Sports Biomechanics Analysis of Xuanfengjiao 360 °Action of High-level Athlete

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ABSTRACT: Grade B difficult actions of Taijiquan Xuanfengjiao 360°+knee lifting alone-standing of five high-lever Wushu athletes in Hubei Provincial Wushu Team were analyzed through three-dimensional high-speed photography. Take-off moment, take-off foot-patting moment and landing knee lifting moment were comparatively analyzed. Actions with high scores method at completion can be discovered.
KEYWORD: Three-dimensional; Difficult actions; Sports biomechanics; Comparative analysis

1 INTRODUCTION

Stated rules of Wushu event are released in 2003. All events should be scored according to three blocks of A (quality of movements), B (overall performance) and C (difficulty), where in difficulty is divided into three grades of A, B and C [1]. Difficulty score is an important link to distinguish athlete scores aiming at high-level athletes. Modern science and technology are utilized to guide athletes to train actions with high difficulty, which is beneficial for the athletes to obtain excellent results in game. Taijiquan xuanfengjiao 360°+knee lifting alone-standing action belongs to Grade B difficulty in Taijiquan event. The author traced previous games from 2004 to 2008. 100% of the athletes choose the action in the game.

Techniques of 'take-off, swivel rising kick circle inward and swivel landing' in Taijiquan Xuanfengjiao 360°+knee lifting alone-standing action are analyzed from the perspective of biomechanics. Therefore, theoretical basis can be provided for athletes to better complete Taijiquan xuanfengjiao 360°+knee lifting alone-standing action. Valuable suggestions can be provided for sports technique training practice. It also can provide reference methods for smoothly completing other difficult actions.

2 RESEARCH METHODS

2.1 *Literature Method*

Relevant literature and information are reviewed through Internet.

2.2 *Comparative Analysis Method*

Kinetic parameters of athletes' actions are analyzed and compared for concluding general technical features of the action.

2.3 *Mathematical Analysis Method*

Statistical processing should be implemented on SPSS 19.0 software.

2.4 *Image Analysis Method*

Difficult actions are shot on fixed position in training ground. Germany SIMI three-dimensional motion analysis software is used for analyzing difficult actions according to 50 images each second on computer.

3 RESEARCH OBJECT

Five athletes in Hubei Provincial Wushu Team are selected as research objects, namely, Wang ＊, Wu ＊＊, Wei ＊＊, Zhou ＊ and Yang ＊＊, wherein one of them is international master class athlete, and three of them are national master class athletes, and one of them is first class athlete.

4 RESEARCH RESULTS AND ANALYSIS

4.1 *Description of XuanFengjiao 360°+Knee Lifting Alone-standing Technique Action*

Taijiquan xuanfengjiao 360°+knee lifting alone-standing action belongs to Grade B difficulty of original ground take-off and single-leg support. Value of the difficult action+ connection difficulty is totally 0.4 score. Athletes should separate two feet in parallel, and right leg is bent for jumping from ground. Left leg is lifted upwards and swung to left upward direction. Upper body is rotated to left upward direction. Meanwhile, two arms are swung to downward and left upward direction. The body should be rotated to left upward s direction for one round[5]. Right leg completes kick circle inward action in the air. Meanwhile, left hand should meet right sole. Then, right foot lands on the ground individually, and the left foot can be in knee lifting shape (as shown in the following Fig. 1).

Figure 1: XuanFengjiao 360°+Knee Lifting Alone-standing Technical Action

4.2 *Success Judgment of Xuanfengjiao 360°+Knee Lifting Alone-standing Action*

The athlete should take off from the original ground during the action, xuanfengjiao should be turned for 360 degrees, and there should be no foot jumping, movement, rolling and other condition after landing according to rules. The action is successful if the above conditions are met.

The difficult action was released in 2003 and implemented for nearly 10 years till present. Five selected athletes repeat the Taijiquan difficult action-xuanfengjiao 360°+knee lifting alone-standing action for ten times, mean value in the ten times is selected in the paper. Three parts of action take-off, body swivel turn kick circle inward and landing are comparatively analyzed according to kinetics data.

