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Biomechanical Analysis and Stability of Body Center of Gravity of Taekwondo Side Kick

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Abstract: To study the overall completion time of taekwondo side kick, the angle change of hip joint, knee joint and ankle joint, the relationship between the three axial changes of athletes' body center of gravity and the quality of action completion. Three groups of 12 subjects of different levels were selected to capture the biomechanical characteristics of the subjects' different stages of action using high-definition infrared camera and force measuring table. Results: The completion time of side kick was shorter, the range of joint change was closer to the theoretical value, and the test results of professional group were in the middle. As a result, the displacement of the body center of gravity in the athletes' group is small and stable, so it can obtain faster instantaneous speed and strike strength. Conclusion: Taekwondo athletes should maintain the stability of body center of gravity and the rationality of joint angle in order to better complete the action quality, shorten the action time and improve the kick intensity; the results were verified numerically by multiple regression linear analysis model, and the results showed $P<0.05$.
Keywords: Taekwondo lateral kick, biomechanics, joint angle, instantaneous velocity, regression model.

Background

Athletic Taekwondo is one of the official Olympic events, Our Taekwondo project started late but developed rapidly. Women in particular have won many gold medals in the Olympic Games. With the introduction of new tae kwon do protective gear (wu jianzhong et al. 2014), and new integral rules adopted (Gao Zhihong et al.2014), The probability of side kick action attack score and the proportion of real score in the game were obviously improved (Liu Weijun et al.2015). Taekwondo side kick is big, to test the consistency of the movement and the stability of the body's center of gravity, so from the point of view of sports biomechanics, to study the rationality and effectiveness of the side kick in taekwondo. And how to shorten the action time and improve the strike strength during actual combat. and keep the body center of gravity stable (Xia Rui et al. 2017). Sports biomechanics combines

the study of body structure, motor function and motor mechanics. To help taekwondo athletes apply sidekick techniques to their best, and avoid excessive movement and injury. In view of the influence of the new taekwondo integral rules on the players' side kicks in the competition, And the biomechanical analysis of side kick, Experts and scholars in domestic and foreign fields have made corresponding research and exploration. The new taekwondo rules, To make players more inclined to use both offensive and defensive side kicks in actual combat, Replacing the original cross kick (He Lu-min 2017), A more defensive side kick is favored by smaller tae kwon do players (Marek et al. 2017;) Yang et al. 2018); There are also scholars from taekwondo perspective, The change of body center of gravity during side kick was studied (Anchen 2017; Angus et al. 2017; Sanorita et al. 2017; Ryan et al. 2017); From the point of view of the weight and level of taekwondo athletes, Some scholars have pointed out the frequency and main points of side-kick movement used by athletes at all levels, It also points out that it is more advantageous for small level athletes to use side kick in the confrontation (Cui Yuhong 2016; Yan Hongwei et al.2015; Mohammad et al. 2018). Based on the existing research, the test data of athletes are extracted by experimental method. To study the side kick of taekwondo from the biomechanical point of view.

Research methods

Experimental subjects

In this paper, 12 subjects were selected from the taekwondo major of Chengdu Institute of Physical Education, all of them were male, the foot was the right foot, of which 4 were active-duty taekwondo athletes (athletes) above the sports grade level, 4 were second-class taekwondo athletes, and the other 4 were taekwondo students, as Table 1.

