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Human posture influences on whirlwind kick technical motion completion quality based on biomechanical analysis

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ABSTRACT

Whirlwind Kick is one of the most basic jumping skills in Martial Arts; the technology has greater values in fighting and watching. In order to get a profound acknowledge of whirlwind kick skill and provide scientific theoretical basis for coaches and athletes, make analysis of whirlwind kick skill motion process, so that can get effective pathway of the skill motion standard and perfect playing through analyzing the motion process human posture and measurement equipment monitoring data. During researching whirlwind kick skill motion process, human posture, motion key point, error-prone motions and precautionary measures, to make preparation for motion skills further researching, analyze human turning stable status affected rotational inertial and eccentricity that generates human rotation and turning, implement mechanical analysis of motion skills completion process, finally make analysis through test equipment's collecting human posture data, gravity center location coordinate and force platform pressure parameters values checking, get successful completion whirlwind kick motions' technical features . Through analysis method and research results in the paper, it provides research methods and theoretical basis for whirlwind kick motion skill perfect completion.

Key words: whirlwind kick, rotational inertia, gravity center coordinate, eccentricity, force platform parameter

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INTRODUCTION

Sports biomechanical theory is the main method to analyze sports movement; this paper applies sports biomechanical theory and method into analyzing Martial arts routines' main jumping skill whirlwind kick, so that provides scientific experience measures and theoretical basis by analysis process and researching results on whirlwind kick motion successful completion [1].

For sports biomechanical sports movement analysis and Martial arts jumping skill whirlwind kick researches, lots of people have made efforts, by which natural science theory is propelled to penetrate towards humanist movement field, some domestic scholars put forward feasible suggestions, from which Liu Jun etc.(2009) on the basis of document literature, mathematical statistics, experts consulting and biomechanical experiments testing, carry on biomechanical analysis with an example of whirlwind kick body rotation 720°, extract motion success rate improvement experimental data[1]; Yang Jia-Peng etc.(2012) make theoretical analysis of Martial arts whirlwind kick 720° completion process rotational inertial, flying postures and eccentricity, and propose reasonable suggestions on such skill completion[2]; Liu Cun-Zhong etc.(2013) summarize sports biomechanics muscle activities sequence principle, rotational inertial minimum principle, impulse formation principle, energy saving principle and extension accelerated distance principle and apply them into Martial arts technical motions, it provides theoretical guidance for coaches and athletes' training [3-5].

Based on previous research, for Martial arts jumping skill whirlwind kick motion process, it utilizes sports biomechanical principle, dynamical principle and mathematical statistics to carry out analysis, with an aim to explore whirlwind kick motion formation causes and error motions causes so that provides theoretical references for

Martial arts athletes successful perfect playing in the skill.

MARTIAL ARTS WHIRLWIND KICK TECHNICAL MOTION BIOMECHANICAL ANALYSIS

In Martial arts, whirlwind kick is one of basic motions in four large jumping, it has higher difficulty in fighting and performance process meanwhile with greater effects, its motion process generally is composed of run-up, windmill takeoff, turn waist in the air and swing leg inward as well as land such four large parts [4, 5].

Whirlwind kick motion difficulty mainly reflects on dismounting of soaring height and landing, from which landing dismount divides from easy to difficulty into 5 grades as left and right legs successively landing, left and right legs simultaneously landing, single leg landing, whirlwind kick connects with vertical fork and whirlwind kick 720° connects with vertical fork. Therefore, in order to play relative successful and wonderful whirlwind kick skill, athletes are required to possess better jumping ability, waist and abdomen strength, coordination and legs ligament flexibility. As Figure 1 shows, whirlwind kick motions space image presentation [6-9].