Table 1 Success Rate of Actions Completed by Athletes

Name	Completion Frequency	Success Frequency	Success Rate
Wang	10	10	100%
Wu	10	10	100%
Wei	10	9	90%
Zhou	10	8	80%
Yang	10	5	50%

4.3 *Condition Analysis of Take-off Moment*

Table 2 Data Analysis of Take-off Moment Time

Name	Left Knee Movement Angle (Degree)	Gravity Center Height (mm)	Left and Right Knee Speed (m/s)	Left and Right Sole Speed (m/s)	Left and Right Sole Height (mm)	Pelvis Displacement Speed (m/s)
Wang	60	490.600	0.298 0.689	0.052 0.120	26.944 26.022	1.036
Wu	58	485.800	0.280 0.630	0.050 0.110	25.550 25.005	1.087
Wei	62	490.450	0.285 0.650	0.058 0.115	26.465 25.793	1.050
Zhou	62	475.850	0.275 0.625	0.048 0.108	25.495 24.535	1.003
Yang	48	473.500	0.270 0.625	0.045 0.100	25.374 24.657	1.000

4.3.1 *Influence of Take-off Knee Joint Angle, Left and Right Knee Joint Speed on Action Completion Quality*

Table 2 shows that: the action speed of left knee joint at the moment of take-off is faster than the right knee joint, which is beneficial for sufficiently conducting right foot take-off and swivel. $F = P/2tg\alpha$ shows that F is closely related with knee joint extension force P and knee joint angle α. It is obvious that F is also related with speed [2] according to $F=(mu - mu1)/t$[6] Movement angle of left knee joints in five athletes are not greatly different before take-off. According to action completion quality, it is concluded that the movement angle of knee joint should be 60 ± 2 before take-off. Left and right knee joint speed should be respectively 0.298 -0.280 and 0.689 -0.630 for the athletes in order to gain better swivel energy and take-off energy.

4.3.2 *Biomechanical Performance before Take-off*

Body gravity center is in three-dimensional motion when the take-off leg is jumped from the ground. The resultant velocity is composed of component velocities along sagittal axis, frontal axis and vertical axis. Then, the left leg is swung in order to maximize the speed along the vertical axis direction [4]. The action is analyzed from the biomechanical perspective. An external force is necessary for generating angular momentum in order to swivel the body. The external force is produced under the foot. Waist can be twisted through frication between foot and ground, and other external force. It is so called 'force from foot' in martial art training. Therefore, the take-off foot should be buckled inwards slightly to feel upward reaction force on the ground. The force can increase frication between foot and ground.

4.4 *Data Analysis during Foot Patting Moment*

Table 3 Data Analysis during Foot Patting Moment

Name	Left Knee Movement Angle(Degree)	Gravity Center Height(mm)	Left and Right Knee Speed (m/s)	Left and Right Sole Speed (m/s)	Left and Right Sole Height(mm)	Pelvis Displacement Speed (m/s)
Wang	165	1725.831	0.955 2.549	1.745 9.018	655.794 1784.256	0.656
Wu	163	1700.558	0.898 2.455	1.650 9.000	644.546 1750.475	0.635
Wei	164	1720.338	0.930 2.500	1.720 8.983	650.634 1773.479	0.640
Zhou	162	1695.742	0.781 2.405	0.632 7.595	643.550 1739.347	0.531
Yang	167	1690.825	0.775 2.475	0.600 7.518	641.235 1703.456	0.515

4.4.1 *Relation between Hopping-step and Foot Patting Completion*

F=I/t can be obtained according to I=Ft based on conservation momentum theorem of physics. Formula F=I/t shows that if 'I' is constant, 't' is smaller, F is larger. Larger upward buffer force F can be obtained if the hopping time of the athlete is shorter. a=F resultant velocity /m=(F-G) (gravity force)/m. According to formula a=F resultant velocity /m= F-G (gravity force)/m, it is obvious that "m" and "G" are constant, F is larger, 'a' is larger. It is obvious that larger buffer force F is beneficial for accelerating gravity center in vertical direction [2]. Conservation momentum theorem of physics shows that shorter hopping-step is beneficial for obtaining larger acceleration on vertical direction, thereby facilitating action completion.