Table 1. Basic information on research subjects

Name	Age	Height (cm)	Weight (kg)	Years of exercise	Sports level	Group
Wang	22	182	71.5	7	Master	High Level
Ding	22	179	70.1	8	Master	High Level
Liu	23	176	69.5	7	Master	High Level
Qi	23	180	71.4	7	Master	High Level
Zhang	23	181	70.5	5	Grade 1	Professional
Du	22	175	71.3	6	Grade 1	Professional
Wang2	21	176	72.3	5	Grade II	Professional
Ma	22	179	69.4	4	Grade II	Professional
Zhao	20	173	73.1	2	-	General

Li	21	181	76.0	3	-	General
Ma2	20	174	67.6	3	-	General
Lu	20	183	75.9	3	-	General
Average	21.58	178.25	71.55	5.83	-	-

Laboratory equipment

$MG-TC26-R-NH3$ Taekwondo side kick experimental design selected high-speed infrared high-speed image recognition system, sports dynamometer selected Switzerland imported Qile Shi 9260 AA6 dynamometer, athletes side kick action acquisition frequency of 1000 Hz, extract 12 subjects side kick process of motion mechanics and center of gravity deviation related data.

Test process

During the test, the subjects were required to stand in front of the foot target and give instructions to kick the foot target at the rear side. The number of tests was 20 times each action interval 30 s, to extract 5 optimal effective data. A three-dimensional mechanical signal sensor was installed symmetrically on a three-dimensional platform to extract three axial forces and upload the real-time data to the control center of the background to test the movement speed and displacement of the legs, hips, ankles and so on during the A/D kick.

Mathematical statistics

Starting from the right foot off the ground, the infrared imaging system was used to capture the tested side kick action and decompose the whole side kick action. The whole side kick action was decomposed into four motion processes: a, keep the right foot standing in front posture; b, start turn, center of gravity backward, right leg pedal knee; c, left foot palm external rotation to support the body, body rotation to the left; d, right leg along a straight line to kick the right foot, the body back to maintain balance. To determine and count the joint angle, motion velocity, motion time and other index values of each stage tester, to use the SAP statistical analysis software to count the original data of all testers, to record and store the experimental data of all testers with EXECL 2019 tools, to express the dominant difference by $P<0.05$, to extract the kinematics related indexes of the tested subjects, and to define the index values of each joint angle of the tester, as shown in the following Table 2.

Table 2. Definition of sports indicators for taekwondo side kick

Serial number	Indicator name	Indicator description
1	Thigh angle	Links between hip and knee Angle between line and body plane
2	Leg angle	Link between ankle and knee Angle between line and body plane

3	Hip angle	Shoulder, hip and knee joint line angle
4	Knee angle	The angle between the three joints of the hip, knee and ankle
5	Ankle angle	The angle between the three joints of the knee, ankle and toe

Results

In this paper, we analyze the biomechanical changes of the side-kick movement of taekwondo athletes from three groups of 12 players, such as time change, joint rotation angle change, joint instantaneous velocity change and body center of gravity shift position, etc.

Timing of completion of side kicks

Under the premise of ensuring the quality of action completion, the shorter the overall completion time of Taekwondo side kick action, the better the impact effect on the target, and the easier to score. The shortest time characteristic information of standard action in 4 stages of 12 subjects was collected from the test bench, as shown in Table 3 below:

Table 3. Temporal characteristics of side-kick break-down of subjects

Tester	Phase a	Phase b	Phase c	Phase d	Overall
Wang	0	0.157	0.410	0.679	1.246
Ding	0	0.149	0.422	0.669	1.240
Liu	0	0.144	0.420	0.670	1.234
Qi	0	0.145	0.415	0.668	1.228
Zhang	0	0.165	0.550	0.773	1.488
Du	0	0.165	0.543	0.765	1.473
Wang2	0	0.167	0.547	0.771	1.485
Ma	0	0.164	0.559	0.718	1.441
Zhao	0	0.191	0.646	0.849	1.686
Li	0	0.239	0.660	0.833	1.732
Ma2	0	0.198	0.709	0.816	1.723
Lu	0	0.188	0.659	0.826	1.673
Average	0	0.172	0.545	0.753	1.471

