

DISCUSSION ON THE CHARACTERISTICS OF LIU-XIANG'S HURDLING TECHNIQUES

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By using the methods of experiment and documentary, the data and motor photo of Liu Xiang attending Olympic and pre-Olympic games were collected and digitized. Based on the sport training practice, Liu-Xiang 110m hurdle sport techniques were investigated. Results show that the performance showing the technique characteristics of short flight time, long offending hurdle distance, short landing distance, high sprint pace frequency and the hip-hurdling style which postponed hold-down-hurdle time, enhanced hold-down-hurdle speed and decreased landing time. His knee conceding angle was small and pelvis swung rapidly.

KEY WORDS: hurdle, hurdling technique, hip, Liu-Xiang, "doubling action"

INTRODUCTION: Liu Xiang, an outstanding Chinese hurdler, made a stunning show in Athens Olympic 2004 with the result of 12.91 s, an original world record. This breakthrough of Chinese sprinting event made great difference and render it necessary to lunch a research on his unique technique, the practical and theoretical value of which will benefit us a lot. Based on data of national try-out, quarter-final and final matches in Athens, the following research gave a detailed analysis of his techniques.

OBJECT AND METHODS:

Object: Liu Xiang with special event of Men high hurdle of 110 M, born on July 13th.1983. His height is 190CG and weighs 80kg. Drew the world record as 12.91 S in Athens Olympic 2004.

Methods: A total survey of techniques analysis of the game and training in recent years was conducted and particularly the material of his performance in 2004 was thoroughly broken down. 3-D kinematics analysis of his running technique was made in April 2004 at China National Tournament held in Shi Jia Zhuang, the shooting frequency of which is 12 Hz, and its shutter speed is 1000Hz with the size of photos as 648×484. The kinematics analysis point at the 9th line of the forth track with the distance covered as 25 m. The cameras had an internal synchronization system, they were placed at an angle of 65°.Thanks to APAS kinematics system (Ariel Dynamics Inc. USA) and our own software and with the help of system for analyzing Body momentum parameter from Japan, we worked out the CG of body limbs and body mass, then all numeric data of each point were smoothed with a 7 Hz digital filter and analyzed on Microsoft Excel, SPSS10.0.

RESULT AND DISCUSSION:

Time Between the hurdle: Time consumed within the three strides between two hurdles can be an essential parameter. Three stride running style is characterized among those high leveled hurdlers and this speaks highly of runners' capacity to blend the running frequency with each stride. This parameter of Liu Xiang's is averagely 0.657 s in try-out and 0.654 s in final. Which showed that this parameter in final is slightly shorter than in try-out with no significant difference. His velocity during this process can be found quite stable and thus the fixed kinematics pattern took shape. This fact gave a hint that the three strides in his final was not a decisive factor in final match.

Table 1 Time between hurdle, velocity index.

	VDC (%)	SDDC (%)	DAHMC (%)	DBHMC (%)	TLA (°)	TCA (°)	AT (s)
Tryout	2.53	3.6	3.5	3.7	59	164	0.657
quarters	2.41	3.4	3.6	3.5	60	167	0.659
finals	2.24	3.1	3.2	3.2	60.8	171	0.654

Deviant coefficient: DC Step distance: SD Distance after hurdle: DAH distance before hurdle: DBH Trunk leaning angle: TLA Average time: AT Trunk Curling Angle.

Time hurdle clearance: Time of hurdle clearance is a key parameter, which reflect the hurdles' clearing techniques. The significant difference can be found in the following Table 2 that his average performance in this respect is 0.349s, which showed distinctive fall in contrast with various try-outs. This in turn illustrate that the technique contribution to his success is the top one. Liu Xiang's most favorable show in this parameter during Olympic final was 0.323S and he simply had four hurdles cleared with such velocity. This constitute a sharp contrast with try-out, in which he did the same a within 0.326S, a 0.16S decrease. This fact proved that his technique played a key role in clearing the hurdle in his success. The maintenance of this favorable technique guarantee his ongoing built-up in speed.

Table 2 Hurdle clearance time (s).