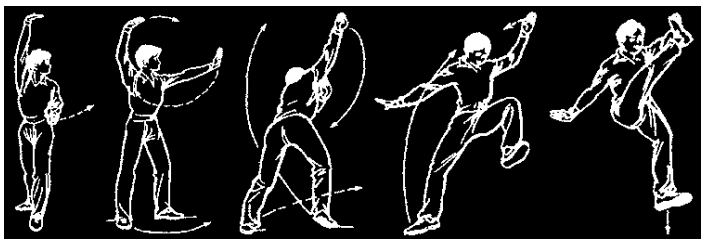

Figure 1: Martial arts skill whirlwind kick motion schematic figure

There are four key points for successful completing whirlwind kick motion as following:

- Swing leg inward should be closer to body;
- When body swings, it needs to be fanwise;
- When completing windmill, skip, body rotation, swing leg inward and other segments, it requires that body each segment in harmony with each other.
- Body rotation angle should be above 270°.

In whirlwind kick completion process, it will appear some error-prone motions, in order to get rid of error motions and understand error motions, it is required to make analysis of error-prone situations, regular errors and correct approach:

- The next step, body rotation perspective insufficient, uncoordinated movements.
- Correct approach : do without legs law body rotation 360° east "emancipated jump" exercises to improve physical-capabilities.
- His back, bend knees in the air, they stick.
- Correct approach: more "turn left, right before one of" legs practicing law in practice emphasized Shenxi correct posture.
- After the upper body moved backwards.
- Correct approach : "to the left knee and right leg muscles jump and twist 360° east of practice, emphasizing upper body upright, head above.

Rotational inertia influence factors analysis

Whirlwind kick skill movement process is the main factor that constraints successful completion, and rotational inertia as human rotational mechanics researching objects becomes the main factor that constraints rotation perfect completion. Rotational inertia is rotational objects inertia, is a physical quantity that owns original status maintaining ability when describes objects rotation, when object rotational inertial becomes bigger, its rotational status would be more stable, rotational status would not prone to change [10].

Rotation objects original status maintaining ability reflections' physical quantity rotational inertia mathematical expression is as formula (1) shows.

$$J=\begin{cases}\sum_j \Delta m_j r_j^2 = m_1 r_1^2 + m_2 r_2^2 + \cdots & (a)\\ \sum_j \Delta m_j r_j^2 = \int r^2 dm & (b)\end{cases} \tag{1}$$

In formula(1), J expresses rotational inertia, (a) expresses rigid body quality scattering distribution rotational inertial computational method, (b) expresses rigid body quality continuously distribution rigid body rotational inertial computational method, Δm_j expresses mass element, r_j expresses mass element Δm_j and spindle distance.

From formula (1), it is clear that athletes whirlwind kick movement process, variables that influence athletes rotational inertia are its own body mass, body mass distribution status and spindle location, then make analysis of above three influence factors.

Body mass: Heavier athletes have bigger rotational inertial than lighter athletes in flying body rotation, their movement status are more stable. On the contrary, lighter athletes have smaller rotational inertia in flying body rotation; corresponding stable status is prone to change; During process from takeoff to soaring body rotation, heavier athletes due to their bigger rotational inertia, let their motion status difficult to change not helpful for rotation, so lighter athletes are more easier to perfect complete whirlwind some high difficulty motions, at the same time in order to reduce injury in competition process, it proposes requests of Martial arts athletes weight controlling.
Mass Distribution: If mass concentrates around the spindle, it can make rotational inertia smaller, rotational speed more fast; when human mass distribution is far away from spindle, human rotational inertia would be bigger, and its rotational speed would be slower. When athlete takeoff, body relaxes and opens, it is helpful for body mass even distribution towards four limbs so as to increase rotational inertia let body status keep stability which is helpful for whirlwind kick smacking motion in the air. But if body distribution excessive extends that would also not helpful for flying rotation. In order to increase rotation, after smacking in the air, it is required to make fast close leg and both arms hug body motions so that helpful for body mass concentrating on longitudinal axis, making rotational inertia reduce and getting good rotation results. In landing stable phase, athletes' four limbs extend can let body mass even distribution as much as possible, so as to increase rotational inertia and achieve reduce rotational speed results, which is helpful for landing buffer and increasing body stability, therefore Martial arts whirlwind kick motion body each phase posture has great influences on rotational inertia distribution.