To analyze the best completion time of the side kick of taekwondo in 12 subjects, the general group, Ding, Liu and Qi have advantages in each decomposition action, which is manifested in the faster movement of lifting knee and kicking, the completion time of the whole action is 1.246 s, 1.240 s, 1.234 and 1.228; while the total time consumption of the four subjects in the general group is 1.701 s, 1.708 s, 1.730 s, and 1.669 s, respectively, the completion time of the whole side kick about 0.5 s behind the professional group test; the test results of the four subjects in the professional group are

about 0.5. The time gap between the healthy group and the professional group and the ordinary group is mainly reflected in the link of the players starting turn, the center of gravity forward, the right leg to bend the knee. The four subjects in the healthy group had better coherence in the four stages of side kick action, which could concentrate their whole-body strength on the right foot and cause more damage to the opponent. The overall side-kick of the four participants in the group took less time to complete, and the time interval between the steps was more uniform and smoother. As the body center of gravity of the subjects did not shake during the whole side-kick movement, the movement was more coherent and efficient.

Changes of the angle and velocity of the hip, knee and ankle in the side kick of Taekwondo

When a taekwondo athlete makes a side kick, the thigh drives the leg and the leg drives the foot to complete the whole movement, and concentrates the whole-body strength on the foot. The angle change and instantaneous speed change of the hip, knee and ankle joint will determine the quality and time of the movement.

Table 4. Changes in hip angle

Tester	Phase a	Phase b	Phase c	Phase d
Wang	0	160.6	156.4	124.3
Ding	0	159.7	155.7	125.0
Liu	0	160.2	154.7	124.7
Qi	0	159.1	156.9	126.8
Zhang	0	162.4	158.6	120.4
Du	0	163.5	159.4	119.4
Wang2	0	162.4	159.3	120.7
Ma	0	161.5	158.4	120.4
Zhao	0	167.7	162.9	115.4
Li	0	168.7	160.7	112.4
Ma2	0	167.5	158.4	113.4
Lu	0	169.7	159.8	114.7
Average	0	163.4	158.4	119.8

Table 5. Changes of instantaneous velocity of hip m/s

Tester	Phase a	Phase b	Phase c	Phase d
Wang	0	0.98	0.50	0.47
Ding	0	0.96	0.49	0.46
Liu	0	0.96	0.48	0.47
Qi	0	0.97	0.49	0.48
Zhang	0	1.22	0.67	0.66
Du	0	1.23	0.68	0.67

Wang2	0	1.19	0.67	0.66
Ma	0	1.22	0.68	0.68
Zhao	0	1.45	1.12	0.78
Li	0	1.44	1.07	0.82
Ma2	0	1.39	1.34	0.84
Lu	0	1.50	1.47	0.85
Average	0	1.21	0.81	0.65

(1) Changes of hip angle and velocity during side kick

When the athlete's right leg makes a knee lift, the angle of the hip joint changes, that is, the hip as the axis of the thigh rotation and drive the calf to make a side kick. In theory, there is no difference in the angle plane of the hip joint between the right and the left, and the direction of the joint will be in the same plane, which can improve the speed and efficiency of the attack. The angle change and instantaneous speed change of the hip joint in 12 subjects in 4 states are shown in the following Table 4 and Table5:

The statistical results of the test data collected by the infrared high-definition camera show that from stage a to stage b professional athletes Wang and Ding have a greater angle of rotation of the hip joint and maintain the same plane as the body center of gravity; from stage b to stage c is the power stage of side kick action. The angle of the hip joint changed between 8-10 b to the stage c, and the angle deviation was much higher than that of the professional group. The change of hip angle is inversely proportional to the change of speed, that is, the smaller the angle of hip rotation is, the faster the instantaneous speed changes. The statistical data in the above table show that the instantaneous speed of hip joint is controlled within 1 m/s in the transformation of stage a to stage b. The instantaneous velocity change process of hip joint between m/s 45 c the stage of side kick decomposition action c stage and stage d is also the advantage of the subjects in the professional group. It can be seen that in taekwondo side kick actual combat, we should take the vertical axis of the body center of gravity of the athlete as the axis to maintain the compactness of the movement, so that the movement track of the hip joint in the plane of the body center of gravity, and improve the instantaneous speed of the hip joint.