4.4.2 *Comparative Analysis of Five Athletes to Complete Foot Patting Action*

According to Table 3, gravity center, pelvic displacement speed and leg stretching speed of five athletes are analyzed to obtain the following conclusion: better action quality can be obtained in case of gravity center of 1720.338 (mm) - 1725.831 (mm), pelvic displacement speed of 0.640 (m/s) - 0.656 (m/s), and leg stretching speed of 8.983 (m/s) - 9.018 (m/s). The action can be completed but action quality effect can not be reached in case of gravity center of 1680.078 - 1695.742 (mm), pelvis displacement speed of 0.510 - 0.515 and leg stretching speed of 7.403 (m/s) - 7.595 (m/s). The action can not be completed easily in case of gravity center lower than 1680.078 (mm), pelvic displacement speed lower than 0.515 (m/s) and leg stretching speeds lower than 7.403 (m/s).

4.4.3 *Vacation Time and Gravity Center Height*

Take-off height depends on take-off initial velocity v, namely, h=v2/2g. Vacation time depends on take-off gravity center height, namely, t= h / 2g. Action completion depends on time [2].Take-off initial velocity depends on takeoff buffer, kicking action and whole-body overall action. Therefore, joint action succession principle is sufficiently utilized by take-off leg. The foot stepping time during take-off stretching should be shorter in order to obtain larger acceleration. Gravity center can be lifted upwards maximally, which is beneficial for completing action in the air with sufficient time.

4.5 *Data Analysis of Landing Moment*

Table 4: Data Analysis of Landing Moment

Name	Left Knee Movement Angle(Degree)	Gravity Center Height(mm)	Left and Right Knee Speed (m/s)	Left and Right Sole Speed (m/s)	Left and Right Sole Height (mm)	Pelvis Displacement Speed (m/s)
Wang	96	832.597	2.281 2.881	1.915 0.179	184.621 19.622	3.260
Wu	93	822.456	2.280 2.798	1.850 0.160	180.555 18.454	3.064
Wei	90	826.159	2.285 2.942	1.889 0.170	182.631 19.004	3.521
Zhou	103	803.355	2.310 2.678	1.798 0.155	175.355 17.636	3.245
Yang	89	790.765	2.195 2.956	1.877 0.153	174.626 17.868	2.924

4.5.1 *Reason of Landing Balance*

The former four athletes had better balance stability during landing. The last athlete had weaker balance ability. Main problem lies in gravity center height and pelvic displacement speed by observation and data analysis. Stability of landing action mainly depends on vacation action jumping action and landing accuracy. It is concluded according to analysis that landing balance can be better when landing gravity center is 803.355(mm)--832.597(mm) and pelvis displacement speed is 3.064 (m/s)-3.521 (m/s).

4.6 *Dynamic Performance at Knee Lifting Balance Moment*

Appropriate landing angle is important condition for landing stability. It reflects position relation between body gravity center and landing point during landing, extent of buffer gravity center movement after landing, and size distribution condition of impulse at different direction. Therefore, the knee joint angle should be 90 degrees or not in the landing process. In addition, the knee joint speed at the landing moment is larger, athlete speed is (2.285±0.025)m/s in order to release load on legs due to larger speed. The legs should actively and controllably conduct ankle bending, knee bending and hip bending in turn after landing. Both arms can swing along, thereby extending action time, reducing impact force, lowering gravity center, and increasing landing stability.

5 CONCLUSION

Knee and hip joints are stretched sufficiently at the moment of take-off and leaving from the ground, which is beneficial for improving vertical speed.

Body should be stretched when the athlete completes action in air, thereby reducing body rotation inertia. It is beneficial for self-rotation of body.

Kick circle inward action should be completed before body gravity center reaches the highest point, which is beneficial for self-rotation. Landing stability also can be strengthened.

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