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## Chinese and foreign excellent men shot putters' back sliding technique optimization model research

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### ABSTRACT

Take China the 11<sup>th</sup> national game 6 athletes' shot putting whole process kinematics parameters as objects, establish speed distance model, carry out kinematics analysis, and make comparison with world excellent athletes' parameters. Research found that Chinese athletes existing following problems as big body swinging, small sliding amplitude, left shoulder left arm poor controlling, small hip rotational strength, small sports speed, long transition time, weak muscle exertion explosiveness, unstable gravity center, discontinuous motions and other problems. For these problems, it makes following suggestions on back sliding method shot putting that is reduce leg drive angle and included angle between two legs, enlarge sliding phase sports amplitude, increase shoulder, hip, arm controlling ability, increase body each part exertion positivist and stability, strengthen daily training, increase body muscle explosive force. Increase body stability and motions' coherency. © 2014 Trade Science Inc. - INDIA

### KEYWORDS

Back sliding throw shot;  
Kinematics;  
Global analysis;  
Optimization model.

### INTRODUCTION

China started late on shot event, and its development is also relative slow. With world sports event development, China has also enlarged sports events' construction and development. In China, men shot comparing with women shot, is relative lagging. By far China national game men athletes' average level is 19.50m, but comparing with world average level of 20.50m, it still has a great gap. Though in 2012 national game, it had man athlete got good results of 20.15m, for national average level, China men shot movement development is still in the relative slow phase. In order to

propel China men shot movement development, we need to make further efforts and exploring, further improve shot performance from technical aspect so that promote China shot movement development, therefore our research is of important significance<sup>[1-5]</sup>.

Shot event is not only athlete strength combating, but also more for shot throwing techniques comparison. Shot throwing techniques, by far, the most used including back sliding, back in spot and side sliding<sup>[6-9]</sup>. While China athletes mostly use back sliding. The method based on athlete strength, with speed as core. Athlete individual quality has already arrived at certain levels, therefore we should start from athletes' speeds

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so that improve athletes' overall levels. When shot throwing force is fixed, initial speed sizes and directions when throwing shot out of hands decide shot flight distance<sup>[10,11]</sup>. Shot throwing moment speed is related to athlete shot throwing process. Athlete shot throwing process including start from shot leaves neck to shot out of hands the whole phase<sup>[12]</sup>. Back sliding shot throwing method can be divided into three phases as sliding phase, transition phase and last exertion phase. Among them, sliding phase is the basic phase of whole technical motions, it makes fully preparation for transition phase and last exertion phase, let shot enter into sports state. Transition phase is the linkage in whole process, it not only links sliding phase and last exertion phase, meanwhile it let body form into reasonable postures, and let shot speed maintain and increase. That is directly affecting whole shot throwing process merits. Last exertion phase is the uppermost segment in shot throwing techniques, which directly affects speed when shot out of hands and decides the whole process merits<sup>[13]</sup>.

However, in China researches on shot movements, they are mostly concentrated on sliding phase and last exertion phase. Most are carrying out research on shot at different stages, global research is relative less, which let shot movements researches and progress have oneness and limits. While shot itself is a kind of overall movement, except for doing well in each phase, the more important is the coherency of each phase motions. This paper melts the whole process into an entity, select shot throwing overall process some parameters that greater affect results to carry out comparison. Through parameters researching, it makes comparative evaluation on techniques merits. It further makes technical improvement suggestions, so that improve China shot putters' technical training quality.

### BACK SLIDING TECHNIQUE KINEMATIC ANALYSIS

Back sliding shot throwing method is mainly divided into sliding, transition, last exertion these three phase. Its basic motions<sup>[1]</sup> is right hand holding shot, back towards throwing direction, left thigh swings in the back, meanwhile right leg kicks out of ground, right foot slides along ground to the center throwing parts, then right leg

fast inner buckling, left foot lands with internal sole forming into back final exertion starting posture. After that, right foot kicks and turns, right hip rotates towards throwing direction, let hip axis rotate above shoulder axis, upper body forms into tighten posture. Concentrate strength on shot gravity center, throwing shot out at maximum speed and proper angle. Rough motions as following Figure 1<sup>[2]</sup>.



Figure 1 : Back sliding technique

The whole shot throwing process should ensure athlete throwing shot strength is large enough, meanwhile correct exertion order. Correct exertion order is shank, thigh, waist back each part, knee, hip, shoulder. So that it can guarantee motion coherency, at the same time let shot throwing speed be big, angle be optimal.

