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*Research Article*

# Multimedia Based Medical Big Data Analysis of Leg Swing Strike Effect in Wushu Sanda Sports

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In order to explore the effect of leg swing in Wushu Sanda, a method based on multimedia medical big data is proposed. The joint torque of hip joint is less than that of healthy subjects. The peak values of the horizontal and vertical components of the joint reaction force are approximately the same as those of the sound subject, and a comparison is made between the two kinds of leg swing strike effects of Wushu Sanda to select the leg swing strike which is more suitable for Wushu Sanda. These results show that the turning strategy of Wushu Sanda on the stairs can be used to swing the legs after turning with similar or smaller hip joint dynamics. Multimedia medical big data analysis has the greatest impact on the variability of simulation dynamic parameters. Six test students turned their knees and turned their heels forward, which is better than the technology without turning their knees and turned to swing their legs in the air. At the moment of striking, the running track of the front striking feet in the air is generally shorter. Therefore, the technology of turning their knees and turning their heels forward has higher concealment and better striking effect. It is proved that the research results may improve the inertia and usability of Wushu Sanda process design.

## 1. Introduction

Big data is a data set characterized by large capacity, many types, fast access speed, and high application value. Globally, big data is developing rapidly, and data has become a basic resource for all walks of life and even the country. It has become a computer technology and service format with wide sources, diverse formats, and a large number of data for collection, storage, and data mining, so as to obtain new knowledge, new value, and new ability (Figure 1) [1]. The medical industry is one of the most important pillar industries of the whole country and the whole society, and medical data, as the carrier of medical industry information, is worth exploring in this field. Many countries are actively promoting the development of medical informatization and medical big data, which makes the medical industry have sufficient financial and human resources to analyze the data [2].

Wushu Sanda is a special sport, so the corresponding effect of its techniques and tactics must be based on the mastery of athletes at the level of "sports biomechanics." Attack effect is usually determined by strength and strike speed, while strength and speed need to be realized by physical training. Therefore, the corresponding basic disciplines and training of Wushu Sanda are the key links to strengthen the sports effect. However, there are still some problems in current training, such as paying attention to technology and skills and ignoring basic disciplines and physical training, which makes it difficult for athletes to effectively apply techniques and tactics to actual combat [3]. Wushu Sanda belongs to the fighting and confrontation project of skill type and takes hitting each other as a form of confrontation. In the competition, the movement usually changes quickly, and the exercise intensity is high, so the injury rate must be higher than that of other events. The sports injury corresponding to this kind of sports is accompanied by many triggering factors: the first is that the preparatory activities have not been paid attention to, the second is technical errors or fatigue, and the former accounts for the largest proportion.

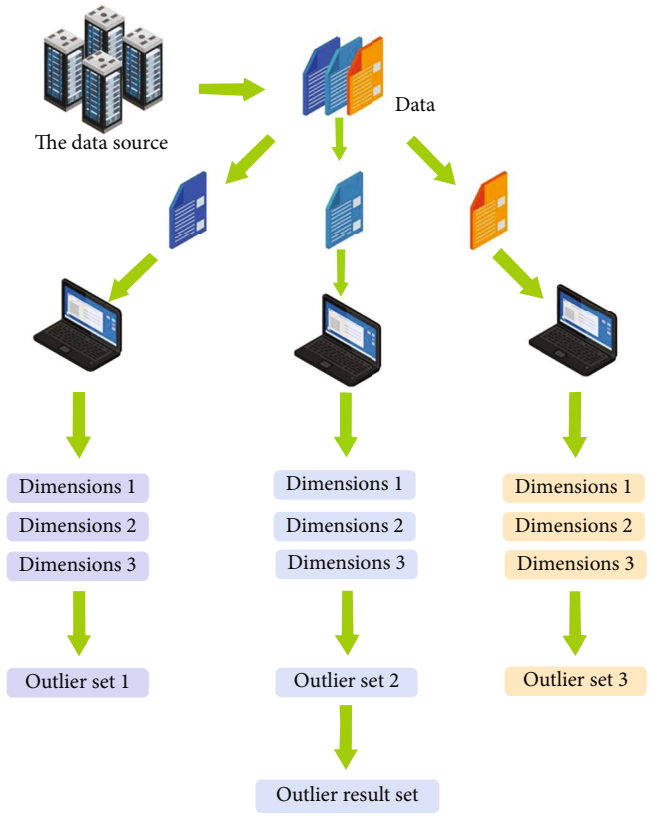


Figure 1: Multimedia medical big data.

In addition, if the coach fails to pay attention to the general training, it will lead to the difficulty of fully carrying out the preparatory activities. At the same time, if they are not reasonably arranged, they will inevitably lead to sports injury [4]. For competitive sports, although strength is particularly important, psychological quality will affect the competitive state and level. Only when athletes are fully prepared from the psychological level can they effectively mobilize their physiological and psychological systems and invest in competitive activities, so as to form the optimal competitive state. At this stage, sports training only pays attention to the training of physical fitness, tactics, or strength and does not focus on the training of psychology and willpower. The psychological state associated with the competition is usually closely related to the training effect and competition results. If the athletes are depressed, impatient, and lack of self-confidence, it will inevitably make it difficult for the self-control to meet the needs of the competition and then affect the competition effect [5].