(2) Changes of knee joint angle and velocity during side kick

Knee joint angle in taekwondo side kick refers to the angle between thigh and calf, and the change of knee joint angle and instantaneous velocity between professional group and ordinary group are shown in Table 6 and Table 7:

The right leg cannot be bent before the start of the action, the side kick in the three stages to avoid the knee deflection angle too large, so as to avoid the body center of gravity deviation. From the infrared test data, the two subjects in the professional group had a knee deflection of less than 5 at different stages, which was able to maintain their own balance while hitting each other and maintain the coherence of their movements. But the normal group was tested, because the right leg knee joint deflection angle is too large, causes the

support leg to have the sloshing, affects the movement stability and the attack speed.

Table 6. Changes in knee angle

Tester	Phase a	Phase b	Phase c	Phase d
Wang	0	160.12	156.23	163.06
Ding	0	159.87	157.12	162.25
Liu	0	160.66	156.56	162.11
Qi	0	159.62	155.67	163.15
Zhang	0	142.21	148.52	155.42
Du	0	143.34	147.58	152.42
Wang2	0	144.52	146.81	153.41
Ma	0	142.52	146.24	154.46
Zhao	0	134.51	141.25	147.56
Li	0	140.23	145.58	148.36
Ma2	0	136.41	144.47	146.84
Lu	0	139.87	145.87	156.98
Average	0	146.99	149.33	155.50

Table 7. Instantaneous velocity changes of knee m/s

Tester	Phase a	Phase b	Phase c	Phase d
Wang	0	0.88	0.50	0.42
Ding	0	0.86	0.51	0.41
Liu	0	0.87	0.49	0.41
Qi	0	0.85	0.48	0.40
Zhang	0	1.12	0.62	0.48
Du	0	1.14	0.61	0.47
Wang2	0	1.20	0.60	0.46
Ma	0	1.25	0.62	0.47
Zhao	0	1.35	0.73	0.54
Li	0	1.24	0.69	0.59
Ma2	0	1.25	0.71	0.61
Lu	0	1.34	0.72	0.58
Average	0	1.11	0.61	0.49

(3) Changes of ankle angle and velocity during side kick

The ankle angle is the angle formed between the calf bone and the foot bone in the side kick movement of the athlete. Since the heel and foot are the output points of the force in the side kick action of taekwondo, the ankle joint is the supporting point of the action. According to the knowledge of sports biomechanics, keeping the ankle close to 90 can form the maximum attack force. From the infrared data of the ankle angle of 12 subjects, it can be found that the ankle angle of professional group athletes is more reasonable in side

kick action, so it can also obtain faster instantaneous speed, as Table 8-9.

Table 8. Changes in ankle angle

Tester	Phase a	Phase b	Phase c	Phase d
Wang	0	94.14	93.24	91.41
Ding	0	94.35	93.12	92.14
Liu	0	95.53	94.14	90.14
Qi	0	96.14	95.32	91.52
Zhang	0	98.41	103.14	100.64
Du	0	98.22	104.52	98.14
Wang2	0	97.64	103.64	99.53
Ma	0	98.01	102.25	101.45
Zhao	0	100.25	109.85	114.52
Li	0	99.87	110.25	113.28
Ma2	0	103.21	112.41	114.47
Lu	0	101.12	115.89	113.47
Average	0	98.01	103.14	101.73

Table 9. Changes of instantaneous velocity of ankle m/s

Tester	Phase a	Phase b	Phase c	Phase d
Wang	0	1.08	0.68	0.51
Ding	0	1.07	0.66	0.52
Liu	0	1.06	0.69	0.50
Qi	0	1.07	0.68	0.49
Zhang	0	1.33	0.75	0.53
Du	0	1.30	0.76	0.52
Wang2	0	1.26	0.74	0.55
Ma	0	1.31	0.75	0.54
Zhao	0	1.48	0.97	0.72
Li	0	1.56	1.02	0.74
Ma2	0	1.39	0.89	0.73
Lu	0	1.44	1.03	0.71
Average	0	1.28	0.80	0.59