	First hurdle	Second hurdle	Third hurdle	Forth hurdle	Fifth hurdle	Sixth hurdle	Seventh hurdle	Eighth hurdle	Ninth hurdle	Tenth hurdle
Tryout	0.363	0.383	0.363	0.383	0.403	0.363	0.403	0.363	0.363	0.403
quarters	0.363	0.363	0.363	0.323	0.323	0.363	0.363	0.413	0.363	0.363
Finals	0.383	0.363	0.363	0.323	0.323	0.363	0.363	0.353	0.323	0.333

Characteristics of takeoff and attack into the hurdle technique: Investigation on his technique of clearance of the 9th hurdle reveal that the 3D velocity at the moment of flying is 9.12 m/s (finals: performance 12.91s) > 9.02 m/s (tryout: performance 13.40 s) > 8.92 m/s (quarters: performance 13.24 s). Individual horizontal velocity is 9.00 m/s, 8.78 m/s and 8.74 m/s, The final score is correlative with 3D velocity and horizontal velocity but bear comparative difference between the try-outs and the final. The possible answer to the phenomena may lay in either of the following two factors. One is that he deliberately slowed down in later part of the match on account of his practical concern. The other may be the tape recording of his performance is a little away from the norm and it cause the inaccuracy of measurement. The distances before hurdle are respectively 2.34 m, 2.56 m and 2.63 m during the try-out, the quarter finals and the final. While the distance after hurdles are 1.59 m, 1.45 m and 1.34 m in order. This fact shows that these two parameters are two of vital factors to the gain in speed when he clearing hurdles (photo 1).

Table 3 Across Hurdle Stride Index.

	VV(m/s)	HV(m/s)	3DV(m/s)	CGH(m)	TA(°)	KA(°)	DMH(m)	DBH(m)	DAH(m)
Tryout	2.06	8.78	9.02	0.15	13	162	0.543	2.34	1.59
quarters	1.78	8.74	8.92	0.14	11.6	171	0.621	2.56	1.45
Finals	1.47	9.00	9.12	0.12	9.2	177	0.645	2.63	1.34

Vertical Velocity: VV Horizontal Velocity: HV Distance Forward Movement of Hip: DFMH Take-off Angle: TA; Knee Angle: KA.

Biomechanics researches tell us that leaning trunk forwards when athlete attack the hurdle can lower range of CG fluctuations. The minimum efforts to clear the hurdle could be obtained when athlete lean his or her trunk as hard as he towards hurdle, which means a natural obstacle against runners. It is therefore a favorable gesture to double upper and lower bodies rapidly while taking hip joint as axis and then immediately draw back and place attacking foot on the ground. Liu's technique exemplifies such feature. During his various efforts, he cleared the 9th hurdle with trunk leaning angle respectively as 59°, 60° and 60.8° which is bigger than other 7 athletes in Olympic final as 58.2. This made it easier to lower body CG. Personally, Mr. Liu claimed immediately after the final that he has ever touched

two hurdles, but it took no effect on his result, for his body CG barely fly over the hurdles. Scrutiny of technique photos showed a bigger angle between upper and lower bodies appeared when Liu Xiang launched his attack upon hurdles than other hurdlers nation or abroad. He almost stretched his upper body and swing legs horizontally while free of bend of either leg or the stomach. Therefore, angles between upper parts of attacking legs and trunk was enlarged whereas other athletes would scarfify to curl either of those parts in order to limit the fluctuation of CG, the result of which find a apparent "doubling action" between upper body and the sawing leg.

Liu Xiang's hurdling technique was regarded as the top one in this field. As a necessary elements of hurdling, his hurdles-attacking demand our through and detailed analysis.

As we all know, human anatomical structure lays basis for human movement. Hip joint, the center of movement, is ball-and-socket joint, and capability of movement on three free latitudes. When the take-off leg lift up with the action of slight reversing outside and joint curling, it can only take move horizontally in a style of hip-thigh-body. Thus the sensible leaning movement should be a leaning of trunk-thigh. But the serious curve happened at stomach would hinder the forward movement of hips on one hand, and on the other would bring the lose connection between hips and upper body. This in turn would sluggish the muscle strength around waist and discourage the effort of swing legs and created problem for "active hip-delivering" action when attacking the hurdles. Leaning movement of trunk-thigh jointly participated and neck-extending are consistent with physiological requirement of rapid draw-back of swing leg at the moment of its reversing outside and joint curling.



Photo.1 Xiang Liu, China.

Strength Reflex happened helping the waist free of collapsing and cause tense in relevant muscle groups. So it is required that hip, waist, stomach, chest and head have to lean forward simultaneously during hurdle-attacking. This is highly characterized in Liu Xiang's attacking style. The traditional view is to maximally lean upper body forward holding by Chinese hurdlers and it is easy to find a clear body-folding phenomenon with a less effective attacking action. The more straight trunk gesture could be identified in Liu's swing leg at the moment of attacking hurdle, which give a full play of Strength Reflex. These facts constitute undeniable evidence of so called 'attacking hurdle with a straight upper body'. The unique skill would be quite helpful to rapid rotation of pelvis and would extend the working distance of hips. Actually, We can find the lengthened working distance of hips occurred in Liu's try-out, quarter-finals and final performance in the order of 0.543 m 0.645 m and 0.651 m.