## 2. Literature Review

Sahin and Polatcan analyzed the research status of sports biomechanics in Chinese Wushu in recent years and pointed out that there are still deficiencies in the research of material selection, movement technology analysis, muscle mechanics, balance, and stability, which is related to the professional level and research conditions of coaches [6]. According to Liu et al., the research results believe that Wushu balance movement is based on Athletes' muscle strength, so strengthening the muscle strength of legs and arms, especially the strength of small muscle groups and the coordinated development of upper and lower limb muscle strength, is the key to doing well. Flexibility is the prerequisite to complete the balance movement. Flexibility and strength should be developed in coordination to avoid the phenomenon of "second leg swing." The speed control of attacking leg and arm and the timing of reaching the maximum swing speed are the key factors affecting the balance quality. The change of center of gravity velocity should float evenly within a certain range, and the center of gravity displacement should remain stable [7]. In the article, Zhang and others made a qualitative analysis on the technical structure, teaching, and training of front leg side kick and expressed their views on common wrong actions and correction methods [8]. Jin and Li focused on the characteristics, functions, and training methods of kicking in a qualitative way [9]; Dong et al. mentioned in the preface that "kick leg technique is one of the main leg techniques in Wushu Sanda. It has fast speed, great strength and many changes." But the author's purpose is to introduce the meaning of antikick counterattack [10]. Rubido et al. mainly introduced the technical essentials and training methods of turn and side kick in a large space [11]. Elizabeth pointed out that the turning side kick is based on the side kick, which uses the amount of throw of body rotation to increase the hitting force. The causes of common misoperation are analyzed [12]. Jain et al. systematically discussed the mastery and application of side kick in Sanshou leg technique in terms of space, angle, sense of distance, and time difference [13]. Chauhan et al. around the whip effect

of Wushu Sanda whip leg, this paper analyzes and discusses the technical structure, technical essentials, and whip force training of Wushu Sanda whip leg. It also lists the special practice and auxiliary practice methods of whip leg whip strength training [14]. Rahman et al. divided the attack leg into three parts: knee lifting, hip spreading, and whip. It also expounds the center of gravity and balance [15].

Based on the current research, a method based on multimedia medical big data is proposed. The joint torque of hip joint is less than that of healthy subjects. The peak values of the horizontal and vertical components of the joint reaction force are approximately the same as those of the sound subject, and a comparison is made between the two kinds of leg swing strike effects of Wushu Sanda to select the leg swing strike which is more suitable for Wushu Sanda.

## 3. Medical Multimedia Big Data Wushu Sanda Leg Swing Strike Effect Analysis

The big data multimedia analysis is carried out, and the inertia characteristics of swinging legs after turning are studied. The martial arts Sanda process allows users to climb stairs with the same thigh movement as strong subjects without colliding with steps. The process of Jinggu Wushu Sanda is modeled as a rigid body pendulum under the knee, which is a passive joint. According to the physical parameters of the subjects in the experiment, the length of Wushu Sanda process under the knee joint is 0.42 m, and the toe forward is set to 0.16 m (Figure 2). The stairs used in this and previous studies have five steps (Figure 3). The height, depth, and width of steps are 0.17, 0.30, and 0.90 M, respectively. The global coordinate system is shown in Figure 3. The origin is at the bottom of the first step. The $x$-axis is horizontal, and the $y$-axis is vertical. The simulated movement of the artificial limb (right leg) swing starts from the toe of the second step to the end of the landing of the fourth step [16].

Equations (1) and (2), respectively, give the angle and linear motion equations for simulating the motion of leg prosthesis:

$$I_{os}\ddot{\theta}_S = (-r_S) \times F_K, \tag{1}$$

$$F_K + m_S g = m_S a_S, \tag{2}$$

Where the moment of inertia of the prosthesis (lower leg part) around the center of gravity, $\ddot{\theta}_S$ is the angular acceleration of the lower leg part

$$r_s = r_s[\sin\theta_S - \cos\theta_S]^T. \tag{3}$$

It is the relative position of the center of gravity from the knee joint to the lower leg

$$F_K = \left[F_{Kx}, F_{Ky}\right]^T. \tag{4}$$

It is the force acting on the tibia from the knee joint and the mass of the tibia

$$g = [0, g]^T. \tag{5}$$

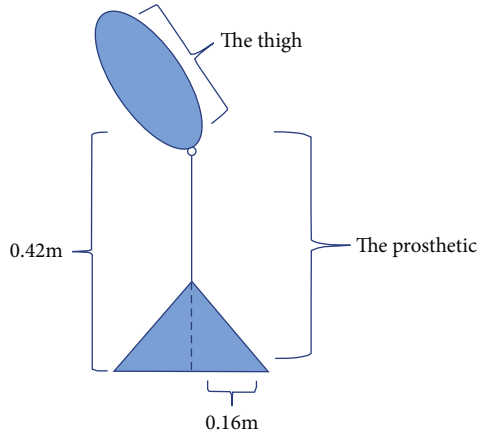


Figure 2: Thigh prosthesis model.

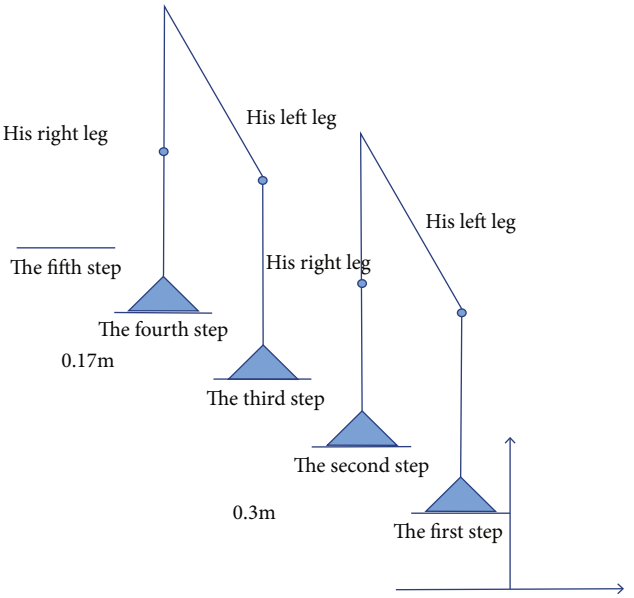


Figure 3: Stairs and global coordinate system used in the study.

It is the acceleration of gravity

$$a_s = \left[a_{Sx}, a_{Sy}\right]^T. \tag{6}$$

It is the linear acceleration of the centroid of the dolphin bone. $a_s$ can be written as

$$a_s = a_K + \omega_S \times r_S + \omega_S \times (\omega_S \times r_S), \tag{7}$$

where

$$a_K = \left[a_{Kx}, a_{Ky}\right]^T. \tag{8}$$

It is the linear acceleration of the knee.