The results showed that the ankle movement of athletes in the healthy group was faster than that of the professional group and the normal subjects. This was mainly due to the lower angle of ankle joint, lower degree of metatarsal flexion and lower resistance of the healthy group. Summary of professional group subjects and ordinary group subjects, in each stage of the instantaneous speed of different joints, because the healthy group subjects were more reasonable to decompose the action hip, knee and ankle angle, so the speed is also better than the professional group of 4 subjects, while the ordinary group of 4 subjects, in the action essentials and skills control, there are shortcomings in the performance of the worst, so affect the instantaneous

speed of action. Using high-speed infrared camera to collect the instantaneous acceleration of the foot of the 15 instantaneous points in the side kick of taekwondo, the change of the body acceleration of the side kick of different levels of athletes is analyzed. If you can get faster attack speed and damage intensity in side kick action, it is also easier to score or knock down opponents in actual combat. The average initial acceleration of the movement was the largest, and the instantaneous speed of the foot reached the maximum when the movement was completed, while the instantaneous acceleration of the foot was negative after the athletes in the professional group and the ordinary group, and there was also a lot of training and promotion space.

Changes in body center of gravity

Taekwondo side kick action is larger than other arm movements, leg cross kick action, the body center of gravity will occur before and after, all, and up and down deviation, if taekwondo athletes side kick when the center of gravity deviation degree is too large, will affect the stability of the left leg standing, but also affect the side kick back attack. Based on the infrared camera and the force measuring table, the deviation degree of the body center of gravity and the direct correlation with the instantaneous speed of the movement were analyzed, as Table 10.

Table 10. Center of gravity moving distance before and after testing

Tester	Phase a	Phase b	Phase c	Phase d
Wang	100.8	+21.23	+29.54	-43.69
Ding	100.5	+20.39	+30.47	-42.41
Liu	100.6	+19.9	+28.67	-41.88
Qi	100.8	+21.56	+30.17	-42.25
Zhang	100.7	+24.14	+34.44	-35.55
Du	97.2	+23.67	+35.56	-34.49
Wang2	98.1	+24.15	+34.98	-37.41
Ma	100.2	+24.45	+33.49	-36.67
Zhao	98.6	+26.41	+37.84	-24.57
Li	101.2	+25.54	+38.67	-25.56
Ma2	96.1	+24.55	+41.74	-26.37
Lu	102.3	+24.17	+37.58	-25.52

When the subject completes the stage a to the stage b, the body center of gravity moves back naturally, but the body center of gravity moves too much back will cause the athlete center of gravity instability on the one hand, on the other hand will affect the next stage of the movement of the knee and ankle joint force. The shift of body center of gravity of athletes in each stage is obviously smaller than that of athletes in professional group and general

group from the data collected, while in the process of stage c to stage d, the body center of gravity of athletes in healthy group quickly returns to its initial position and maintains the stability of standing, as Table 11.

Table 11. Left and right center of gravity moving distance

Tester	Phase a	Phase b	Phase c	Phase d
Wang	100.8	+1.35	-1.34	+1.01
Ding	100.5	+1.32	-1.25	+0.85
Liu	100.6	+1.31	-1.36	+1.07
Qi	100.8	+1.34	-1.19	+1.13
Zhang	100.7	+2.96	-4.45	+2.57
Du	97.2	+2.81	-4.36	+2.67
Wang2	98.1	+3.17	-4.17	+2.55
Ma	100.2	+3.57	-3.96	+2.67
Zhao	98.6	+5.52	-6.54	+3.67
Li	101.2	+5.68	-8.89	+2.36
Ma2	96.1	+3.39	-6.21	+3.33
Lu	102.3	+4.52	-5.62	+3.21

The best condition is to keep the center of gravity in a plane, that is, to keep the center of gravity from shifting to the left and right, but it is difficult to keep the center of left and right in Taekwondo actual combat. Test data collected from infrared cameras show that professional athletes are less likely to shift from center of gravity to center of gravity when they make sidekicks, as Table 12.