Spindle location: Object in rotation process lies in one end of object, Martial arts athletes in rotation process, when spindle is far away from body center, his rotational inertia would be bigger, motion difficulty would be increased; when spindle gets closer to body center, motions are more easily to fulfill. When Martial arts athletes change body postures, their radius turning around vertical axis would be changed to adjust rotational inertia size so as to achieve controlling of angular speed, which let athletes more smoothly complete high difficulty motions in the air. When athletes human body in soaring status, they follow angular momentum conservation law in horizontal plane. In such status, human body adopts any motion would change its body posture, therefore Martial arts whirlwind kick skill every technical motion in the air is surrounding increase or decrease rotational inertia and angular speed that used for propelling body rotation successfully completion. Athletes' swing leg inward smacking moment, the swing leg inward and body draw close to longitudinal axis, so that rotational axis keeps in the body center line as much as possible and reduces rotational radius, achieving reduce rotational inertia propel to rotation results.

Table 1: Skipping previous step's step length and step forward angle parameters

Type	Step length(cm)	Right leg and horizontal axis included angle(°)	Step Index(Step/lower limbs length)
Athlete 1	71.90 cm	104.35°	0.83
Athlete 2	70.65 cm	102.32°	0.86
Athlete 3	66.23 cm	106.17°	0.83
Average value	69.59 cm	104.28°	0.84
Variation	8.15 %	3.69 %	4.19 %

Human each segment parameter influences analysis on whirlwind kick motion completion

The process of one step ahead of whirlwind kick motion skipping is the beginning of whole skipping phase, during its movement step plays a very important role in gravity center can rational shift to supporting leg or not. In order to provide more standard motion constraints for athletes, specially carry out test analysis of three athletes steps in phase before skipping when complete whirlwind kick body rotation 720° connecting with horse stance motion, as Table 1 shows skipping previous step's step length, right leg and horizontal axis positive direction included angle

and step index.

From Table 1 data, it is known that three athletes' skipping previous step's step length have certain differences, its maximum value is 71.90cm, minimum value is 66.23cm, total average value is 69.59cm, its variation is 8.15%, and also dig out that the three athletes have certain differences in height and lower limbs length. In order to control athletes' height and lower limbs length, it brings into step index concept, three athletes' step index have significant differences, the maximum value is 0.86, minimum value is 0.83, total average value is 0.84, its variation is 4.19%. It can be concluded that athlete has certain individual differences in lower limb length and other aspects, therefore coaches and athletes make research on step index data differences is helpful for scientific analysis.

Data in Table 1 also reflects that skipping previous step right leg footing angle has an influence on skipping quality and skipping way, three athletes' footing angles average values are respectively 106.17°, 102.32° and 104.35°, total average value is 104.28°, variation is 3.69%, right leg heel and right leg toe connection line and horizontal axis positive direction included angle should slight above right side ankle joint lateral and toe connection line and horizontal axis positive direction included angle. Experiences summary thought that in order to helpful for body gravity center shifts towards supporting legs so that improve skipping results and provide guarantee for whirlwind kick 720° connecting with horse stance motion smoothly completion, it is proper to control right leg footing angle around 104.28°.

Smacking in the air and body rotation phase plays an important role in the whole whirlwind kick body rotation 720 connecting with horse stance motion. From the aspect of time distribution, smacking in the air and body rotation phase accounts for 48.11% of whole technical motion; From the perspective of Martial arts competitive rules, insufficient body rotation degree and soaring swing leg inward moment swing leg height cannot achieve standard level, then the whole motion is assessed as failure, so smacking in the air and body rotation phase technical motions merits have direct effects on whole technical motion and participate grading.