$\dot{\omega}_S$ is the acceleration vector of the lower leg, and $\omega_S$ is the angle vector of the lower leg.

$$\left(I_{OS} + m_S r_S^2\right)\ddot{\theta}_S = m_S r_S\left(g \sin\theta_S - a_{Kx} \cos\theta_S - a_{Ky} \sin\theta_S\right). \tag{9}$$

The translational motion parameters of the knee joint, including position and acceleration ($a_k$), were obtained from the experimental data of healthy subjects. The sixth-order polynomial is fitted to the acceleration data and used to solve the differential equation of prosthetic motion (9). All combinations of inertial characteristics were tested under FFC and HFC conditions. After determining the success or failure, the joint reaction force $F_H = [F_{Hx}, F_{Hy}]^T$ simply related to segmental motion and the joint torque $M_H$ acting on the hip joint are calculated for the successful test. Calculate these values using the thigh motion equation given below. The angular motion equation and linear motion equation of the thigh are given (Figure 4).

$$I_{OT}\ddot{\theta}_T = r_{T2} \times (-F_K) + (-r_{T1}) \times F_H + M_H, \tag{10}$$

$$F_H - F_K = m_T(a_T - g), \tag{11}$$

where $I_{OT}$ is the moment of inertia of the thigh around the center of gravity, and $\ddot{\theta}_T$ is the angular acceleration of the thigh,

$$r_{T1} = r_{T1}[\sin\theta_T, -\cos\theta_T]. \tag{12}$$

It is the relative position of the center of gravity from the hip to the thigh,

$$r_{T2} = r_{T2}[\sin\theta_T, -\cos\theta_T]. \tag{13}$$

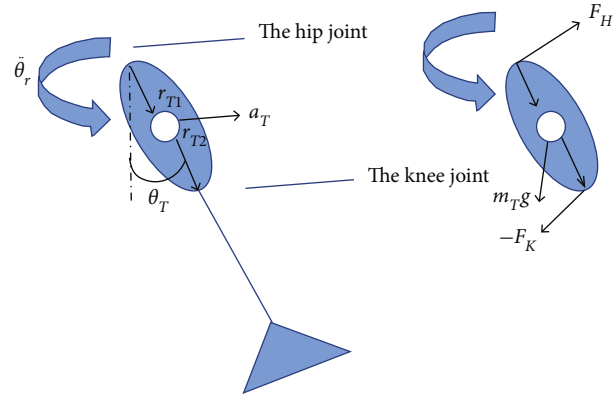


Figure 4: Free body diagram of prosthetic thigh.

It is the product of the mass of the thigh to the knee joint from the relative position of the center of gravity, and $m_T$ is the mass of the thigh,

$$a_T = \left[a_{Tx}, a_{Ty}\right]^T. \tag{14}$$

It is the linear acceleration of the center of mass of the thigh. $a_T$ can be written according to the following (15):

$$a_T = a_H + \dot{\omega}_T \times r_{T1} + \omega_T \times (\omega_T \times r_{T1}), \tag{15}$$

where $a_H = [a_{Hx}, a_{Hy}]^T$ is the linear acceleration of the knee, $\dot{\omega}_T$ is the angular velocity vector of the thigh, and $\omega_T$ is the angular velocity vector of the thigh. Therefore, write it as follows:

$$\begin{aligned}\left(I_{OT} + m_T r_{T1}^2\right)\ddot{\theta}_T = {} & m_S r_T\left\{g \sin\theta_T - a_{Kx} \cos\theta_T - a_{Ky} \sin\theta_T - \ddot{\theta}_S r_S + \dot{\theta}_S^2 r_S(\sin\theta_S \cos\theta_T - \cos\theta_S \sin\theta_T)\right\} \\ & + m_T r_{T1}\left\{g \sin\theta_T - a_{Hx} \cos\theta_T - a_{Hy} \sin\theta_T\right\} + M_H.\end{aligned} \tag{16}$$

$r_T = |r_{T1}| + |r_{T2}|$ is the length of the thigh. In order to evaluate the influence of inertia characteristics on thigh dynamics, the joint torque $(M_H)$ of hip joint and the joint reaction force $(F_H)$ of hip joint were calculated.

The free body diagram of prosthetic thigh is shown in Figure 4.

## 4. Experimental Results and Analysis

### 4.1. Research Object and Method

(1) Research object

The six test students in Table 1 are Sanda level II athletes from the Department of traditional national sports of the Institute of physical education. They can skillfully complete the flying, turning, and swinging legs of the two techniques, and the gap between height and leg length is within 2 cm, which can reduce the error caused by height factors. For the convenience of research, the names of six students are represented by the code composed of the first capital letter of Chinese phonetic alphabet. The flying, turning, and swinging legs of knee turning technology are represented by the name code plus (z). The flying, turning, and swinging legs of nonknee turning technology are directly represented by the name code. The hitting legs of WCV and ex are different from those of the other four students, and the test rotation direction is opposite under the same conditions. When studying vector velocities such as vy partial velocity and angular velocity, the direction of velocity and angular velocity at the moment of attack is just opposite to that of the other four students. In the research process, only the actual

Table 1: Natural conditions of the research object.

| Full name | No knee rotation | Turn knee | Age | Height | Leg length |
|---|---|---|---|---|---|
| CDF | CDF | CDFZ | 20 | 1.81 | 1.04 |
| EY | EY | EYZ | 20 | 1.84 | 1.07 |
| HUI | HUI | HUIZ | 20 | 1.86 | 1.06 |
| LHG | LHG | LHGZ | 20 | 1.84 | 1.06 |
| WCV | WCV | WCVZ | 20 | 1.83 | 1.08 |
| EX | EX | EXZ | 20 | 1.84 | 1.05 |

data size is compared (the direction of attack has no impact on this study). In order to facilitate comparison, the positive and negative are removed [17, 18].