Similar to the movement of the body center of gravity before and after the completion of the side kick, the smaller the movement of the body center of gravity up and down, the better the stability of the body in the confrontation, and the lower the movement of the body center up and down of the two subjects in the same professional group. It can be seen from the point of view of data analysis that when making side kick action, if the amplitude of body center of gravity deviation is smaller, then the stability of the action is better, which can improve the instantaneous speed of each joint and shorten the overall time consuming of the whole side kick action.

Table 12. Moving up and down center of gravity

Tester	Phase a	Phase b	Phase c	Phase d
Wang	100.8	-4.51	-1.24	-7.14
Ding	100.5	-4.52	-1.17	-6.98
Liu	100.6	-5.01	-1.09	-7.87
Qi	100.8	-4.69	-1.24	-7.68
Zhang	100.7	-6.67	-1.79	-8.67
Du	97.2	-6.68	-1.77	-8.88
Wang2	98.1	-6.98	-1.76	-8.96

Ma	100.2	-6.64	-1.58	-9.01
Zhao	98.6	-8.74	-2.98	-10.97
Li	101.2	-7.41	-3.36	-10.85
Ma2	96.1	-8.85	-3.01	-10.14
Lu	102.3	-7.64	-2.94	-11.20

From the simulation results, we can analyze the body center of gravity deviation degree of the 2 subjects in the professional group, compared with the 4 subjects in the ordinary group, the center of gravity deviation degree is smaller, the stability is stronger, and has the advantage in Taekwondo actual combat or competition.

Discussion and validation

From the results of the previous section, it can be concluded that the quality of the side kick can be expressed by the weighted average of the instantaneous speed of the athlete's foot contact to the target and the intensity of the hit. The weight ratio is 0.5, and all the collected data (including instantaneous speed and strike strength) are weighted and expressed by variables. The results also show that the completion time of the side kick, hip joint, knee joint, ankle angle of change, instantaneous speed, and the movement of the body's center of gravity will affect the variables. ξ_i

H1: the total completion time of the side kick is inversely proportional to the comprehensive index variables: ξ_i

H2: change speed of each joint of the lateral kick action is proportional to the index variable: ξ_i

H3: distance of the movement of the three axes of the body center of gravity is inversely proportional to the index variable.

ξ_i A multivariate linear regression analysis model was constructed to verify the authenticity of the hypothetical conditions in the paper, and to verify the authenticity and reliability of the results from the perspective of mathematical statistics, as Table 13.

Table 13. Setting of model variables

Serial number	Variables	Symbol
1	Action completion time	*Time*
2	Hip angle	*Kca*
3	Knee angle	*Xca*
4	Ankle angle	*Hca*
5	Transient velocity of hip	*Kis*
6	Instantaneous knee speed	*Xis*
7	Instantaneous ankle speed	*His*
8	Center of gravity moving X axis	*Xmg*

9	Center of gravity moving Z axis	*Zmg*
10	Center of gravity moving Y axis	*Ymg*

A multiple linear regression model is constructed as follows:

$$\xi_i = \beta_0 + \beta_1 Time + \beta_2 Kca + \beta_3 Xca + \beta_4 Hca + \beta_5 Kis + \beta_6 Xis + \beta_7 His + \beta_8 Xmg + \beta_9 Zmg + \beta_9 Ymg + \varepsilon \quad (1)$$

β_0 β_1 β_9 ε ξ_i *Time* where, is the model constant coefficient, - is the control variable coefficient, is the model residual term. Based on the SPSS24.0 statistical analysis software, the descriptive statistical results, correlation statistical results and multiple regression results are analyzed, as Table 14.

