KINEMATIC ALTERATIONS IN WOMEN'S 100M HURDLE TECHNIQUE OVER CURRENT 84CM HURDLE AND PROPOSED 91CM HURDLE HEIGHTS

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Alterations in collegiate women's 100 m hurdling technique were examined over the proposed hurdle height (91.4cm) compared to the current hurdle height (84cm). Four female collegiate hurdlers at Indiana State University were given 4 hurdle practice days over the current height and 8 hurdle practice days at the proposed hurdle height (91cm). The 3rd hurdle clearance was videotaped for each athlete performing 4 trials at race speed over 4 hurdles for each height. The fastest 3 trials at each height were analyzed using an Ariel APAS. The results indicated that the COM was lower at take-off in the higher hurdle height trial, higher at the peak, and closer to the hurdle at the peak height. The higher height hurdles had the athlete in an ideal sprint position at the landing for the higher hurdle height with a smaller reach distance.

KEY WORDS: women's hurdle technique, kinematics, hurdle heights.

INTRODUCTION: In 1932 Olympic Games, the first women's hurdle race was run over 8 hurdles at a total distance of 80 m with a hurdle height of 76.2 cm and a 8m spacing between hurdles (Stein, 2000). In 1969 the women's hurdle race was increased to 10 hurdles over 100m with a height of 84.0 cm with a spacing of 8.5 m between hurdles, which is still the standard in today's races (IAAF, 2002). Currently, women hurdlers exhibit a lower technical difficulty plus a different optimal hurdle clearance technique when compared to the men (Etcheverry, 1993; Salo and Grimshaw, 1998; Stein, 2000). The women's 100 m hurdles have undergone one height increase to boost the technique difficulty and the International Association of Athletics Federation (IAAF) has been debating over a proposed hurdle height change. The proposed height of the hurdle and the distance between the hurdles would be 91.4 cm and 8.8 m (Hoggard, 2001). Studies examining the effect of the height increase are being conducted through out the entire 2002 year, to decide whether to reject the idea or refer the concept of altering the hurdle standard to the IAAF for further consideration (Hoggard, 2001). The main reason for a change being discussed is the differing technical demands of the two races (Men's -110m and Women's -100m). The general goal of the hurdle races is to generate as much speed as possible while negotiating ten hurdles (McFarlane, 2001). However, the fastest women with modest technique on the track are winning the hurdles more often than not, instead of the fastest women with excellent hurdle technique winning. When comparing men and women hurdlers, the best variable to examine the discrepancies is the relative height of the hurdle to the height of the athlete ratio. This allows for a comparison between the heights of men and women with respect to the different hurdle heights. The men's hurdle height is 57-58 % of the average men's hurdlers standing height, whereas the women's hurdle height is only 48-49 % of the average women's hurdlers standing height. The greater proposed hurdle height for women would increase this ratio to 53-54 %, which would be much closer to the men's ratio (Etcheverry, 1993). Raising the hurdle height for women would increase the demand for technique causing their technique to become similar to that of the men's race. The height increase would not eliminate the shorter hurdlers, but it would place an increased emphasis on technique.

The purpose of this study was to evaluate the kinematic changes in women's hurdle technique necessary to clear an increased hurdle height from the present 84 cm to the proposed 91.4 cm height.

METHOD: Four female collegiate hurdlers at Indiana State University aged 19 -21 years and injury free for 3 months volunteered to participate in the study, and informed consent were obtained. The subjects' physical characteristics of height, mass, and leg length were measured after the conditioning period and prior to the first data collection. The subjects' mean height was

166.25 ± 7.63 cm, the mean hurdle height to overall height was 50.6 % at the current height of 84.0 cm and 55.1 % at the proposed height of 94.4 cm, the mean mass was 57.53 ± 6.64 kg and the mean leg length was 88.50 ± 3.87 cm. The subjects' mean personal best performance in the 100 m hurdles was 15.56 ± 1.39 s. The subjects finished a 6 week fall conditioning period, and were then given 2 weeks or 4 hurdle practice days to acquire the timing and feel for the hurdles, before the first data collection. They were then given 4 weeks or 8 hurdle practice days to habituate to the new height and possible technique, before the second data collection. On the practice and collection days the subjects performed their normal team warm-up. The warm-up consisted of an 800 m jog, static stretching of legs, dynamic stretching in the form of sprint form drills and hurdle specific drills. Reflective markers for 16 body data points were affixed to the subjects, 6 hurdle markers, and a fixed reference point were digitized for the video images by an Ariel APAS. The 3rd hurdle clearance was videotaped by 2 JVC 9500 cameras from left front and sagittal views at 60 Hz for each athlete performing 4 trials at race speed over 4 hurdles for each height at the indoor track at Indiana State University. The fastest 3 trials at each height were selected for film analysis. A calibration cube was placed along the movement plane and the data points were scaled to real distances using the 3-D direct linear transformation and the data was smoothed using a 2nd order Butterworth low-pass digital filter with a 6 Hz frequency cut-off. The hurdling movement was delineated into the phases of: preparatory step, take-off, clearance, landing, and recovery step. The position of the hurdlers' COM for the hurdle phases were calculated. Dependent t-tests were performed on selected kinematic variables.

RESULTS AND DISCUSSION: The t-test results for the height of the COM through each hurdle phase for the current and proposed hurdle heights are presented in Table 1.