In October, 2009, the 11th national game, athlete performance was relative excellent that could roughly represent China modern phase shot putters' basic levels. Therefore, it takes October, 2009 the 11th national game shot competition six athletes and world excellent athletes as research objects, and extracts every athlete best trial throwing performance as research samples. National game six athlete's basic status<sup>[3]</sup> as following TABLE 1 shows:

Throwing parameters that decide shot throwing distance are mainly release speed ( $v$ ) 0release angle ( $\theta$ ), release height ( $H$ ), shot throwing distance  $S'$ :

$$S' = S_0 + S \quad (1)$$

Among them,  $S'$  is shot ground projection point to throwing arc distance,  $S$  is shot projectile distance after out of hand,  $S_0$  is shot leaving point land projection point and projection circle distance. For the same athlete, it has following computational formula:

$$S = \frac{v \cos \theta}{g} + (v \sin \theta + 2gH) \quad (2)$$

TABLE 1 : The 11th China national game shot men athletes' basic information

Name	Date of birth	Height	Weight	Ranking	Performance
Jia Peng	1984.01	1.86	96	1	19.20
Guo Yan-Xiang	1987.01	1.92	127	2	19.11
Xu Zhong-Nan	1989.11	1.98	150	3	19.10
Wang Li-ke	1991.07	1.88	100	4	18.83
Wang Guang-Pu	1987.11	1.92	110	5	18.72
Ding Yong-Heng	1989.04	1.86	101	6	18.49

According to formula (2), it is known that shot final throwing distance is related to height, angle and speed when shot is out of hand. According to before throwing shot essential exercise and kinematics analysis<sup>[5-8]</sup>, appoint following indicators as reference parameters as shot release height, shot release angle, body trunk front lean angle, left shoulder back lean angle, elbow joint and trunk included angle, left hip speed, right hip speed, two thighs included angel, human body displacement gravity center speed, left leg swinging speed, right leg drive angle, center height gap.

**SHOT THROWING OPTIMIZATION MODEL ESTABLISHMENT AND APPLICATION**

Shot throwing three phases are closely linked; therefore we cannot single research from one phase. Make comparison from each phase, then according to overall

way to analyze. Link each phase influences together, it conforms to shot throwing process integrality and continuity.

In order to more precise clear reflect athletes' technical features and sports parameters, at the same time easier to research process calculation, comparison, analysis, when makes videos on athletes' technical motions, divide technique into 5 phases:  $R \uparrow$  right leg out of ground instantaneous,  $R \downarrow$  right leg landing instantaneous,  $L \downarrow$  left leg landing instantaneous,  $L \uparrow$  left leg out of ground instantaneous,  $O \uparrow$  shot out of hand instantaneous.

**Sliding phase parameters analysis**

Sliding phase athletes each sports parameters can refer to TABLE 2.

Sliding phase is whole shot throwing process pre-

TABLE 2 : Sliding phase athletes' parameters analysis

Name	Right leg drive angle(°)	Right knee angle(°)	Two thighs included angle(°)	Shot height $m/s$	Shot speed $m/s$	Gravity center height gap $m$	Gravity center speed $m/s$	Time $S$
Jia Peng	75.46	106.8	108.1	1.02	2.39	0.07	2.28	0.59
Guo Yan-Xiang	64.13	121.5	88.4	0.94	2.78	0.06	2.47	0.43
Xu Zhong-Nan	59.81	102.5	98.5	1.16	2.66	0.07	2.39	0.83
Wang Li-ke	76.34	109.9	113.7	1.11	2.38	0.07	2.22	0.77
Wang Guang-Pu	77.03	105.3	96.8	1.02	2.75	0.06	2.29	0.59
Ding Yong-Heng	63.22	104.6	95.4	0.98	2.57	0.07	2.38	0.55
Average value	69.33	108.5	100.2	1.04	2.58	0.06	2.34	0.62
S	$\pm 7.301$	$\pm 6.84$	$\pm 9.06$	$\pm 0.117$	$\pm 0.176$	$\pm 0.016$	$\pm 0.185$	$\pm 0.177$

