Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2013, 5(12):296-301

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Analyze the characteristics of force-measuring curve of rings movement technology based on sports biomechanics

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ABSTRACT

In this paper, we analyze the rings sports based on biomechanics. First, the rings movement is divided into four phases and two stages by using the rings five basic movement characteristics and situation of muscle force. Then analyze the characteristics of rings technology for the two stages using the principle of dynamics. Finally, analyze the characteristics of rings movement force value biomechanical parameters through force-measuring curve value data captured by measurement equipment and summarized the technical causes in all stages of force. This article methods and results analysis provides certain theoretical for our country's rings movement.

Key words: Biomechanical Parameters, Dynamics Theory, Value Force-measuring Curve, the Kinetic Energy Theorem, Conservation of Mechanical Energy

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INTRODUCTION

Modern rings movement is inspired by acrobats dangling ropes performance, which is originated in France, and then introduced to Germany and Italy, until in 1896 is listed as one of the first Olympic Games. A complete set of rings movements consists three parts of proportion approximately equal swinging, strength and static, between actions through suspension, support handstand to complete, usually completes the movement by straight-arm. At present, the studies on rings movements are less at home and abroad, mostly stay on the basis of the experience of preaching. This article specifically analyzes the power sport of rings by biomechanics, in order to provide certain theoretical basis for rings technology.

Many scholars who study on rings movement have put forward some ideas and research methods, and which are also important factors leading the development of the sport. Domestic scholars: Zhou yuezhi, etc(2009) research individual final action of the 29th Olympic Games men's gymnastics from the movement type, difficulty of movement and the usage of action. They have summarized and analyzed the main points of each type action, all kinds of difficulty action, individual action and connection action [1]. Niu Jianzhuang, etc(2000) has analyzed the force-measuring curve characteristics of hanging back-wing by measuring instruments of monitoring data. It concluded that there was difference in all character gradation of pull-force, there exist common characteristics in technical mechanism and the pull-curve. There has supplied the teaching and training of those movements with theoretical basis. Wei Jikang, etc (1995) concluded that there was large gap to the rules at the completion of action in the quality and the proficiency degree for our athletes, through the statistical analysis results of the rings specifications in1994 national gymnastics championship. It is mainly manifested the poor physical qualities and special skills in the athletes', basic technology is not high, the insufficient recognition of the key movements and the connection. They put forward the corresponding improvement suggestions for the problem [3].

In this paper, we do biomechanics analysis for rings movement on the basis of previous studies, in order to provide certain theoretical basis for rings movement training of our country through this research.

THE TECHNICAL FEATURES ANALYSIS OF THE RINGS MOVEMENT

There are five basic movements of rings, including giant swing forward, backswing to handstand, turning shoulder forward, backswing and drape after pendulum. According to the characteristics of movement muscle strength in five movements of rings, the movement can be divided into two stages and four phases, the four phases are lower hem, heavy shoulder, vibration wave and leg lift. Table 1 shows the division of phase stage.

Table 1- The rings movement stage and phase division

First stage		Second stage	
A phase lower hem	B phase heavy shoulder	C phase vibration wave	D phase on leg lift
From the beginning to 45° before the post	45° to15° before post	before post 15° to 10° after post	After post 10°

Technical Features Analysis of the First Stage of the Rings Motion

The first stage rings movement refers to the athletes from a handstand state to hem to the front of the post Angle 45 °, then heavy shoulder to continue 30 ° to 15 °before post, at the moment end the first stage motions. Figure 1 shows the movement.

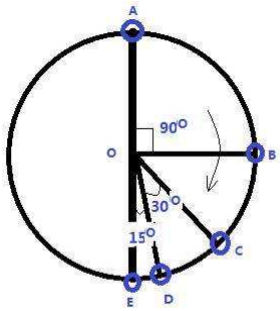

Figure1: The first stage of pendulum Angle of ring athletes

In figure 1, point A represents the athlete foot position of initial state of handstand, point B represents the foot and hand griped ring in the same level in the process of the hem of athletes body strain, C point represents the position of hem to forward post 45° at A phase state, D point represents the position of hem to forward post 15° at A phase state, E point represents the foot lowest point, O represents the position of the hand griped ring. Because rings is required at the static state as far as possible in the process of grip rings, so this paper assume that rope and columns keep parallel. AE represents straight line of wire.