### 4.2. Method

(A) Experimental design

The self-made simple and practical foot target frame ensures that the hitting target height is fixed, which is convenient for athletes to hit the target and can realize the conditions for athletes to hit the target with all their strength, so as to obtain real measurement data. First, make sure that the target height of 6 students is fixed when they swing their legs to hit the target. The foot target is firmly fixed on the foot target frame, and the foot target center is marked with a cross, 1.72 m away from the ground. The target center is the same height as the athlete's ear, ensuring that the foot target height is fixed during the strike. Second, it is conducive to shooting. The target frame arm with the foot target fixed at the end extends 1 m out of the support to ensure that the foot target is in the surrounding space without any obstruction, which is convenient for athletes to move freely. In addition, it is convenient for the test athletes to hit the target with all their strength. The foot target is fixed by two elastic wax rods. When the athlete turns around and swings his legs to strike at high speed, the foot target will push the wax rod to bend and move back, which plays a buffer role, effectively avoid the injury of the students' feet, and relieve the worries of the test team members, so as to fully hit the target, give full play to the real technology of the team members, and ensure the authenticity and reliability of the experimental data [19].

(B) 3D fixed-point shooting and analysis

In the experiment, two Panasonic (SDR-H85) digital cameras were used for synchronous fixed-point and fixed focus shooting. The machine height was 1.25 m, the main optical axis intersected 90°, and the shooting frequency was 25 Hz/s. Aijie 3D DLT frame was used for calibration. Each subject completed six movements of turning the knee forward rotation heel and nonturning the knee forward rotation heel to fly, turn, and swing the leg back. The technical action images with high quality, clear, and less interference were selected and digitally analyzed by Aijie motion analysis system. The analytical model selects the Japanese Hideki Matsui manikin, with the truncation frequency of 8 Hz, and obtains the kinematic parameters such as the target foot synthetic speed V, the cross attack partial speed vy, the strike time, the strike trajectory, and the angular velocity.

*4.3. Statistical Analysis.* SPSS17.0 statistical software was used for statistical processing, and the value was expressed in the form of mean ± standard deviation. *T*-test was used to statistically compare the experimental results between groups, and the significance was $p < 0.05$.

### 4.4. Results

(1) Comparative analysis on strike time of two kinds of flying, turning, and swinging leg techniques

The strike time is the time from the start of the action to the moment of completing the strike. The shorter the time from the start of action to the moment of attack, the shorter the reaction time left to the other party. The other party is not conducive to organizing effective defense, and the better the attack effect. By comparing the strike time of the two technologies, the shorter the time, the better the strike effect.

In terms of the strike time of the two techniques, the $p$ value is 1.54 ($p > 0.05$) by $t$-test. There is no significant difference in the strike time of the two techniques. As can be seen from Figure 5, although the difference between the two techniques is not significant. However, from the comparison between the two technologies of six test students, in addition to the hitting time of flying, turning, and swinging legs of WCV knee forward rotation heel technology, the hitting time of flying, turning, and swinging legs of the other five test students' knee forward rotation heel technology is shortened accordingly. In the case of e065, there is less time for people with different degrees of knee pronation, and there is also a shorter time for people with different degrees of heel pronation. From the average time spent by 6 people in the two technologies, the average time spent by 6 people in striking with knee forward rotation heel technology is 0.99 s, the average time spent without knee forward rotation heel technology is 1.12 s, and the average time spent by knee forward rotation heel technology is 0.13 s less. It can be seen that the hitting time of the flying turn back swing leg of the knee forward rotation heel technology is correspondingly shorter than that of the flying turn back swing leg of the nonknee forward rotation heel technology [20].

(2) Comparison of the time from the start of the striking foot to the moment of leaving the ground

It is analyzed that this period of time is from the beginning of the action to the moment when the hitting foot leaves the ground. The shorter this stage takes, the shorter the whole strike time.

By t-test, the $p$ value is 0.323 ($p > 0.05$). There is no significant difference in the time between the two techniques from the moment when the kick is off the ground. As can be seen from Figure 6, four of the six test students used the knee forward rotation heel technology, which took less time from the start of the swing leg to the hitting foot off the ground than the nonknee forward rotation heel technology. The time spent

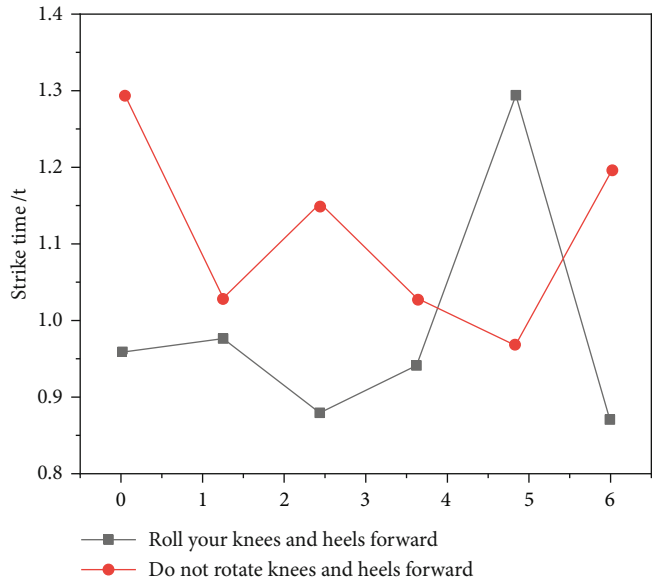


Figure 5: Comparison of two different actions performed by subjects.

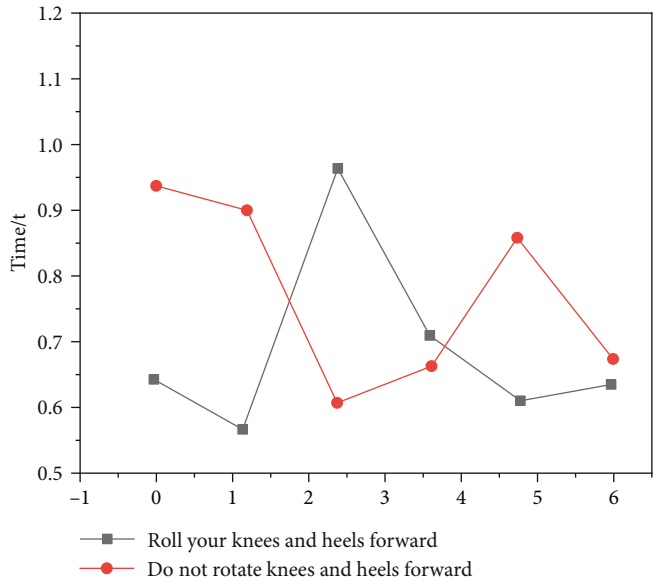


Figure 6: Linear diagram of time from starting to the moment when the striking foot is off the ground.

by two students increased, and the difference was not significant from the overall point of view of the six students.