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liminary phase. In sliding phase, in order to let the latter two phases get excellent results, it firstly should maintain stable gravity center, meanwhile let shot horizontal direction accelerated speed increases as much as possible. By consulting, world excellent athletes' leg drive angle normally is between  $55^\circ$  and  $59^\circ$ , two thighs included angles values are between  $99^\circ$  and  $116^\circ$ . While above TABLE 2 indicates China athletes average is  $69.32^\circ$ , from which the minimum is  $59.8^\circ$ , which is bigger than world normal level. Two legs included angle China athletes' are between  $88.4^\circ$  and  $113.7^\circ$ , average value is  $100.2^\circ$ , which gets relative closer to world level. Leg drive angle and two legs included angle affect gravity center stability. The bigger leg drive angle is, the bigger two legs' included angle is, the higher gravity center is the unstable would be, is not helpful for smoothly entering into latter phases. On the contrary, if control leg drive angle in smaller range, shot and body received horizontal component force would become big.

Therefore, it suggests that China athletes should reduce leg drive angle in training process, properly decrease two legs included angle so as to reduce gravity center, and increase accelerated speed. Body gravity center shifting speed directly affects shot shifting speed. So it should try to improve gravity center shifting speed as much as possible, it can improve shot accelerated speed. But if blindly only improve gravity center speed, while shot speed cannot catch up with causing body

unstable, it will cause influences on subsequent phase. It needs to improve gravity center accelerated speed, meanwhile increase shot accelerated speed, let its accelerated speeds gap reduce as much as possible.

### Transition phase each parameter analysis

Transition phase is linking phase to sliding and final exertion phase. The key in the phase is to control and handle with motion rhythms so as to smoothly enter into final exertion phase. Important tasks in the phase are to maintain and properly add shot horizontal speed. Transition phase athletes' basic kinematics parameters are as TABLE 3 shows.

Consulting information[5-8], it is clear that shot throwing transition phase, hip twisting beyond shoulder, in this way it is helpful for hip driving shoulder, adding body twist force, and body gravity center shifting speed, it can increase shot shifting speed. And analyze TABLE 2 data, it is clear that above 6 athletes' hip leading shoulder motion haven't well completed. Root analysis might be when left leg landing, body controlling left shoulder and left arm is not quite good. It suggests that China athletes add left shoulder and left arm controlling when training. Meanwhile, control hip twist strength, let it goes beyond shoulder, and drive shoulder twisting.

One point that cannot ignore in transition phase is transition time. Excessive long transition time will loss sliding phase speed is not helpful for shot and human

TABLE 3 : Transition phase athletes' basic parameters

Name	Trunk front lean angle( $^\circ$ )	Left shoulder back lean angle( $^\circ$ )	Right landing angle( $^\circ$ )	Left knee angle( $^\circ$ )		Right knee angle( $^\circ$ )		Right hip angle( $^\circ$ )		Shot projection point and left leg supporting point distance m	Transition time s
				R $\downarrow$	L $\uparrow$	R $\downarrow$	L $\uparrow$	R $\downarrow$	L $\uparrow$		
Jia Peng-Guo	51.06	53.28	96	155	169	106	113	131	142	1.12	0.15
Yan-Xiang	53.13	56.15	90	149	161	129	155	139	147	1.19	0.17
Xu	55.20	56.41	97	159	148	138	177	159	172	1.13	0.13
Zhong-Nan	57.34	65.82	87	180	169	126	141	121	128	0.99	0.15
Wang	60.03	65.84	79	167	146	129	159	157	159	1.09	0.15
Guang-Pu	63.22	69.06	92	153	146	125	172	248	146	1.03	0.14
Ding	63.22	69.06	92	153	146	125	172	248	146	1.03	0.14
Yong-Heng	63.22	69.06	92	153	146	125	172	248	146	1.03	0.14
Average value	56.66	61.08	90.16	158.7	156	125	152	149	150	1.09	0.15

body gravity center speed increasing and maintaining. World excellent players' transition time normally will not beyond 0.12s, while China players average transition time is 0.15s. Main reason is that right leg drive strength is small. Suggest China athletes increase right leg drive training. But right leg driving strength excess large will let gravity center unstable that it needs certain techniques when kicking. In this phase, the important is to maintain gravity center stability, meanwhile add kicking strength, and shorten kicking time.

In left leg landing right leg landing phase, athlete each physical parameters are as TABLE 4 shows:

Research<sup>[9]</sup> shows, shot movement speed reduces 10% per time, shot can be thrown 0.22-0.27m further. Therefore, when throwing shot, it needs to reduce shot speed waste as much as possible. Here it can be realized by adding right hip speed. Above Table 4 data shows right leg landing and left leg landing instantaneous, right hip speed increasing is not remarkable, which indicates that hip rotation is not enough, suggest athletes adding right hip rotation.

