THE KINEMATIC ANALYSIS ON THE TRANSITION TECHNIQUE BETWEEN RUN AND HURDLE CLEARANCE OF 110M HURDLES

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The sixth hurdle clearance of the first six hurdlers who took part in the preliminary contest of the Eighth National Games was filmed with a "CHUN FENG" camera (China) with a frequency of 96Hz. The film was then digitized using JTK—1 film analysis system. The results showed that the essence of hurdle race is the transition between run and hurdle clearance. The speed rhythm shown in the stride before the clearance of the hurdle and the first stride after the hurdle is a crucial factor that determines whether or not the hurdle clearance technique is satisfactory.

KEY WORDS: kinematics, hurdle, velocity

INTRODUCTION: In recent years, with the development of hurdle clearance technique and the improvement of hurdle runners' sprint speed, the modern high hurdle is characterized by quick and fluent speed rhythm. Experts in the field have defined the hurdle clearance as hurdle running. The essence of the modern "hurdle running" concept is actually integration of hurdle clearance and sprint. However, the speed rhythm of the stride before hurdle clearance and the first stride after touch -down are crucial parts that complete the hurdle running technique. Hurdle stride technique is directly affected by the stride before the hurdle. In addition, the landing technique after the hurdle can also affect the first stride pattern speed rhythm. The second stride pattern is similar to that of the sprint. Therefore, the purpose of this paper is to analyze the characteristics of experienced Chinese hurdle runners in order to provide possible suggestions that may improve the performance of Chinese hurdlers.

METHODS: The first six experienced hurdle runners who were recruited as subjects for this study, took part in the preliminary selection contest of the Eighth National Games of China. in April 1997, ZhaoQing, HuBei Province.

In the Track and Field events, the performance of first six hurdle runners in the sixth hurdle clearance was filmed with a CHUNFENG (China) cinecamera which has a frequency of 96Hz (having been corrected by shooting a stopwatch). The camera was fixed at a height of 1.25m and placed at a distance of 42.5m from the first lane line .The course from the athletes' landing after the fifth hurdle to the completion of the seventh hurdle clearance was photographed. Then the film was processed with JTK—1 film analysis system and the original data was dealt with using the mathematical method. Finally, some interrelated data was also dealt with by normal statistical methods.

RESULTS: The characteristics of the stride before hurdle clearance. The stride before the hurdle is the stride when athlete steps on the takeoff point before the hurdle and the continuity of the second stride pattern is basically similar to the sprint. But the stride before the hurdle should create the optimum condition for the hurdle clearance because it is also the preparation phase. The characteristics of the stride before the hurdle are as follows:

The shortened stride. According to the data that has been analyzed, the average length of the stride before the hurdle performance of the six athletes is 1.92±0.05 m, which conforms to the demands of the stride before hurdles of modern hurdle running (about 1.90m). The reason the stride before hurdles is shortened is that the takeoff leg swings downward and actively steps onto the takeoff point. The effects are as follows: the first effect is to quicken the velocity of the action and prepare for hurdle clearance; the second is to increase the horizontal velocity of the body's center of gravity (C.G.) in order to create the optimum condition for the transition of the takeoff leg from landing buffer to eccentric.

The straight and smooth moving route of the body's center of gravity (C.G.). As a result, the wave difference of the C.G. is 2.6cm (centimeters) during soaring phase, which is lower than sprint in mid way (4.4cm). This straight and smooth moving route of the C.G. can

shorten the soaring duration and reduce the vertical force downwards.

The technical characteristics during hurdle attacking phase. This phase will complete the transition from sprint to the hurdle clearance. The quality of completion of the hurdle clearance can directly affect the takeoff angle and the moving locus of the C.G. over hurdles. Table 1 shows the technical characteristics of the six hurdlers during hurdle attacking.

Table 1 Kinematics Parameters of the Six Elite Hurdlers during Hurdle Attacking Phase

Variable	A	B	C	D	E	F	Mean±S.D.
Horizontal velocity of the C.G. at landing	8.43	8.96	8.41	8.27	8.42	8.48	9.49±0.05
Distance of buffer	0.35	0.4	0.45	0.42	0.37	0.40	0.39±0.03
Duration of buffer	0.045	0.047	0.056	0.06	0.045	0.05	0.05±0.01
Horizontal velocity of the C.G. in vertical support phase	7.45	8.16	7.98	6.92	8.05	7.85	7.73±0.46
Distance of stretch	0.52	0.55	0.53	0.57	0.51	0.5	0.53±0.03
Horizontal velocity of C.G.	0.07	0.07	0.065	0.08	0.07	0.06	0.07±0.01
Horizontal velocity of C.G. at takeoff	8.01	8.59	8.29	7.81	7.76	8.48	8.15±0.34
Ascending height of the C.G.	0.14	0.13	0.13	0.13	0.17	0.11	0.14±0.02
Takeoff angle	10	12	11	9	13	10	11±2
Maximal angle of the takeoff lower leg	142	148	157	143	147	140	146±6
Landing angle of the take of leg	78	76	75	77	79	74	76±2
Eccentric angle of takeoff lower leg	54	54	57	54	61	55	56±3
Ankle angle buffer changing	40	39	46	39	31	33	38±5
Eccentric ankle angle changing	55	43	51	49	48	53	50±4
Included angle between thighs at take off moment before the hurdle	112	113	119	124	110	118	116±5
Knee angle of the lead leg in vertical support phase	24	28	28	30	30	27	28±2