Data in Table 2 shows three athletes' lumbosacral junction position and body rotation angle status when completing soaring swing leg inward motion, so as to get reasonable smacking time. From Table 2 data, it is clear that three athletes in completing soaring swing leg inward motion, average rotate hip joint 137.79° at 0.685s. It can be concluded that athletes body surrounding vertical axis rotation angle is not very big when soaring swing leg inward. If complete body rotation 620° at such angular speed, it would need 1.237s, while athletes average soaring time is 0.685s, three athletes during completion whirlwind kick body rotation 720° connecting with horse stance motion, their body soaring time are respectively 0.742s, 0.664s and 0.650s, their total average value is 0.685s.

Table 2: Lumbosacral junction position and body rotation angle parameters when smacking

Type	S1	S2	A1	A2	T
Athlete 1	1526.44	1633.43	232.39	253.22	0.383
Athlete 2	1348.59	1482.91	237.51	256.96	0.342
Athlete 3	1320.44	1433.43	244.81	265.64	0.325
Average value	1398.49	1516.59	238.24	258.61	0.350

Note: S1 represents lumbosacral junction in Z axis direction displacement when smacking(mm)；S2 represents lumbosacral junction in Z axis direction displacement after smacking(mm)；A1 represents hip axis already rotated angle when smacking(°)；A2 represents hip axis already rotated angle after smacking(°)；T represents the time after body soaring when hip joint rotation arrives at 270°(s).

According to oblique projectile theory in mechanics, it is clear that object in oblique projectile movement, when its particle arrives at top point, the time is the same as particle moves from top point to landing point, so when three athletes' body total gravity center arrive at top point, their body soaring time generally that is also leaving ground 0.371s, 0.322s and 0.325s, average value is 0.343s, at that time athletes soaring swing leg inward smacking motion occurs, while actual occur time are 0.308, 0.3292 and 0.225s, average value is 0.275s, smacking motion happens 0.068s ahead of gravity center arriving at top point.

Athlete motion completion landing moment postures are also regarded as grading, its parameter status as Table 3 shows, Table 3 showing landing moment right knee angle, right hip angle, two legs included angle as well as trunk and three coordinate axis included angle.

Table 3: Athlete completing motion landing moment body posture parameters

Type	Landing moment right knee angle(°)	Landing moment right hip angle(°)	Landing moment two legs included angle(°)	Landing moment trunk and coordinate axis included angle(°)		
				X axis	Y axis	Z axis
Athlete1	147.94°	111.34°	53.85°	76.60°	106.94°	21.86°
Athlete 2	148.51°	125.83°	50.93°	90.83°	112.34	22.38°
Athlete 3	145.70°	110.62°	54.16°	83.78°	108.37°	19.64°
Average value	147.39°	115.93°	53.85°	83.74°	109.22°	21.29°

From Table 3 data, it is clear that three athletes' two legs have already apart to a certain extent when landing so that it plays an important role in increasing body surrounding vertical axis rotational inertia and deceasing body rotational angular speed, which can also reduce ankle, knee joint loading and impulse force when landing and achieve improve landing stability results. Through trunk and each axis included angle, it is known that athletes' trunk will slightly bend forward in front left when landing.

Influence analysis of human gravity center status affecting motion completion

Human gravity center coordinate will continuous changing with Martial arts athletes' whirlwind kick motion implementation. Explore successful complete skills parameter change rules by gravity center coordinate changes, as Figure 2 shows gravity center height correlated parameters analysis.

