of body's moving chain produce high moving speed and hitting strength. When an athlete doing whiplash movement, his proximal link (thigh) stops suddenly and passes its angular momentum to distal link (calf) nearby. Having little momentum of inertia, Terminal link (feet) could get a higher angular velocity and line velocity through each link of lower limbs stopping suddenly one by one and passing angular momentum constantly. When doing whiplash movement, the lower limbs' bending could reduce the momentum of inertia of lower limbs, make the muscles participating in whiplash movement being the best state of giving strength and is convenient to rise muscles' contracting speed so that momentum could be passed in a proper way and hitting effect could be magnified.

The principles of joints' moving chronological order: with human body's four limbs from the distant to the near, the cross sectional areas of muscles become smaller and smaller gradually. Because of this structure, when human body needs to overcome resistance or to show high moving speed, the big joints always move first and show a certain order. In the course of finishing moving technique, it's good to force big joints to give more strength actively and make full use of their potential. The strong or the weak of small joints determine it to join in working sooner or later directly. If his muscle's moment of force is large, the small joints could join in working ahead of time so that the finishing time could be reduced and the speed could be raised. Twisting of trunk: It's good for achieving technique requirement to twist trunk properly. Twisting of trunk is an inherent way to coordinate body's movement. Making use of it intentionally and properly could enhance the effect. Because of the same direction of pelvis' turning and swinging, twisting of trunk promotes step-on and stretching movement and whiplash movement, increases the quality of swinging movement and improves the effect of step-on further. Consequently, twisting of trunk could extend the span, speed and step-on strength of swinging movement. Trunk's twisting actively increases the elastic energy of contracting muscles and the distance of muscles' working.

Proper span of swinging and cushioning movement makes muscles do polymeric contraction and uses the energy of elastic composition in tendons and muscles. Doing polymeric contraction in step-on and swinging movement, muscles could send out larger strength so as to achieve hitting effect expected and enlarge limbs' hitting force.

CONCLUSION: According to the data and basic mechanic principles coming from players' doing whiplash movement, we should pay attention to several problems:

When doing whiplash movement, an athlete should bend the lower limbs as soon as possible, which could reduce the turning momentum of inertia of lower limbs speed, get a higher angular velocity, make the muscles participating in whiplash movement being the best state of giving strength and rise muscles' contracting speed to magnify hitting effect.

When doing whiplash movement, an athlete's body trunk's twisting actively increases the elastic energy of contracting muscles and the distance of muscles' working. Turning of support legs and feet could increase the turning speed of trunk and hipbone further and the effect of whiplash movement.

Human joints' moving chain accords with the principles of joints' moving chronological order. In the course of finishing moving technique, it's good to force big joints to give more strength actively and make full use of their potential.

When doing whiplash movement, an athlete should try his best to make all the joints nearby stop suddenly one by one. So all the moment of force from each joint could be passed to distal links in a proper way and the moving speed of distal links could be increase effectively.