The technical characteristics of the takeoff leg before the hurdle:

The greater degree of landing angle. The average knee joint angle and the landing angle of the take off leg are 161±5°and76 ±2°, respectively which are bigger than sprint action at the same point (the sprint knee angle and the landing angle are 156° and 68°).

The smaller knee angle buffer. The smallest average knee angle buffer of the six athletes is 146±6 ° during hurdle clearance which is bigger than sprint (136 - 142°) and characterizes the high support and the high center of gravity of the body.

Buffer and stretch of ankle phase. The ankle angle changes are separately 38±5°and 50±4°during braking and stretch phase, which embodies the technical characteristic. This is shown by ankle joint connecting with the buffer and stretching intuitively. The eccentric phase of ankle comes when the C.G. passes over the support point. During this stage, the horizontal and vertical velocity all begin to increase. The stretch occurring at this time will certainly lead to greater vertical velocity, a wider takeoff angle and higher soaring during hurdle clearance .The stretch of the six hurdle runners is not evident at the beginning of eccentric phase. However, the knee joint eccentric angle reaches maximal angle velocity when the body's center of gravity moves over the support point (at 30 - 40 cm). It is also noted that the ankle angle velocity will reach maximal levels during later stretch phase. Therefore, it can be seen from above calculations that the takeoff leg goes on accumulating

strength at the beginning of eccentric phase and the large and small muscle groups will release strength in turn at suitable angle.

The technical characteristics of the lead leg. The knee-joint of the lead leg folds tightly and swings upward highly. The knee angle of the lead leg becomes minimal when the trunk is in vertical position, which is smaller than sprint (about 30°) at the same time. The knee angle of the lead leg is higher 4±2cm or so than the same side hip joint at the takeoff moment. This also indicates that experienced hurdle runners pay much more attention to increasing the velocity of the lead leg, which can benefit the forward moving speed of the body's center of gravity.

The changing characteristics of the trunk action. The forward inclination of the trunk is 3—6° at the beginning of buffer and becomes apparently larger with the C.G. moving forward when entering stretch phase. At the end of stretch phase, it reaches about 16 - 18°, which is helpful in achieving a suitable takeoff angle.

The changing characteristics of the C.G. locus. In this phase, the height of the body's center of gravity ascends. During the whole hurdle clearance phase, the average height of the C.G. was 14±2cm and did not decrease or decreased only slightly in the buffer phase. The average height of the C.G. was 112±2cm when take off which was higher than hurdles and consequently caused the runner to complete the hurdle clearance action phase with a smaller take off angle.

The long forward horizontal moving distance of the C.G. The C.G. moved forward by an average of 0.92 ±0.08m, during the whole support phase prior to the hurdle and 0.53±0.02m during eccentric phase. . As the horizontal distance of the C.G. from landing point is further, so the horizontal force is greater and therefore the take off angle is smaller.

The technical characteristics during landing phase after the hurdle. This phase will complete the transition from clearance to sprint. According to results of research, the characteristics of the hurdle are indicated as follows:

Table 2 Kinematics Parameters of the Six Hurdlers during Landing Phase after the Hurdle

Variable	A	B	C	D	E	F	Mean±SD
Horizontal velocity of the C.G. at landing	7.53	8.42	8.07	7.46	7.42	8.29	7.86±0.44
Distance of buffer	0.16	0.13	0.27	0.23	0.22	0.16	0.19±0.05
Duration of buffer	0.02	0.02	0.04	0.03	0.03	0.02	0.03±0.01
Horizontal velocity of the C.G. in vertical support phase	7.48	8.27	7.67	6.5	7.04	7.9	7.47±0.57
Distance of stretch	0.47	0.61	0.57	0.49	0.55	0.56	0.54±0.05
Duration of stretch	0.06	0.08	0.07	0.07	0.07	0.07	0.07±0.01
Horizontal velocity of C.G. at takeoff	8.06	8.2	8.13	7.8	7.27	8.07	7.92±0.34
Changing height of the C.G. at landing and at takeoff moment before hurdle attacking	0.02	0	0.01	0.03	0.03	0.02	0.02±0.01
Landing angle of the lead leg	0.08	0.09	0.08	0.08	0.09	0.05	0.08±0.01
Takeoff angle	83	84	81	80	82	83	82±2
Decreasing ankle angle in buffer phase	59	57	52	60	58	57	57±3
Ascending ankle angle in eccentric	30	38	50	41	33	43	39±7
Knee angle in landing phase	175	169	164	168	166	173	16±4
Knee angle change during buffer	-5	-2	-3	-6	-2	-3	-3±2