Serious stomach-curling would give less room for hips to move at high speed and within a broader range and also shorten its working distance. While, attacking hurdle with a straight upper body will lend more chances for the ample muscle groups around hip to release power and then create a more favorable position for take-off leg to yield power which would accelerate swing speed. It embodies clearly the biomechanics' feature of what we called hurdling mainly by hip. As we conclude that this is the essence of Liu's unmatched hurdling technique.

Characteristics of the clearance of hurdle technique: Leaning trunk forward during hurdle clearance would on the one hand guarantee stability of CG and provide power for swing lower leg forward and make it ready for the occurrence of eccentric-concentric muscular contraction and the following rapid downward movement before landing. On the other hand,

too early approach of trunk towards the hurdles would hinder swing leg's upward swinging and irrationally change the moving path of center of gravity. The take off angle would be unfavorably increased and cause the CG fluctuation and finally encumber the landing action. No significance of time spent on trunk's dipping over hurdles has been found between Liu's try-out and final, being showed as 0.058 s and 0.050 s in each performance. There appeared minor delay compared with 0.043 s of quarterfinal. The gain for his thigh to swing upward is due to his delay of leaning forward at the moment of attacking hurdle, which in turn owing to his distance before the hurdle was enlarged. As showed in photo 1, that his leg has been fully stretched when his toe fly over the hurdle. His knee angle of 177° at this moment is considerably larger than other hurdlers 161° by average. This gesture would limit fluctuation of CG and also give anatomical latitude for the gain of swing speed of lower limbs. As showed in Table 3, all his trunk curving angles during three matches are smaller than other runners' average as 163° , an obvious evidence of attacking hurdle with a straight upper body. Specifically, the larger scope of leaning forward by his upper body is actually against our intuitive observation. His unique rapid rotation of pelvis is quite functional for his take-off leg's quick folding and its swinging forward. 0.12 S, his time spent on dipping over hurdles, is notably shorter than 0.14 s of others'. It contributes greatly to his fast speed of dipping over hurdles.

Characteristics of landing after the hurdle technique: The main task of this phase is to maintain a stable CG and then to avoid speed loss. This facilitates a smooth transition to the next phase, running between two hurdles. In his Olympic final, the angle between his take-off thigh and horizon is 35° , a smaller one than average 65° by other runners. Thus, no occurrence of over-lift of thigh has been found. The angle of his leaning trunk forward in his final is 6° significantly smaller than that of his try-out (11°) and quarter-final (8°). His way shorten the flying time is by quicker trunk upward movement and his take-off leg moderate lift-up and swift swinging action.

His power yield from hip was fully made used of. Smooth movement of CG combined with the less time spent on braking phase help to diminishing the speed loss and contribute a lot to accelerating the running speed. The paramount factor for a full play of this technique is the swing speed of hip. The speed of his swing leg downward action in Olympic final is 450 %/s and that of take off leg forward movement is 489 %/s. The speed of horizontal movement of his hip axis is 600 %/s (higher than 510 %/s of try-out). His hip axis rotating speed bear high correlation with his swing leg and take off leg (respectively as $r = 0.652$ and $r = 0.685$). This may due to the fact that hips quick rotation lend a hand to the downward swinging action immediately after it depart hurdles. The instants that take off leg catch up with swing leg shorten the time for the swing leg to support body. This is clearly showed as 0.163 s of final, with 0.03s shorter than that of try-out 0.193 s. His shorter time obtained during support phase come from his manipulation of hurdling rhythm.

Thanks to quick swing movement in the order of hip and leg, his swing leg was highly motivated and then can undertake the intense crashing workload. During his final, his knee angle of 177° in final is larger than either 162° of try-out or 171° of quarterfinal. The process of knee angle's reducing accompanied the loss in the time for braking bring about quick and smooth finish of supporting phase and thereafter cause quick forward movement of CG and speed up the unification of clearance and running.

All in all, we can summarize Liu Xiang's hurdling technique with the expression as 'straight in three respects, quick in two ways and a critical power release'. Specifically, keep a straight leg and a straight trunk while attacking, and have straight leg at landing moment; a quick movement of hip at attacking movement and speedy folding up of two thighs; release power mainly from hip.

CONCLUSION:

1 Liu Xiang' technique characterized by the following features as short flight time. distance before hurdle is longer and distance after hurdle is shorter, high sprint frequency and the hip-hurdling style which postponed hold-down-hurdle time, enhanced hold-down-hurdle speed and decreased landing time.

2 Hurdling technique embody Attacking hurdle with hip, favorable delay of trunk leaning forward. A less obvious curling of upper body, the simultaneous movement of body and hip during dipping the hurdle. The speedy scissor movement, His knee conceding angle was small and pelvis swung rapidly.

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