(3) Comparative analysis of the running time of two kinds of flying, turning, and swinging back leg techniques in hitting the foot in the air

The air running time of striking foot refers to the running time from the moment of striking foot off the ground to the moment of striking foot. The shorter the time, the shorter the whole striking time. By $t$-test, the $p$ value was 0.038 ($p < 0.05$). There was a significant difference in the running time between the two techniques. It can be seen from Figure 6 that the five test students' running time in the air is less than that of the nonknee pronation technology. Only eyz's running time in the air is more than that of the nonknee pronation technology. Therefore, the running time of the nonknee pronation technology is less.

(4) Analysis of horizontal characteristics of two techniques of flying, turning, and swinging legs

The swing of legs after turning in the air belongs to the curve leg method of Sanda. In practical application, it mainly hits the opponent from the side. The higher the level of cross attack, the better the effect. The horizontal strike level of the

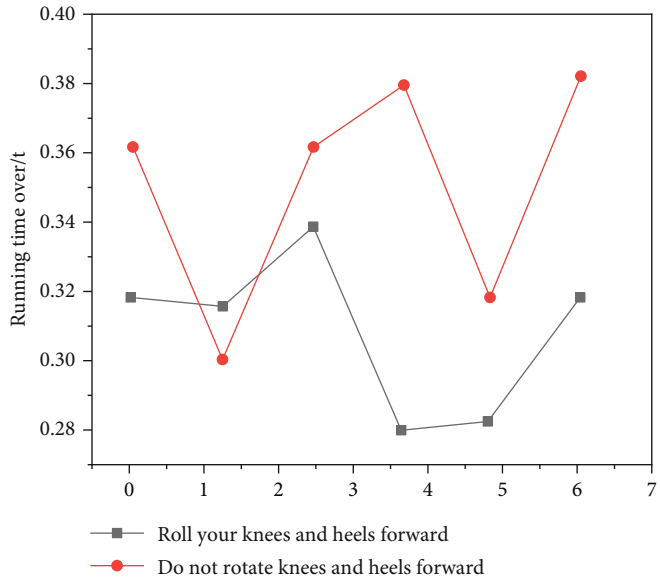


Figure 7: Linear diagram of running time of striking foot in the air before the moment of striking.

striking leg can be reflected through the elevation line of the striking foot before and after the striking point. The smaller the change of the elevation angle of the striking leg before and after the strike, the smaller the floating of the striking foot up and down before and after the strike, the closer the running track of the striking foot is to a straight line, and the higher the horizontal strike level.

As shown in Figure 7, the horizontal axis 3 is the instant point of strike, 2, 1, 4, and 5 are the time of 0.02 and 0.04 s before and after strike, respectively, the vertical axis is the foot elevation value, and the connecting line of foot elevation value at different time points is the foot running track. It can be seen from Figure 8 that except for WCV students, the other five test students have the same running track of the two technical feet at the moment of strike, with no big change. The running track of the feet at 0.02 s before the moment of strike and at the moment of strike is close to the horizontal straight line, and the highest level is CDF. The two technical feet almost move horizontally before the moment of strike. It can be seen that there is little difference between the two techniques in the level of cross attack. Both techniques can approach the level of horizontal cross attack through scientific training.

(5) Analysis of striking speed characteristics of two techniques of flying, turning, and swinging legs

In the instant of strike, the speed of Vy minute reflects the characteristics of strike speed. The faster the speed of Vy minute at the instant of strike, the better the strike effect. The velocity of the cross attack Vy is the velocity of the vertical foot facing the target. In actual combat, the faster the velocity of the vertical cross attack vy is, the greater the momentum of the foot will be, the greater the impact intensity will be, the greater the impact degree will be, and the better the impact effect will be. Therefore, the faster the velocity of the two technologies at the moment of impact Vy is, the better the impact effect will be.

(6) Comparison of two techniques of flying, turning and back swinging legs

It can be seen from Table 2 that there are four test students (PTL, GX, LLL, and DYC) who hit the instant horizontal volley and Vy split speed. There is a large gap between the two technologies of flying, turning, and swinging the legs after turning, and the knee forward rotation heel technology is dominant. GX students with the largest advantage gap have a speed of 5.038 m/s faster than the nonknee forward rotation heel technology. There was a classmate. The difference of Vy minute speed between the two techniques was 0.129 m/s, which was basically the same. Only one test student SLJ turned his knee and pronated his heel at the moment of hitting, and the Vy minute speed was less than that of the nonturned knee and pronated heel technology, but the gap was very small, and the speed was only 0.541 m/s slower. Therefore, at the moment of attack, the technology of Vy minute speed knee forward rotation heel has obvious advantages. The faster the Vy minute speed is, the better the impact effect is [21].