Athletes bear external force only gravity and rings to the person's reaction in the first phase of the movement. If the body hem for freedom in the process of movement, because rings position will not change, so only gravity doing work, it is satisfy the law of conservation of mechanical energy. As shown in (1):

$$\begin{cases} E = mgh_0 + \frac{1}{2}mv_0^2 \\ E = mgh(t) + \frac{1}{2}mv^2(t) \end{cases} \tag{1}$$

In the formula (1), E represents the total mechanical energy of athlete during exercise, h_0 represents the athlete's center of gravity height in the initial position, v_0 represents the speed of center of gravity position in the initial position, m represents the athlete body mass, g represents the acceleration of gravity. The formula (1) shows that the speed of the center of gravity is constantly increasing in the process of hem， the greater the centripetal force generated by the greater speed, formula (2) can describe the point.

$$ma_\tau = m\frac{v^2}{r} \tag{2}$$

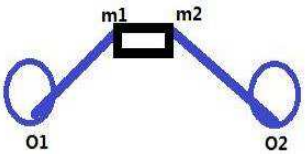

Figure2: Grip ring hand and shoulder position the first stage

In the formula (2) a_τ represents the centripetal force, r represents the center of gravity position and the distance of rings position does not change, so the line speed increases the greater the centripetal force. The centripetal force is generated by joint force of the gravity and the rings and the arm.

Rings athletes follow the rules that try to keep the body stationary state and strain state of rings in the first stage. So the shoulder and the hands griped rings horizontal line does not overlap. Figure 2 shows the location between them. In the figure 2, O1 and O2 represent grip ring hand location, m1 and m2 represent shoulder location. Angle of the connection and horizontal line should decrease as the hem degree. Only in this way can reduce the control difficulty of arm to force, therefore it is need to do be heavy shoulder movement in the second phase.

Rings Movement Analysis of Technique Characteristics of the Second Phase

The second stage of rings movement refers that start from the second phase angle 15° with the state of heavy shoulder to before the column, and end with angle 10° after column at the end of third phase shock. Then athletes do forward wing movement by controlling body. In the process, heavy shoulder causes the shock. In the process of heavy shoulder arms have a downward acceleration produced overweight status. It is said that the wire of power will change from big to minimum in the process, and then the rope bear force will rebound after bypass the nadir. The dramatic change of wire stress generates the oscillation of the body and the wire. Figure 3 shows the second stage of athletes body line changes.

Figure 3: The second stage of rings athletes swing Angle

In Figure 3, F represent the starting position of heavy shoulder in the first phase, G represent the foot position at the end of shock of the third the phase. The human body turning Angle is small in the first and second phase in the process of movement, the wire can be as the body without turning, only the process of heavy shoulder to turn shoulder. Impulse changes of grip ring hands to wire is from big to small, then from small to big in the process. According to formula (3) of the theorem of momentum can know the principle of speed variation of human body.

$$\int f(t)\,dt = mv_1 - mv_2 \tag{3}$$

As shown in formula (1), the greater the speed changes the greater changes of impulse, so the wire shock in the second and third.

Rings athletes need to control the body maintain strain state in the second stage process, do the movement of heavy shoulder and turning shoulder in the process of the wire vibration. Then adjust shoulder position to leg lift by overcoming gravity, finally complete the action. Figure 4 shows the relative position of shoulder and grip rings hands in the four phases.