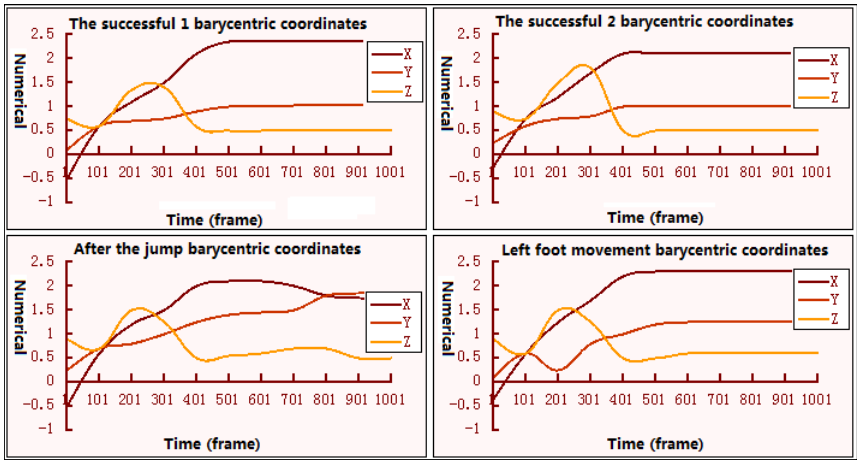

Figure 2: Four times' motion process body gravity center three directions' coordinates changes

From Figure 2 image, it is clear that four times motions gravity center Z axis trajectory changes are quite small; its crest top point is soaring maximum height moment gravity center location. In soaring process, right leg is fanwise swinging from right side and turning onwards; when it goes through front side of body, left hand smacks right foot, data indicates that athletes still have short time gravity center rising after smacking, then gravity center starts to fall, four times smacking motion happens moment, their differences with maximum soaring height are all 0.02mm.

From whirlwind kick body rotation 720 ° connecting with horse stance time distribution, it is clear that from run-up last step to soaring and landing accounts for different time of whole motion will generate different results; From success two times time distribution, total time are the same, the second success case leg closing and body rotation time after kicking is longer than the first success case, it can be concluded that proactive fast skipping can make better takeoff.

Athletes' gravity center Z axis coordinate maximum value shows athletes' maximum soaring height. To achieve perfect soaring process, athletes are required to own good jumping ability. If athletes have stronger jumping ability, it can let their whirlwind kick motion completion cool and graceful.

Human rotation process eccentricity formation and influence analysis of its effects on motion completion

Movement status after human body soaring is a compound movement of translation and rotation. Such compound movement formation causes is when whirlwind kick run-up and skip, the takeoff leg generates ground a upward action force F ; According to Newton third law, it is known that ground would generate takeoff leg a upward reaction force F' , when makes forward braking, it gets backward friction force Q , above two human bodies force

bearing are not just pass total gravity center point O, so that the two forces are the eccentric forces to each other, their torque with gravity center form eccentricity $F'a$ and Qb, the eccentricity has directions, only when body rotates in counterclockwise direction, the moment of couple $F'a$ would be root cause of propelling whirlwind kick rotation, therefore reaction force F' and vertical axis form into eccentricity, backwards friction force Q generated torque Qb is causes of side somersault turns surrounding the capital axis.

According to human rotation motions differences, eccentricity directions are changing at any time, as Figure 3 shows mechanical analysis of athletes in skipping board takeoff, intuitional reflect human rotation process eccentricity formation and functions.

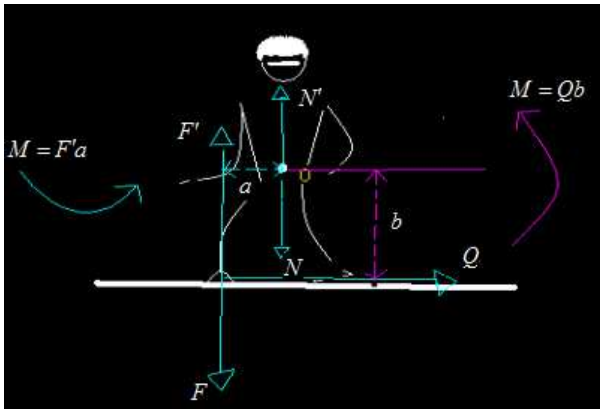

Figure 3: Eccentricity formation and function schematic figure

From above analysis, it is known that whirlwind kick 720° such high difficulty motion completion is required to achieve higher moment of momentum as much as possible before soaring. Only athletes get enough moment of momentum, store energy when takeoff leg supports with ground, till achieve propelling body rotation results after body soaring. Both increase eccentric force F or force arm r can achieve eccentricity increasing results，let human body complete a certain turning over motions in the air.