Table 14. Descriptive statistical analysis

Variables	Max	Min	μ	σ
ξ_i	3.652	-1.245	2.322	3.265
Time	2.564	0.125	1.557	2.154
Kca	4.254	3.521	3.851	3.698
Xca	0.958	-2.256	0.124	0.024
Hca	2.154	-1.154	0.985	0.745
Kis	1.326	0.012	0.958	0.815
Xis	0.451	0.232	0.332	0.025
His	11.125	5.512	8.526	7.315
Xmg	9.154	0.412	5.054	7.152
Zmg	1.254	-1.251	0.526	0.256
Ymg	0.845	-2.235	0.021	0.015

From the mean and variance statistical analysis results of the explained variables and the explanatory variables and the control variables in Table 14, we can see that there is no singular distribution in the descriptive statistical results, in which the mean value of the explained variables is 2.322 and the mean value of the explanatory variables is 1.557. The test results of each control variable also meet the requirements of the model, and can carry out the next step correlation detection and regression detection results analysis. A statistical analysis based on the SPSS24.0 is presented in Table 15 below:

Table 15. Statistical analysis of correlation between model variables

	Time	*Kca*	*Xca*	*Hca*	*Kis*	*Xis*	*His*	*Xmg*	*Zmg*	*Ymg*
Time	1	-	-	-	-	-	-	-	-	-
Kca	0.2415	1	-	-	-	-	-	-	-	-
Xca	0.3651	0.4158	1	-	-	-	-	-	-	-

Hca	1.2541	0.9854	0.9584	1	-	-	-	-	-	-
Kis	0.2103	0.1251	0.4582	1.5471	1	-	-	-	-	-
Xis	0.0145	0.3564	0.6564	1.3652	3.2514	1	-	-	-	-
His	0.1564	0.2584	0.7451	0.2577	2.3658	0.6985	1	-	-	-
Xmg	2.2541	0.1365	0.6325	0.3546	1.2415	1.3564	0.1547	1	-	-
Zmg	0.2145	1.2541	1.2547	0.1451	0.4854	1.2415	0.0014	1.2541	1	-
Ymg	0.9854	1.0254	1.3651	0.0251	0.0154	0.1256	0.0251	1.5641	0.2365	1

Note: *, **, ***represent significant levels at 10%, 5% and 1%, respectively

The statistical results of correlation between the variables in Table 15 above show that the correlation coefficient of each index variable affecting the kick strength and instantaneous speed of Taekwondo side does not appear negative value, and the mean absolute value of the statistical results of the control variables is smaller than the explanatory variables, which can prove that the setting of the model is more reasonable, and there is no multiple collinearity among the influence variables. The multivariate regression results can calculate the influence coefficient, standard error, t value, P value of each variable on the explanatory variable, and the multivariate regression analysis results of the variables, as shown in Table 16 below:

Table 16. Multiple regression empirical results of model

Variables	Variables Coefficient	Standards Error	t	Sig.
Time	5.1541***	0.8564	0.152	0.000
Kca	0.12511***	1.2564	0.315	0.008
Xca	1.2541***	0.0000	0.047	0.000
Hca	3.6254***	0.0008	1.452	0.001
Kis	1.6547***	0.0001	1.457	0.007
Xis	0.5547***	0.0000	1.451	0.000
His	1.6541*	0.0015	3.564	0.021
Xmg	0.5687**	1.3369	2.5641	0.085
Zmg	3.2514***	0.0001	1.457	0.007
Ymg	3.6521***	0.123	0.056	0.000
R^2	0.7985			
Adjusted R^2	0.7998			

Note: *, **, ***represent significant levels at 10%, 5%and 1%, respectively

Time the coefficient value of the explanatory variable coefficient is 5.1541, which indicates that there is a strong correlation with the explained variables, and the coefficient values of the other control variables are all positive, which

indicates that the index of each variable selected in the model is effective, that is, the change of joint angle, instantaneous velocity and body center of gravity are positive for the explained variables, thus verifying the authenticity of the three hypotheses proposed in this paper. From the explanatory variables and the P value changes of each control variable, it is significant at the level of 1%, and the other control variables have passed the significance test of the model. The modified model goodness of fit index value is 0.7998, which is much higher than the critical value of 0.5, which indicates that the goodness of fit of the multivariate regression linear model is good. $^{Time}R^2$.