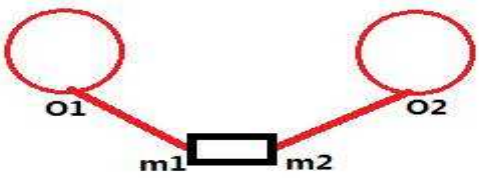

Figure 4: The position of shoulder and grip rings hands in the four phase

BIOMECHANICS PARAMETER ANALYSIS BASED ON THE CHARACTERISTICS OF RINGS FORCE-MEASURING CURVE

For the five main players of men's gymnastics team, using the HYL - 1 type tension sensor, LBS – 16A high-speed video camera and NAC MOVIES type 100 film automatic analytic instrument, measure biomechanics parameters of the athletes five action in the complete process. According to the changes of force-measuring curve, analyze the biomechanical parameters of rings movement. Analyze biomechanics parameters of the five movements, according to the characteristics of the force-measuring curve, the minimum value instant, during the recovery, overweight instant moment, the first wave moment and the second wave instant moment.

The Biomechanics Parameter Analysis of Force-measuring Curve has the Lowest Strength to Force Rise Again

Five basic actions of biomechanical parameters as shown in table 2, force-measuring curve is lowest. Five basic biomechanical parameters show in table 3, when the force-measuring curve started to pick up.

Table2- The biomechanical parameters of the lowest value of force-measuring curve

Name	Value	∠1	∠2	∠3	V1	V2	V3	T
1	12.99	38	163	173	1.19	1.96	1.08	0.28
2	23.33	-	-	-	-	-	-	-
3	31.00	-	-	-	-	-	-	-
4	34.58	-	-	-	-	-	-	-
5	29.32	-	-	-	-	-	-	-

Note: Name represents the action name, 1 represents giant swing forward, 2 represents backswing to handstand, 3 represents turning shoulder forward, 4 represents backswing, 5 represents drape after pendulum, Value represents the value of force-measuring curve (kg); ∠1 represents hem Angle（○）; ∠2 represents shoulder Angle（○）; ∠3 represents hip Angle（○）; V1 represents hip velocity (m/s); V2 represents ankle speed (m/s); V3 represents velocity of the center of mass (m/s); T represents weight ratio.

Table 3- The biomechanical parameters of force-measuring curve value picks up

Name	Value	∠1	∠2	∠3	V1	V2	V3	T
1	18.33	140	149	150	4.10	8.00	3.92	0.38
2	36.00	144	134	147	3.27	6.76	2.95	0.88
3	37.89	140	133	143	3.51	7.92	3.25	0.87
4	37.00	146	131	150	3.12	6.45	2.79	0.78
5	36.24	148	139	153	3.25	6.86	3.14	0.79

The movement of giant swing forward into a handstand forward the initial state is handstand, and then began to fall hem, trajectory of the body center of gravity gradually put to the front of the support point. The pendulum to 20 ° ~ 30 °, the force-measuring curve begin to decline. When nearing to 38 °, barycenter track gradually get rid of the support point, the test force-measuring curve sharp drop, achieve the minimum value of 12.99 kg, the process call weightlessness. In table 1, hip Angle keep near 173 °, achieves the maximum value, causes the body's centre of gravity far to rope. The distance helps the body gain kinetic energy, hip velocity increases to 1.19 m/s, ankle speed increased to 1.96 m/s.

As athletes control body continues to hem, the force-measuring curve value begins to rise. Data in table 2 show that the shoulder Angle of giant swing forward into a handstand reduce from 163 ° to 150° , ankle movement speed increased by 1.96 m/s to 8.00 m/s, hip speed increased by 1.19 m/s to 4.10 m/s. In the process of force-measuring curve back, hip flexion movement accelerated the speed of hip joint and body center of gravity.

The Biomechanics Parameter Analysis when the Force-measuring Curve Value Overweight

Force-measuring curve value also continues to rise when the value up to its own gravity, the movement process call overweight. Its boundaries is the force-measuring curve value equal to its own gravity, the moment of biomechanical parameters of athletes five basic actions as shown in table 4. Trunk actions exist two directions rotation in the movement process, one is the plane of the center of gravity and plane perpendicular to the plane of the trunk, the other direction is a plane perpendicular to the center line. Its rotation can be described by the angle changes over time as shown in Table 4.