(7) Ratio of Vy minute speed to the maximum value of Vy minute speed

When the hitting moment is close to the maximum value of Vy minute speed, Vy minute speed is close to the fastest. If you hit at the maximum value of Vy minute speed, the momentum is the largest, the impact on the other party is the largest, and the hitting effect is good. If you do not strike when approaching the maximum value of Vy minute speed, the strike speed will be reduced accordingly, the impact strength against the other party will be reduced accordingly, and the strike effect will be reduced accordingly. As can be seen from Table 2, five test students were able to hit the other party at the maximum speed at the moment of hitting, and the hitting effect was good. Only one student hit at a

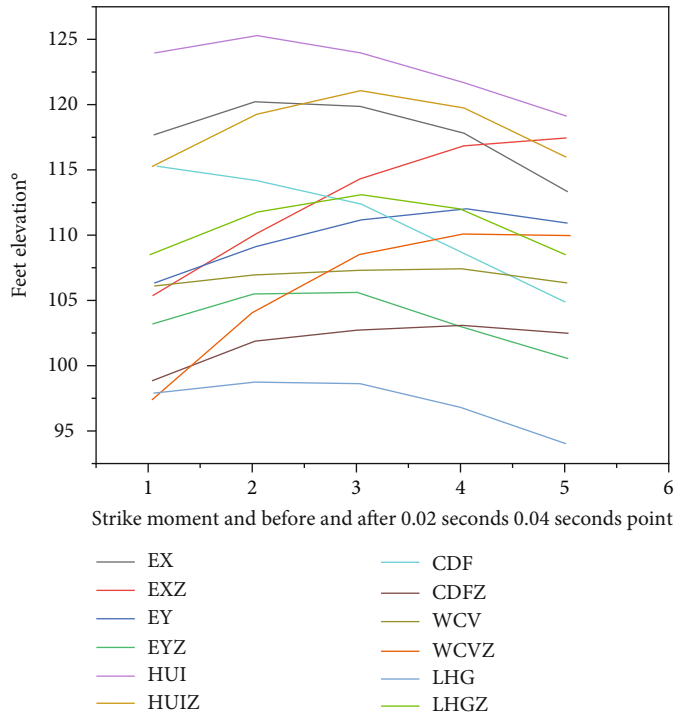


Figure 8: Connecting line of hitting leg elevation degree.

Table 2: Instantaneous Vy minute speed and maximum Vy minute speed of two technologies.

| | Turn the knees and rotate the heels forward | | | Rotate the heel forward without turning the knee | | |
|---|---|---|---|---|---|---|
| | Vy moment | Vy max | Difference | Vy moment | Vy max | Difference |
| CDF | 10.089 | 10.089 | 0 | 8.15 | 8.28 | 0.13 |
| EY | 8.519 | 8.519 | 0 | 3.436 | 6.163 | 2.727 |
| HUI | 9.918 | 9.918 | 0 | 8.175 | 8.405 | 0.23 |
| LHG | 6.475 | 6.475 | 0 | 6.346 | 7.171 | 0.425 |
| WCV | 6.58 | 7.245 | 0 | 7.121 | 7.347 | 0.226 |
| EX | 7.423 | 7.423 | 0 | 6.369 | 6.369 | 0 |

speed slightly lower than the maximum speed; without turning the knee and rotating the heel forward, only one test student's Vy minute speed coincided with the maximum speed of Vy at the moment of striking, and the other five test students were lower than the maximum value, so they could not strike at the fastest speed, and the striking effect was reduced. Therefore, the utilization rate of Vy minute speed at the moment of turning knee forward rotation heel technology is higher than that of nonturning knee forward rotation heel technology, which can give full play to the role of maximum Vy minute speed, hit the other party with maximum strength, and give full play to the best striking effect.

(8) Analysis of concealment characteristics of two kinds of flying and turning back swinging legs

The use process of swinging legs after turning in the air goes through the process of turning, flying, and hitting. The whole process is complex and takes a long time. In addition, the action intention of hitting in the process of flying is obvious, which is easy to be seen through by the other party to resolve our attack and easy to be caught by the other party. We have not yet implemented the attack process and have a favorable opportunity to counterattack. Counterattack our side through leg methods such as positive kicking and side kicking or effective falling methods to obtain effective blows. Before the moment of striking, the striking foot experiences the time before striking the foot off the ground and the air operation time. In the stage before striking the foot off the ground, the concealment is mainly reflected in the action amplitude before striking the foot off the ground. In the stage of striking foot in the air, the concealment is mainly reflected in the length of striking foot in the air. The smaller the action range of the striking foot before leaving the ground, the shorter the air running time of the striking foot before the moment of striking, and the stronger the concealment.

(9) Comparison of the range of action before hitting the foot off the ground by two techniques of flying, turning, and swinging the legs

The range of action before hitting the foot off the ground can be judged by the time from the start of the action to the moment of hitting the foot off the ground. The same test student turns around and swings his legs with two different techniques. The shorter the time of that technique at this stage, the smaller the range of action, the greater the difficulty of accurate prediction of the other party, the stronger the concealment, and the better the hitting effect.

By $t$-test, the $p$ value is 0.323 ($p > 0.05$). There is no significant difference between the two techniques from the moment when the kick is off the ground. The time difference between the two techniques from the start to the moment when the hitting foot is off the ground is small, and the concealment is close, but individual athletes show great differences. For example, LHG, the time difference between the two techniques is 0.44 (M/s), which shows that the concealment of the knee turn forward heel technology is high (Figure 9).

(10) Comparison of the running time of two kinds of flying, turning, and swinging back leg techniques in hitting the foot in the air

In the air running stage of striking feet, the action characteristics are obvious, and the opponent is easy to judge and make corresponding targeted defense or defensive counterattack, which is not conducive to obtaining good striking effect. When the air running time of the striking foot is shortened, the concealment is improved accordingly. Even if the other party determines the attack intention in time, due to the short attack time, although it is aware of it, it cannot form an effective defense, it will still be attacked, and the attack effect will be improved.

The $T$-test showed that the $p$ value was 0.038 ($p < 0.05$). There was a significant difference in the running time of the two techniques in the air. The knee rotation and heel rotation technique took a short time and had high concealment. It can be seen from Figure 10 that the five test students' knee rotation and forward rotation heel technology have less time in the air than the nonknee rotation and forward rotation heel technology. Only Hui's knee rotation and forward rotation heel technology takes more time than the nonknee rotation and forward rotation heel technology. Therefore, the knee rotation and forward rotation heel technology has high concealment.

