KINEMATIC ANALYSIS OF JUNIOR WOMEN HURDLING

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The purpose of this study is to provide a kinematic analysis of the hurdling techniques of two junior women hurdlers to ascertain the importance of speed and technique in hurdling. Kinematic performance variables including the horizontal and vertical velocities at takeoff and landing, the clearance distance and the flight time were obtained and analyzed. In order to evaluate the techniques used by the two junior hurdlers, their hurdling performance variables were compared with the published data of Coh et al. (1998) of an elite hurdler. The junior hurdlers had a higher take-off angle (23.5 °) at hurdle clearance compared to the elite hurdler (10 °) The take-off distance (1.62 m) was also closer to the hurdle than the elite hurdler (2.09 m). This may suggest that the junior hurdlers lack horizontal speed and hence adopted a less efficient hurdle clearance technique.

KEY WORDS: junior hurdler, hurdling technique, speed, kinematics

INTRODUCTION: The 100m hurdles event for women is a demanding track event because it requires a high level of complicated coordination of movement sequences (Razumovsky, 2000). McNab (1982) claimed that hurdling is sprinting, emphasizing that the importance of speed running in hurdling. However, McFarlane (1987) added another dimension to hurdling by stating that an athlete can not run faster than the technique will allow. Therefore, an effective technique is just as important for excellence in hurdling. In fact, Letzelter (1992) looked at the relevance of sprinting speed and hurdling technique towards hurdling performance. She came to the conclusion that the hurdling technique plays a larger role particularly at the lower performance levels. However, the number of kinematic studies performed on hurdlers of lower performance levels may be too few to justify such a claim. The purpose of this study is to provide a kinematic analysis of the hurdling techniques of two junior women hurdlers and to ascertain the importance of speed and hurdling technique.
Singapore women's hurdlers used to be a force to be reckoned with in the South East Asia Peninsular (SEAP) Games. But currently, Singapore enjoys no success at regional or international competitions. Although one may attribute numerous reasons to this lack of success, local track and field coaches could use the information of this study to raise the current standard of hurdling in track and field. The use of kinematic analysis has yet to be in the menu of tools used by local track and field coaches. It is hoped that the present study will provide insights to technique differences that will enable coaches to bridge the gap in performance levels as well as convince them of the relevance of kinematic analyses in coaching.

METHODS: The hurdling performances of two junior women hurdlers were video recorded during a training session. Details of the subjects' physical and performance characteristics are summarized in Table 1.
During an earlier training session, the time taken between hurdle clearance touchdowns and the cumulative time of the trial were recorded for both subjects. Their two fastest hurdle-to-hurdle times (hurdle unit) were from the 2nd hurdle touchdown to the 3rd hurdle touchdown (1.43 s and 1.58s) and from the 3rd hurdle touchdown to the 4th hurdle touchdown (1.44s and 1.57s). This agrees with Hay (1993) who found that the athlete's average speed usually reaches a maximum between the 2nd and 3rd hurdles or between the 3rd and 4th hurdles for the women's 100m hurdles. As both subjects used an alternate lead leg 4-step approach between hurdles, it would be more appropriate to analyze two consecutive hurdle clearances to examine the different lead leg clearance technique. Therefore, for this present study the performance variables for the subjects during the hurdle clearance over the 3rd and the 4th hurdles were analyzed.

Table 1 Physical and performance characteristics of the subjects.

Subjects	Height	Weight	Personal Hurdles	Record 100m	Lead Leg Action
Subject 1	1.63m	49kg	19.4s	15.4s	Alternate lead leg with a 4-step pattern, odd hurdles with right lead leg
Subject 2	1.62m	51kg	18.1s	14.8s	Alternate lead leg with a 4-step pattern, odd hurdles with left lead leg

Two Peak Performance Technologies HSC-200 cameras were used to record each hurdle clearance. A total of four cameras were used in this study. The cameras were positioned at the spectators' stands, approximately 5m from the run track and with optical axes of the cameras intersecting at approximately 90 degrees as shown in Figure 1. The field of view of each camera was set to include the entire hurdle clearance from the takeoff (before the hurdle) to the landing (after the hurdle). Each pair of cameras was gen-locked to each other to ensure that they captured the same phase of movement. Calibration was performed using the three-dimensional Space Calibration Frame a product of Peak Performance Technologies. The calibration frame was placed at the positions of the hurdles to be recorded. The set-up of the calibration frame was video recorded by the two cameras at both positions before the video recording of the hurdles trials by the subjects. Once the calibration frame was video recorded, caution was taken to ensure that the location of the cameras remained unchanged throughout the video recording of the hurdling. The subsequent video recording of the hurdle clearances were carried out at 50 fields per second. Synchronization was achieved by means of a manual trigger switch through an Event & Video Control Unit (Peak Technologies Inc). The signal was recorded as a bar code as part of the image.

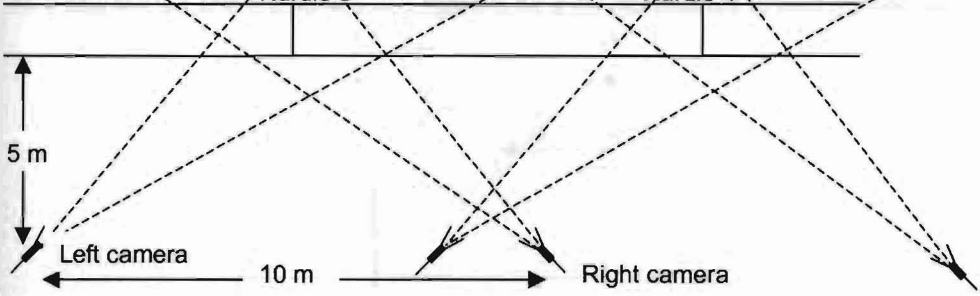

Figure 1 Positions of the cameras relative to the hurdles.