Force platform parameters analysis

For athletes four times whirlwind kick motion process skipping process, it carries out force measurement and gets force platform records Z axis pressure oscillogram, as Figure 4 shows two times success two legs pressure Z value, backwards falling two legs pressure Z value and left leg two legs acting pressure Z value.

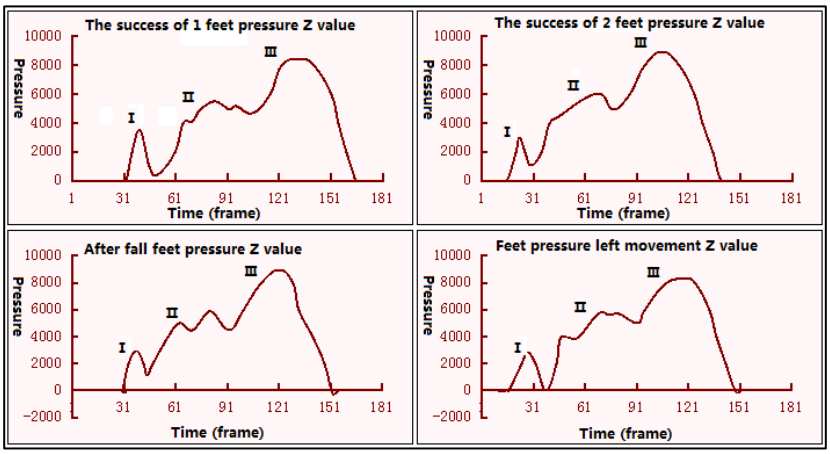

Figure 4: Whirlwind kick skipping moment force platform parameters values oscillogram

In Figure 4, parameter value waveform I represents first ground left leg suffers ground impulse force, waveform II represents right leg grounding moment impulse to ground, left leg supporting buffer makes waveform at this time is relative gentle, waveform III represents after left leg swinging and leaving ground, body ground force starts from

right leg squatting, its value expresses swing segments positive swinging and right leg pedaling and stretching received ground action force. From images, it can be seen that when takeoff pedal and stretch and leave the ground, body gravity center speed is not always totally decided by the maximum pedaling ground force in pedaling and stretching process, waveform I and waveform II trough express buffer and braking process when left leg functions as supporting. Waveform curve slope is athlete supporting process techniques and body ability records, waveform crest slop can explain hip and waist remnant sports status, if crest appears point, then result is not good, if crest is relative smoothly then athlete hip and waist have already good participated in buffer and takeoff process.

CONCLUSION

Through analyzing whirlwind kick motions movement process, athlete body posture as well as motion key points and error-prone motions correct approaches, it provided space image basis and experienced expectation for sports analysis; In researching whirlwind kick process rotational physical quantity rotational inertia functions, through analysis of rotational inertia computational formula's variables, human mass, mass distribution and spindle location effect on rotation status stability, got rotation status reasonable changing motion postures that provided theoretical basis for athletes making stable and perfect motions; Carried out biomechanical parameters analysis of human each segment in whirlwind kick motion process, achieved that last step before skipping, the optimal smacking moment and stable landing, proposed data basis and experience references; By human gravity center coordinate monitoring data analysis, it got reasonable soaring height and soaring process human gravity center change rules; For eccentricity formation causes and functions, it implemented theoretical analysis that revealed rotation and turning causes from dynamical perspective; Made image analysis of human foot's action force on force platform monitoring data when skipping, it got that human body action status on skipping board in whirlwind kick motion process, and put forward deducted athletes hip and waist function results in buffer and takeoff process by crest smooth extents situations.

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