## 5. Analysis and Discussion

In terms of the characteristics of strike time, the two technologies show significant differences in the air running time of the striking foot. The reason is that the knee rotation forward heel technology shortens the running range of the striking leg and effectively shortens the strike time. Knee rotation and forward rotation heel technology realizes knee bending and knee lifting in the process of turning, reduces the running range of striking leg, effectively reduces the striking time, and improves the striking effect. The process of bending, lifting, and widening the pedaling and stretching of the striking leg can effectively shorten the running time and track. The running time and track of the striking foot before the moment of striking are shorter than those before the moment of striking with the technology of turning the knee forward and rotating the heel in the air, turning ,and swinging the leg back without turning the knee forward and rotating the heel. It is due to the technology of turning the knee, rotating the heel forward, turning, and swinging the leg back. From the moment when the striking foot is off the ground to the moment of striking, the striking leg actively bends the knee, raises the knee, and quickly widens and stretches. On the one hand, it increases the swing speed of the striking leg and reduces the knee flexion angle of the knee joint of the swinging leg. This action reduces the turning radius of the leg and is conducive to improving the swing speed of the thigh. On the other hand, reduce the striking radian, bend the knee, and lift the knee of the striking leg to make the striking foot move forward and upward close to the rotation axis. When the trunk rotates, the striking foot moves forward and upward close to the straight line with a small radian, ensuring that the small radian moves towards the striking target. Through hip extension, the movement of the striking foot is closer to the straight line, ensuring that the striking foot runs to the side of the striking point under a small radian to carry out transverse strike.

The flying, turning, and back swinging leg vy minute speed of the knee forward rotation heel technology is greater than that of the flying, turning, and back swinging leg of the nonknee forward rotation heel technology. The reason is that the flying, turning, and back swinging leg of the knee forward rotation heel technology plays a role in the whipping of the lower leg during the striking process of the striking leg. Whipping action is an action form in which the limbs accelerate and brake in turn in the process of overcoming resistance or self displacement, making the end link produce great speed, which is called whipping action. The whipping action of the human body is a process of constantly generating new momentum moment. Both the transmission of momentum moment and the generation of momentum moment are realized through the sequential acceleration and timely braking of the limb from the proximal link to the distal link. By analyzing the change of momentum moment, we can infer whether the striking foot is whipped or not. In the same test, students can determine whether the lower leg is whipped by analyzing the difference between the angular velocity of the knee joint and the striking foot at the moment of striking. At the moment of striking, the angular velocity of the striking foot is significantly greater than that of the knee joint, the rotation of the lower leg around the $z$-axis (vertical axis) is greater than that of the thigh around the $z$-axis, the rotation speed of the lower leg is fast, and the momentum moment is large, indicating that the lower leg is in the whipping state at this time. The greater the angular velocity difference, the better the whipping effect. On the contrary, the smaller the difference between the two indicates that the whole striking leg basically moves at the same angular velocity, there is basically no difference in the momentum moment between the proximal and distal limbs, and there is no whipping movement in the lower leg, so the whipping effect is not obvious.

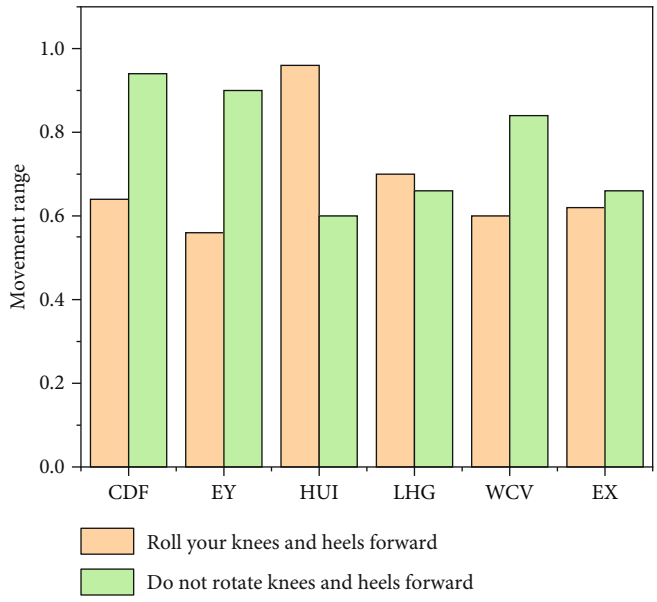


Figure 9: Time from starting to the moment when the striking foot is off the ground.

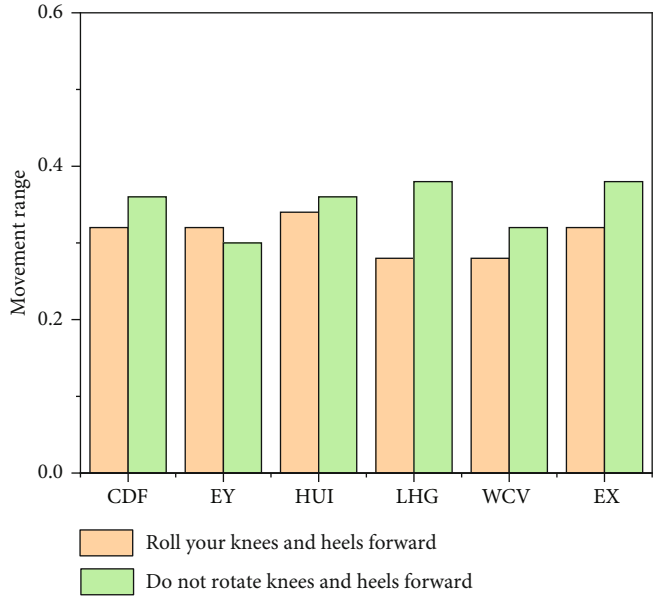


Figure 10: Running time of striking foot in the air before the moment of striking.