For each subject, a total of three trials were video recorded. However, only the fastest trial of each of the subjects was analyzed. Fifteen body landmarks of each subject and six points on the hurdle were digitized using the Peak Motus motion analysis system (Peak Performance Technologies, Inc., Englewood, Co). With Peak Motus software, the three-dimensional co-ordinates were reconstructed from digitized data and then smoothed using quintic splines. The location of the centre of gravity was also calculated by the Peak Motus software using the reconstructed digitized data and the inertia data as described in Hay (1993).

RESULTS AND DISCUSSION: The performance variables at the take-off phase of hurdle clearance of the two subjects are presented in Table 2. The performance variables of an elite hurdler (Olympic silver medalist, Brigita Bukovec) reported by Coh et al. (1998) are also included in Table 2 for comparison.

Table 2 Performance variables at takeoff, step lengths and hurdle clearance times.

Performance Variables	Subject 1		Subject 2		Brigita
	Right Lead Hurdle 3	Left Lead Hurdle 4	Left Lead Hurdle 3	Right Lead Hurdle 4	Hurdle6
Horizontal velocity (m/s)	5.08	5.23	5.48	4.78	8.66
Vertical velocity (m/s)	2.20	2.29	2.31	2.14	1.58
Takeoff angle (°)	23.4	23.6	22.9	24.1	10.3
Take-off distance (m)	1.76	1.80	1.40	1.52	2.09
% of clearance step length	60.5	63.4	50.7	57.8	67.0
Flight time at clearance (s)	0.50	0.46	0.44	0.44	0.30

It is noted that the two subjects had markedly lower horizontal velocities but higher vertical velocities at take-off. The differences in the distribution of the vertical and horizontal take-off velocities predisposed the two subjects to a much higher take-off angle than the elite hurdler (mean of 23.5° versus 10.3°).

The difference in these performance variables at take-off illustrates the different techniques used in take-off between the subjects (junior women) of this study and the elite hurdler. The implication is that the subjects of this study 'leapt' over the hurdles (with higher take-off angle) while the elite hurdler 'ran' over the hurdles. The subjects of this study were also observed to have approached the take-off at an average distance of 1.62 m (horizontal distance measured from take-off toe to the hurdle). This take-off distance represented a 58 % of the hurdle clearing step. In comparison, the elite hurdler took-off from a further distance of 2.09m (that represented 67% of her hurdle clearing step). This implied that the subjects of this study (junior hurdlers) were too near the hurdle at take-off and hence adopted a higher take-off angle in order to avoid the hurdle. This led to the adoption of a less efficient technique as the trajectory of the mass center takes a longer path or longer time to clear the hurdle. The hurdle clearing time of the subjects were on average 0.46s while the elite hurdler was 0.3s.

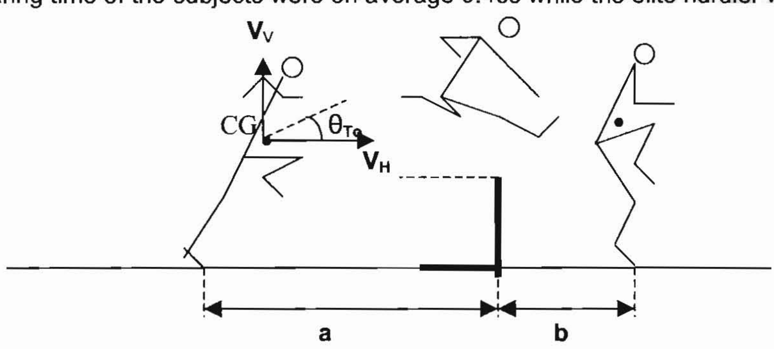

Figure 2 Representation of mass center (CG), take-off vertical velocity (V_V), take-off horizontal velocity (V_H), take-off angle (Θ_T), take-off distance (a) and clearance step length (a+b).

It was also noted that the subjects in this study used a 4-step approach between hurdles. This is contrary to the approach of most elite hurdlers who typically employ a 3-step approach (Letzelter, 1992). This difference in the approaches used would suggest that the current subjects either had smaller step lengths or simply lacked horizontal speed. Hence, they resorted to four steps to cover the distance between the hurdles. However, the use of 4-step approach between hurdles, in turn, predisposed them to a shorter take-off distance from the hurdle and consequently to a higher flight trajectory due to a large take-off angle (23.5°). In short, the 4-step approach 'forced' them to adopt a less than efficient clearance technique (one with a higher take-off angle).

CONCLUSION: Although Letzelter (1992) claimed that technique played a larger role in performance for hurdlers of lower performance level, this study showed that technique used may be constrained by step length and the ability to generate horizontal speed. From this study, it is found that the junior hurdlers used the four step approach between hurdles because they have shorter step length and possibly lack of horizontal speed. This 4-step approach to the hurdles, predispose hurdlers to a short take-off distance and hence 'forced' them to adopt an inefficient technique primarily to avoid the hurdles in clearance. In hurdling, coaches should not overlook the relevance of hurdler's step length as well as sprinting speed.

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