Less transition phase time, lower speed wastes would be, therefore it needs athletes reduce rotation time, increase gravity center and shot speeds. That needs to increase body active rotation. In rotational process, it also needs to keep gravity center stability. It has great relationships with body coordination and left right leg pedaling and stretching as well as landing time. Suggest when athletes throw shot, increase right leg active pedaling and stretching, increase right hip twist strength and speed, enlarge left leg landing force so as to maintain body gravity center stability and motions coherency.

### Last exertion phase kinematics analysis

Final exertion phase is shot throwing total perfor-

mance decisive phase. The phase requires human body concentrate whole body strength on right hand, throw shot out powerfully, and keep shot angle when it leaves hands. To concentrate whole body strength on left hand, let shot can throw at maximum speed and best speed, it must let whole body exert according to correct exertion order. Correct exertion order is hip exerting, driving knee, ankle joint exerting, let the whole lower limbs common acting on ground, finally trunk, upper limbs, and finger powerful throwing shot out.

Final exertion accelerated phase, athletes' body kinematics parameters are as TABLE 5 shows:

The phase first needs left leg applies brake on body, keep body stable. Right leg and right hip positive moves, ensure that shot speed ratio wastes be minimum. Through consulting relative documents<sup>[9]</sup>, world excellent athletes' during final exertion phase, shot running distance is 1.5~1.8m, running time is 0.22s. China players' shot running distance is  $1.21 \pm 0.124m$ . The larger shot running distance is, the larger shot release speed would be. In the aspect, China player is still need to be improved. It has a relationship with player sports amplitude; therefore suggest athlete increases sliding phase sports amplitude. For shot accelerated speed running time, it is the same as world excellent athletes' average level.

Observe above TABLE 5, China athletes' gravity center speed is larger than world excellent athletes' gravity center shifting speed. China athletes thrown shot speed is smaller than world excellent athletes thrown shot speed. It indicates that China athletes' strength explosiveness is small. Suggest China athletes' strength physical quality training at ordinary time so that increase muscle explosive force. Shot releasing moment each

TABLE 4: R↓L↓ phase athlete kinematic parameters

Name	Right hip speed		Left knee angle(°)		Right knee angle(°)		Right hip angle(°)		Left leg landing(°) L↓
	R↓	L↓	R↓	L↓	R↓	L↓	R↓	L↓	
Jia Peng-	2.27	2.14	2.22	2.14	2.20	2.12	2.96	2.32	49.47
Guo Yan-Xiang	2.22	2.15	2.13	2.05	2.12	2.23	2.79	2.26	46.73
Xu Zhong-Nan	2.15	2.10	2.22	2.14	2.08	1.97	2.54	2.21	50.62
Wang Li-ke	1.87	1.97	1.77	1.93	2.02	1.86	2.84	2.29	47.44
Wang Guang-Pu	1.86	1.98	1.87	1.87	1.86	1.78	2.35	2.40	57.29
Ding Yong-Heng	2.22	2.14	2.16	2.16	1.92	1.83	2.93	2.68	60.34
Average value	2.09	2.08	2.06	2.08	2.21	1.95	2.76	2.36	52.01

TABLE 5 : Last exertion phase kinematics parameters

Name	Shot running distance (m)	Gravity center speed (m/s)	Shot speed (m/s)	Gravity center height (m)	Last exertion time (s)	Shot running time (s)
Jia Peng-	1.27	2.45	12.67	1.15	0.22	0.21
Guo Yan-Xiang	1.36	2.52	11.87	1.36	0.25	0.25
Xu Zhong-Nan	1.08	2.53	11.04	1.12	0.22	0.19
Wang Li-ke	1.14	2.35	10.59	1.18	0.28	0.24
Wang Guang-Pu	1.11	2.57	10.12	1.28	0.24	0.22
Ding Yong-Heng	1.27	2.50	10.29	1.23	0.27	0.23
X	1.21	2.49	11.09	1.22	0.25	0.22
S	0.124	0.079	1.035	0.089	0.031	0.069
World excellent player	1.53	2.41	12.61	1.32	0.19	0.22

item kinematics parameters can indirect reflect shot throwing distance, analyze these data can deduce what shortcomings athletes still have during shot throwing whole process. Before shot releasing shot each kinematics parameters are as TABLE 6 shows.