It can be seen from Figure 11 that five of the six test students are with the technology of turning the knee forward and rotating the heel in the air and turning and swinging the leg after hitting the foot, and the angular velocity of the foot is significantly higher than that of the knee joint. Among them, the maximum difference between the instantaneous angular velocity of Ey striking foot and knee joint is 251.035°/s, and the minimum LHG is also 32.074°/s. It can be seen that the technology of turning the knee forward and rotating the heel in the air and turning and swinging the leg after hitting the leg has whipping action. Without turning the knee and rotating the heel technology, there were two students in the moment of swinging their legs in the air. The angular velocity difference between CDF and Ey striking feet and knee joints was very small, and there was no whip on the lower leg at the moment of striking. The angular velocity difference between the striking foot and knee joint of Hui and ex at the moment of striking is significantly less than that of their knee forward rotation heel technology. The whipping effect is not as good as that of the knee forward rotation heel technology. Four of the six test students are lower than that of the knee forward rotation heel technology. Therefore, the leg whipping effect of the knee forward rotation heel technology is better than that of the nonknee forward rotation heel technology. The leg whipping effect of the knee forward rotation heel technology is

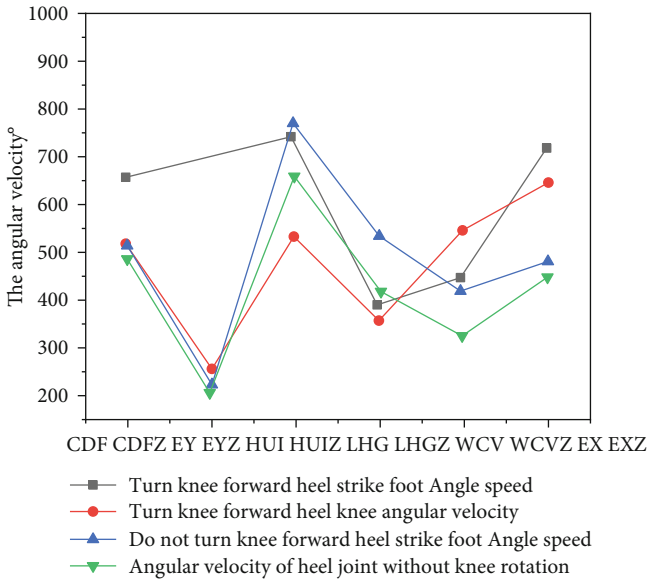


Figure 11: Comparison of angular velocity between striking foot and knee joint.

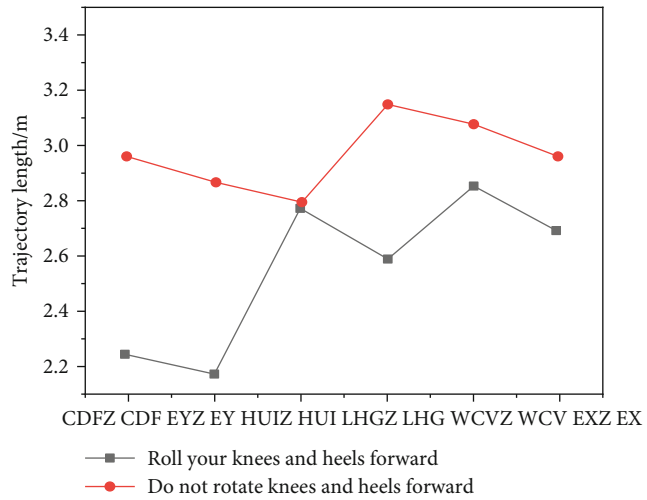


Figure 12: Length of air running track of striking foot before the moment of strike.

good, which is an effective factor to form a large moment of Vy split speed attack.

The human body itself can transfer the momentum moment to the most needed part, so as to increase the effect of the rotation action. The energy source of the calf whip comes from the storage and transfer of the momentum moment. The more the momentum moment is stored, the more the momentum moment is transferred, the stronger the effect of the rotation action is, and the faster the whip speed is. Turning the knee and rotating the heel forward can not only store more momentum but also promote the rapid rotation of the waist and hip, improve the speed of turning the waist, drive the rapid rotation of the whole body, and store more momentum before taking off. In the state of conservation of momentum moment after taking off, the moment braking is formed by rapidly expanding the hip and pedaling and stretching the striking leg. With the help of more complete transfer of momentum moment, more momentum moment is transferred to the lower leg, so as to improve the whipping speed of the lower leg and increase the striking effect. The knee rotation and forward rotation heel technology drives the trunk to rotate directly along the strike direction. At the same time, the squatting range of the whole process before taking off is small, so the trunk premovement range is small, and the amount of information provided to the other party for accurate judgment is relatively small, which increases the difficulty of the other party's correct judgment, improves the concealment, and has good hitting effect.

The concealed knee rotation and forward rotation heel technology realize the knee flexion and knee lifting of the striking leg. Through the knee rotation and forward rotation heel, the hip joint pulls the striking leg to bend and lift the knee during the take-off process, so as to realize the knee flexion movement of the striking leg before the strike and reduce the running track of the striking foot. The whole process of striking is to quickly move the striking foot to the striking point. The shorter the running track of the foot, the shorter the running distance from the starting point of the foot to the striking point, the higher the concealment of the foot, and the better the striking effect. By $t$-test, the $p$ value was 0.011 ($p < 0.05$). There was a significant difference in the length of running track between the two techniques.

It can be seen from Figure 12 that the six test students' knee rotation and forward rotation heel technology is better than the nonknee rotation and forward rotation heel technology. The air running track of the front striking foot is generally shorter at the moment of striking. Therefore, the knee rotation and forward rotation heel technology has higher concealment and better striking effect.

## 6. Conclusion

Through the turn simulation of Wushu Sanda with some sports strategies, the influence of the inertia characteristics of the swing leg after turn on the thigh dynamics was evaluated. The joint torque of the hip joint was less than that of the strong subjects. The peak values of the horizontal and vertical components of the joint reaction force are approximately the same as those of the sound subject. These results show that when half foot contact is used as a martial arts Sanda strategy, the leg swing after turning can have similar or less dynamic requirements at the hip joint compared with robust subjects. It is found that among all inertial characteristics, mass has the greatest influence on the variability of simulated dynamic parameters. The results of this study may enhance the inertia and usability of Wushu Sanda process design.

## Data Availability

No data were used to support this study.

## Conflicts of Interest

The authors declare no conflicts of interest.

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