Table 4- Biomechanics parameter list of force-measuring curve value is equal to the gravity of the value

Name	Value	∠1	∠2	∠3	V1	V2	V3	T
1	40~45	153	142	145	4.34	10.17	3.93	1
2	40~45	150	137	144	3.36	7.27	3.13	1
3	40~45	146	140	140	3.65	9.07	3.52	1
4	40~45	159	135	146	3.23	9.01	3.08	1
5	40~45	159	142	151	3.64	8.08	3.56	1

Data in table 4 shows that the moment the force-measuring curve value equals the gravity value, the shoulder Angle of all the movements is narrow besides giant swings forward movement, the rest of the shoulder Angle movement are in gradually increases. Prepare for heavy shoulder, hip Angle reach minimum range, the speed of hip movement and the human body center of gravity reach maximum rate. In table 4, the five basic motion of hip joint average speed is 3.23 to 3.23 m/s, the speed of the human body center of gravity is 3.08-3.93 m/s.

Biomechanics Parameter Analysis of two Peak of Force-measuring Curve

When the body fall forward and hem down to 162 ° - 176 °, the force-measuring curve appears the first peak. Table 5 shows biomechanical parameters of the athletes doing five basic actions.

Data in table 5 shows that the hip joint Angle decreased to the minimum when force-measuring curve first appear peak value. Hip Angle average 131 ° to 145 °in the five basic actions, hip joint Angle increasing after the first peak appeared. The first peak appeared marked the beginning of backward pendulum swings action, the moment of hip flexor to stretch, extensors complete the transition process of centrifugal centripetal contraction. The centripetal contraction is based on the completion of the centrifugal. Data in table 5 shows the less changes of the force-measuring curve value and the ratio of the weight does not change, respectively is 4.27-1.66 times of the weight. The reason of this phenomenon is hem heavy shoulder vibration wave action is completed by natural hem, at this time muscle group no active contract or in a state of eccentric contraction.

When the body through the vertical surface and lap time in 4.50 s to 13.00 s will occur the second peaks. Table 6 shows the biomechanical parameters of athletes doing five basic actions.

Table 5- Biomechanics parameter list of force-measuring curve value reaches the first peak

Name	Value	∠1	∠2	∠3	V1	V2	V3	T
1	207.83	162	152	135	3.84	11.82	3.27	4.66
2	200.64	167	149	131	2.79	11.20	2.80	4.55
3	200.25	176	160	134	1.62	11.16	2.17	4.55
4	187.40	174	154	143	1.97	10.80	2.53	4.40
5	182.10	172	165	145	2.15	11.20	2.64	4.27

Table 6- Biomechanics parameter list of force-measuring curve value reaches the second peak

Name	Value	t	∠1	∠2	V1	V2	V3	T
1	349.75	8.00	179	188	1.55	13.45	0.90	7.50
2	336.98	11.33	177	187	1.58	12.87	0.78	6.94
3	327.26	4.50	177	188	1.77	12.29	1.32	6.73
4	312.70	13.00	178	188	1.92	11.68	1.03	6.59
5	300.78	11.00	176	190	1.50	11.60	0.85	6.30

Table 6 shows that after heavy shoulder vibration wave the power further increases, the force-measuring curve value reached 300 kg - 349 kg, the value is the maximum value, and also the maximum ratio of weight. Because when the action is harder, the strength of muscle contraction will become greater, thus the greater the reaction force of support exerting on the rings, so the value of force-measuring curve related to the difficulty of movement. At the second peak ankle speed decreased, and the speed of hip and the body center of gravity is picked up, which is prepared for the second half leg lift and action completion.

CONCLUSION

This paper first introduces phases and the classification of stages in accordance with the rings five basic movement characteristics, and focuses on the rings technical characteristics of the first and the second stage. Analyze and summarize the principle of movement characteristic by using dynamics to the technology of two stage rings. Adopt scientific analytic instrument equipment such as sensors, cameras and films, to analyze the strength curve of five basic rings movement, and analyze athletes biomechanical parameters through the strength characteristics.

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