Findings

In order to study the influencing factors of side kick of taekwondo athletes, this paper builds a simulation environment based on infrared high-definition camera and force measuring table. Three groups of 12 athletes with different levels are selected as subjects to extract the overall time for the tester to complete the side kick in taekwondo side kick, the angle change of hip joint, knee joint, ankle joint, instantaneous speed change and body center three axial changes. The results show that the instantaneous speed and intensity of the attack of the four athletes in the healthy group are obviously better than those in the professional group and the ordinary group. In order to further verify the linear relationship between the influencing factors and the instantaneous speed and the strike intensity of the side kick, the multiple linear regression model was constructed with the original data of the side kick action collected by the high-definition infrared camera as the sample data and the hypothesis.

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References

[1] Wu, J.Z., Wang, D., Wu, S.Y. 2014. Study on daedo new score technique of taekwondo under electronic protective equipment. Journal of Beijing University of Physical Education, 37(10): 119-124.

[2] Chang, Q.C., Gao, Z.H., Dou, Y. 2014. Characteristics and training countermeasures of taekwondo competition under new rules and electronic protective equipment. Sports Journal, (3): 114-118.

[3] Ma, X.L., Liu, W.J. 2013. Analysis of technical characteristics of women's final athletes in world taekwondo championships. Journal of Beijing University of Physical Education, (2): 117-121.

[4] Chang, X.N., Fu, W. S. 2017. Effects of different fatigue induction schemes on lower limb joint mechanics, stiffness and energy absorption when landing. Sports Science, 37(11): 48-55.

[5] Hel, L.M. 2017. A brief analysis of the changes caused by the change of project rules. Competitive Sports, (5): 28-29.

[6] Marek, S., Arkadiusz, S. 2017. Piotr krezałek butterfly sprint swimming

technique, analysis of somatic and spatial-temporal coordination variables. Journal of Human Kinetics, 60(1): 51-62.
[7] Yang, W.H., Oliver, H., Marijke, G. 2018. Rapid weight reduction does not impair athletic performance of Taekwondo athletes –A pilot study. Plos One, 2018, 13(4): e0196568.
[8] Chen, A. 2017. Study on the application and training of men's taekwondo side kick technology. Hubei Sports Science and Technology, 36(4): 324-327.
[9] Angus, H., Andrew, B., Sarah, M. 2017. Churchill performance indicators that discriminate winning and losing in elite men's and women's rugby union. International Journal of Performance Analysis in Sport, 1-11.
[10] Sanorita, D., Brittany, D., Karrie, K. 2017. The art and science of persuasion: not all crowdfunding campaign videos are the same//the 2017ACM Conference. ACM.
[11] Ryan, P.D., Sarah, R.N., Marohn. J.A. 2017. Microsecond photo capacitance transients observed using a charged micro cantilever as a gated mechanical integrator. Science Advances, 3(6): e1602951.
[12] Cui, Y.H. 2016. Analysis on the application of taekwondo side kick technology in men's major competition in the 2015 world championships. Sport World, (11): 3.
[13] Yan, H.W., Shan, W., Gao, Z.H. 2015. Technical application characteristics of kg major competitors of Chinese taekwondo women-49. Journal of Beijing University of Physical Education, 38(2): 112-116.
[14] Mohammad, A.V., Ahmadreza, A., Ebrahim, H. 2018. Relationship between anthropometric findings and results of corticosteroid injections treatment in chronic plantar heel pain. Anesthesiology &Pain Medicine, In Press.