China athletes' shot release speed and release height are lower than that of world excellent athletes. It also generates throwing shot distance is smaller. The larger shot release speed is, the further shot flight distance would be. China athlete release speed lower reason is that sliding and transition phase preparation work not perfect implementation.

Besides, when releasing shot, body muscle exer-

tion explosive degree is also an important reason. Suggest athletes strengthen explosive force training, and whole phase coherency and fast speed. Shot release angle is not the larger the better, world excellent athletes' release angle normally are between  $34^{\circ} - 38^{\circ}$ . China athletes are obvious too low. But athletes cannot blindly pursuit the best release angle. Release angle not only has connections with motions coherency, speed sizes, but also have certain relationship with athletes' themselves physical conditions. China athletes compare with foreign athletes, height is too short. Therefore, only suggest China athlete under initial release speed guarantee circumstance, properly improve release angle. The more

TABLE 6 : Before shot releasing kinematics parameters

Name	Performance	Release speed (m/s)	Release angle( $^{\circ}$ )	Release height (m)	Last exertion speed (m/s)
Jia Peng-	19.20	12.75	36.85	2.11	0.22
Guo Yan-Xiang	19.11	12.5	36.57	2.20	0.26
Xu Zhong-Nan	19.10	12.41	34.74	2.18	0.21
Wang Li-ke	18.83	12.14	34.85	2.13	0.29
Wang Guang-Pu	18.72	12.31	35.75	2.15	0.25
Ding Yong-Heng	18.49	12.38	35.65	2.13	0.27
X	18.90	12.42	35.66	2.15	0.25
S	0.336	0.206	1.312	0.034	0.30
World excellent player	21.21	13.64	36.50	2.28	0.22
S	0.810	0.242	2.358	0.048	0.035
T		12.430	3.398	4.503	1.929
P		0.001	0.019	0.006	0.112

important is increasing three phases' coherency, body stability. So that let release speed, height, angle best cooperate, and get excellent results.

## CONCLUSIONS

Through comparing China athletes and world excellent athletes' kinematics parameters when throwing shot, it get following conclusions (1) China athletes leg drive angle is big, two legs included angle is big that cause gravity center unstable. Body gravity center shifting speed and shot accelerated speed is small. (2) Transition phase: left shoulder and left arm poor controlling ability, hip speed is not big, which cannot drive shoulder moving. Right leg drive strength is not enough that causes long transition time, it is not helpful for shot and human gravity center speed increasing and maintaining. Left right leg landing phase, hip is not rotating enough. The process athletes body stability maintaining is not well enough. (3) Final exertion phase: Body exertion order needs to be adjusted. Small sliding phase movement amplitude causes shot running distance small. China athletes shot throwing speed is small, indicates China men athletes muscle handling explosiveness is small. China athletes' shot releasing height and angle are too small. Throughout shot throwing whole process, China athlete motion continuity needs to be improved. Stability needs to be strengthened. China athletes' body coordination and positivity are not good enough.

According to athletes problems and shot movement features, combining China men shot putters' physical quality features, we make following suggestions: (1) Sliding phase requires athletes first should keep gravity center stability, meanwhile increase horizontal direction accelerated speed. According to our country athlete features, suggest to reduce leg drive angle, reduce center height gap, meanwhile properly decrease two legs included angle. Increase gravity center shifting speed and shot speed, meanwhile let the two gap decrease as much as possible. (2) Transition phase, in left leg landing right leg rising phase, suggest athletes increase left shoulder and left arm controlling, control hip and should twist force, let hip beyond and drive shoulder. Increase right leg drive force, increase body gravity center stability, shortens leg drive time. In left leg landing right leg landing phase, suggest athlete increase right hip rota-

tional and twist speed, increase right leg active pedaling and stretching, increasing left leg landing force, keep gravity center stability and motion coherency. (3) Final exertion phase, adjust correct exertion order, increase sliding phase sports amplitude. Strengthen daily physical quality training, increase muscle explosive force. Increase continuity of each phase, on the premise of best coherency and maximum exertion; properly improve shot release speed and angle. Besides, to China athletes, the important is to increase daily physical quality training, increase muscle explosive force and gravity center stability, phases' continuity, so that it will helpful for final shot releasing moment, it can become more perfect, athlete can get more excellent performance.

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