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COMPARATIVE BIOMECHANICS ANALYSIS OF HURDLE CLEARANCE TECHNIQUES

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The purpose of this study was to investigate Yin Jing's hurdle clearance techniques. Through a follow-up study on his training, some experiments were performed using 3D kinematics. The best one of each year's performances from 2007 to 2009 was chosen for comparative analysis in this paper. It was found that his techniques improved significantly and became more stable, but the supporting time needs to be reduced.

KEY WORDS: biomechanics, hurdle clearance, technique.

INTRODUCTION: Hurdles are a combination of cyclic sprinting and a cyclic clearance of ten 1.067m hurdles, being the hurdle clearance technique one of the key elements determining the competitive result. There have been kinematic and dynamic studies on hurdle clearance (Salo & Grimshaw, 1998; Kampmiller, Slamka & Vanderka, 1999; Coh, 2001), but a follow-up study and comparative analysis on one hurdler has not been reported. Yin Jing is one of the best young 110-meter hurdlers in China with a great potential. The aim of the follow-up study is to find out his technical shortages and provide valuable information for training and improving his hurdle techniques.

METHODS: 3D photogrammetry: The 5th hurdle clearance in training was recorded with two synchronized video cameras (BASLER A6) at 100Hz (Figure 1). A radial frame with 24 control points was used to calibrate the space. Nineteen body marks (top of head, neck, both shoulders, elbows, wrists, fingertips, hips, knees, ankles, toes and the midpoint of hips) were manually digitized with video processing software (3D-SignalTEC V1.0c) and the raw data were smoothed by low-pass filter with a cutoff-frequency of 8Hz.The measurement setup and data processing methods were consistent throughout the studies.

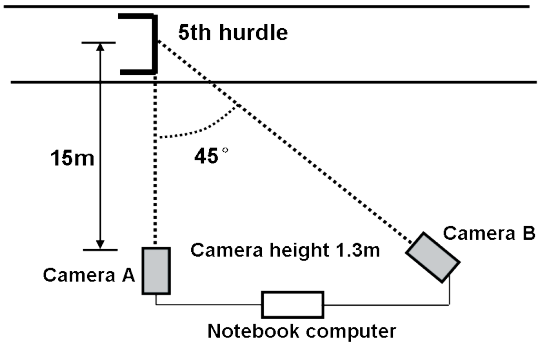

Figure 1: Measurement setup.

RESULTS: The definitions of kinematics variables are shown in Figures 2 to 5. The results are presented in Table 1.

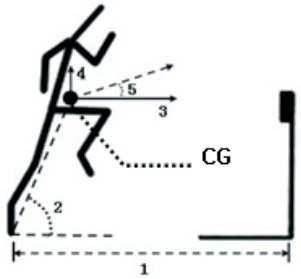

Figure 2: Variables at the moment of take off before hurdle.

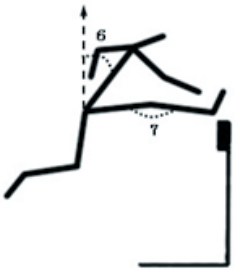

Figure 3: Variables during clearance.

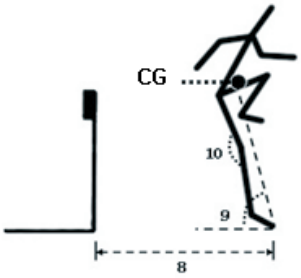

Figure 4: Variables at the moment of landing.

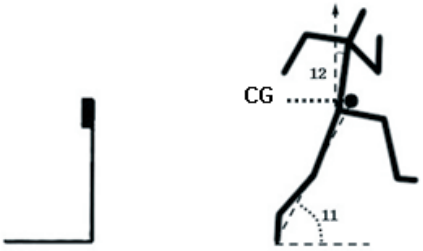

Figure 5: Variables at the moment of take off after hurdle.

Notes: CG: centre of gravity
1: Distance before hurdle
2, 11: Take off angle
3: Horizontal velocity
4: Vertical velocity
5: Take off angle of CG
6, 12: Trunk angle
7: 10. Lead knee angle
8: Distance after hurdle
9: Landing angle

DISCUSSION: Table 1 shows that compared with other year's performances, the 2007's performance had larger take off angle and takeoff angle of CG but smaller horizontal velocity at takeoff, which would prevent the body from moving forward quickly. His stride length and the distance before hurdle were both not sufficient and the proportion was unreasonable. The smaller maximum trunk angle and maximum lead leg knee angle in the flight phase showed the lack of muscle flexibility. In the second support phase, the knee angle at the landing phase was not sufficient.

From the results of the first evaluations some training exercises were prescribed as follows: calculating optimum takeoff point and marking on the ground before the hurdle; doing stretching exercises for the rear thigh muscles; improving flexibility of gluteus maximus and hamstrings with dynamic mobility exercises; developing the ability to split legs which allows a rapid contraction of the muscles of the trailing leg and rapid recovery; increasing the hip and pelvis flexibility so that the trunk can be bent forward toward the legs over the hurdle; developing ankle's explosive strength.

After a period of training the techniques of the athlete have been significantly improved, which was shown in the 2008's data in the Table. Through 2009's training his techniques became more stable and more progress was achieved. However, more efforts still need to be made in order to reduce the support time in future training.

Table 1
Comparison of kinematics variables for Yin Jing (2007, 2008, 2009), Liu Xiang (2005) and the technical model of Wen (2005)

Variables	Date			Liu Xiang	Technical model (Wen, 2003)
	Apr 2007	Jun 2008	May 2009		
Takeoff (first support phase)					
takeoff angle (°)	74.31	63.84	62.43	62.78	less than 70
takeoff angle of CG (°)	17.36	10.07	9.79	9.91	less than 12
horizontal velocity (m/s)	8.96	9.12	9.16	9.30	—
vertical velocity (m/s)	2.80	1.62	1.58	1.62	—
support time (s)	0.13	0.12	0.12	0.10	0.11-0.13
Clearance (flight phase)					
stride length S (m)	3.18	3.66	3.70	3.60	—
distance before hurdle S_1 (m)	1.75	2.34	2.36	2.22	2.1-2.2
distance after hurdle S_2 (m)	1.43	1.32	1.34	1.38	—
S_1/S	55%	64%	64%	62%	60%
maximum trunk angle (°)	38.95	43.87	43.62	40.60	more than 43
maximum lead knee angle	161.56	174.22	174.86	176.55	180
over hurdle time (s)	0.39	0.33	0.34	0.33	0.30-0.33
Landing (second support phase)					
landing angle (°)	78.99	79.35	78.73	78.82	78
knee angle at landing (°)	171.53	175.32	176.87	178.43	180
takeoff angle (°)	74.31	63.84	62.43	60.40	60
trunk angle at takeoff (°)	10.44	10.02	8.65	8.07	10
support time (s)	0.12	0.11	0.11	0.10	0.10

Note: The data of Liu Xiang (the 110-meter hurdles champion of 2004 Athens Olympic Games) was obtained on the final race of 110-metre hurdle of the 10th national games in 2005 (Liu, 2008). The technical model was from The High-grade Tutorial of Track and Field (Wen, 2003)

CONCLUSIONS: In July 11, 2009, Yin won the gold medal of The 25th Universiade with the result of 13.38s. This showed that our long term follow-up study was helpful to the training practice and the improvement of his hurdle techniques. All these demonstrate that biomechanics study on techniques can improve the efficiency of scientific training for coaches and athletes.

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