The height of C.G. on landing after the hurdle. The knee angle of the lead leg was between 168° and 175° and almost straight .The landing angle was about 82±2°. The height of the C.G. at moment of landing was higher by about 2 cm than that of the C.G. at the end of hurdle clearance. Consequently, this causes the vertical velocity to be relatively smaller and so lightens the support load of the lead leg in the landing phase. This action permits the C.G. to move forward quickly and to make the transition from clearance to sprint more natural and coordinated.

The smaller knee joint buffer, buffer and stretch of ankle. During the buffer phase, the maximal knee angle buffer of Wan Wenyuan was 6°. BaiYong's knee angle was not decreased but increased. This result showed that the athletes have an active support action during the phase. However, the ankle angle change is larger (about 30±10°). These calculations imply that the athletes try to make their knees straight to preserve greater support. Because of the smaller knee joint buffer, the ankle eccentric action occurs mainly during stretch phase and the increased angle was 39±7°, which also indicated that the experienced hurdlers actively support with their lead legs during landing phase after the hurdle.

The high takeoff leg swing. The six experienced hurdle runners swung the takeoff leg higher than the same side hip joint at the moment of touchdown. The knee of the takeoff leg has a short duration of moving in an upward direction. After entering stretch phase, the included angle between the two thighs increases above 110°. The bigger swing and stretch extension are advantageous for increases in the stride length after the hurdle.

The three strides length: relationship and proportion among the stride, before the hurdle, the hurdle clearance stride and the first stride after the hurdle. Using the data from table 3, the mean length of the step before the hurdle was calculated at 1.92±0.05m. These measurements are fundamentally in accord with the technical pattern for hurdle running. The average total length of hurdle stride and the stride after the hurdle was 3.69±0.06m and 1.55±0.12 m, respectively. This result indicated that there is a longer hurdle clearance stride and the relative shorter stride after the hurdle. The discrepancy is evident compared with data from world class experienced hurdlers. The reason for that was the landing distance from hurdle is longer (1.57±0.09m. This demonstrates the importance of athletes' control of the first stride after touchdown in order to adjust the length of the last two strides. They must be appropriate after the big extended swing and stretch of the first stride after the hurdle. The length of stride pattern changes evidently because of the longer landing distance from the hurdle, limiting the greater velocity in full play. From the proportion of the three strides, Tan LingJun's come near to each other which is in accordance with technical characteristics of hurdle running ---the "long distance takeoff, short distance landing " .The active and initiative landing technique after the hurdle has effects on speed rhythm.

Table 3 The Three Strides Length Relationship and Proportion Among the Stride before the Hurdle, the Clearance Stride and the Stride after the Hurdle

Variable	A	B	C	D	E	F	Mean±S.D.
Length of the step before the hurdle	1.93	1.88	1.99	1.97	1.90	1.87	1.92±0.05
Take off distance	2.09	2.19	2.13	2.11	2.13	2.10	2.12±0.04
Landing distance	1.67	1.39	1.56	1.58	1.59	1.62	1.57±0.09
Total length of the hurdle step	3.76	3.58	3.69	3.69	3.72	3.72	3.69±0.06
Length of the first step after landing	1.42	1.78	1.58	1.48	1.55	1.53	1.55±0.12
Proportion among tree steps	51:100:37	52:100:49	53:100:42	51:100:41	51:100:41	50:100:41	52:100:42

CONCLUSION: The hurdle clearance and landing techniques after the hurdle can enhance the hurdlers' ability to combine the sprint and clearance, clearance and run at peak performance. These are important components that can greatly affect the speed rhythms and ultimately the final outcome.

During hurdle clearing phase, the take off leg should incorporate a faster landing characteristic and longer and more rapid stretching characteristic. The lead leg should fold tightly and swing high. The body's center of gravity should move actively forward during the forward inclination of the body's trunk.

The Chinese elite hurdlers need to be encouraged to coordinate the lead leg for landing in order to cause the takeoff leg to fold and swing upward rapidly. This is of critical importance, shortening the hurdle stride and increasing the first stride after hurdle. It is also one of the most significant characteristics of hurdle running.

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