Table 1 Height of COM through each phase at the current and proposed hurdle heights.

	Current Hurdle	Proposed Hurdle	
Phase	**COM Height cm**	**COM Height cm**	**Ht Difference cm**
Preparation	91.2	88.9	-2.3 *
Takeoff	102.2	99.6	-2.7 *
Clearance	124.8	127.8	3.0 **
Landing	104.3	103.3	-1.0
Recovery	95.6	94.7	-0.8

Note: n = 4, * Indicates Significance at = .05, ** Indicates Significance at = .01

The significance of the height of the COM variable from the preparation step phase through the clearance phase is the way in which the athlete sets up and attacks the hurdle. The athletes had a significantly lower COM value in the preparation step phase 2.3 cm ($p = .029$) and in the takeoff phase 2.7 cm ($p = .031$) when performing at the proposed height of 91.4 cm. The lowering of the COM in these two phases allowed the athlete to generate more vertical lift while trying to maintain speed through the hurdle stride. This lowering of the COM in the preparatory step phase lead to a significantly higher peak COM value in the clearance phase of 3.0 cm ($p = .003$) at the proposed higher hurdle (see Figure 1). There were no significant changes in the athlete's COM height either the landing phase or the recovery step phase. In both phases the proposed height had a slightly lower COM value with a difference of 1.0 cm in the landing phase and 0.8 cm in the recovery step phase. McDonald and Dapena (1991) reported similar COM movement patterns during the hurdling phases.

A t-test on the vertical displacement of the COM above the hurdle revealed that statistically significant differences occurred between the 2 hurdle heights. The subjects had a higher peak COM position for the proposed hurdle height but the vertical clearance of the COM in respect to the hurdle was 4.38cm less for the subjects when they negotiated the proposed higher hurdle than the current hurdle height. This would indicate that the athlete was not as upright but more flattened when clearing the higher hurdle. The peak COM height values were consistent with the findings by Salo and Grimshaw (1998) and the vertical clearance of the COM (36.4 cm) for the proposed hurdle height was halfway between what Salo and Grimshaw reported for the men's hurdle (27 cm) and the women's COM clearance for the current hurdle height (41cm). The closer the COM is maintained to the natural sprinting path, the faster the hurdler will be able to recover during the landing and recovery step phase (McFarlane, 2001)

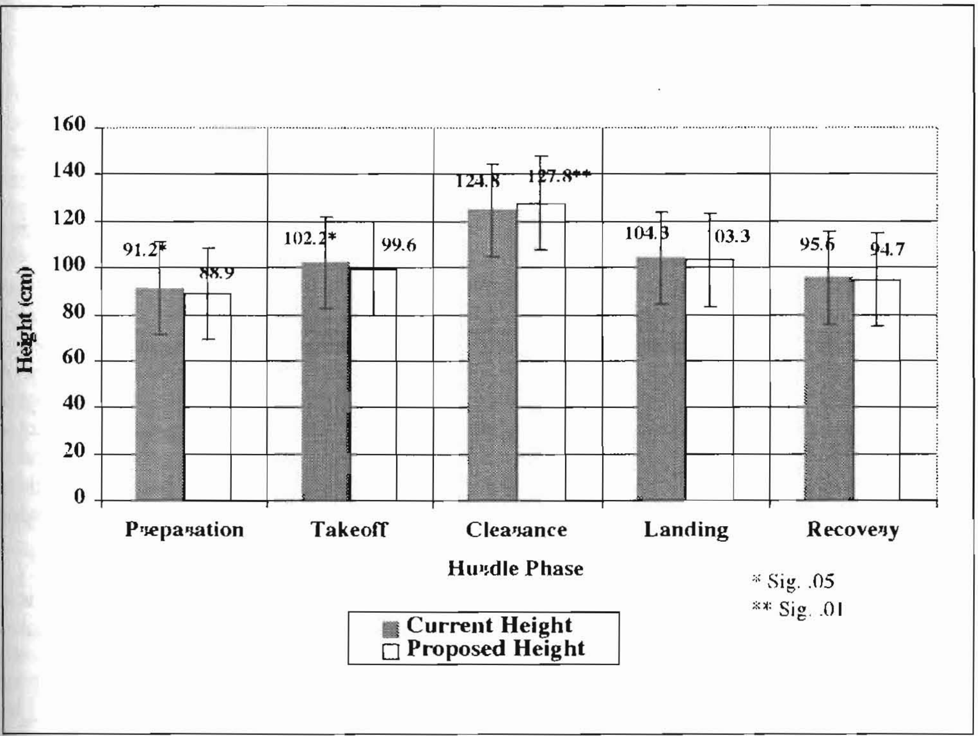

Figure 1: Hurdlers' COM heights during phases over current and proposed height hurdles.

Table 2 Peak displacement of COM above hurdle in the hurdle phase at the current hurdle and proposed hurdle heights.

Variable	Current Hurdle Height	Proposed Hurdle Height
COM Mean Vertical Displacement Above Hurdle cm	40.82 ∀ 5.43	36.44 ∀ 3.67
Height Difference Current – Proposed cm		-4.38

The horizontal displacements from the hurdle for the foot at take-off, landing, and the hurdle stride length for the current and proposed height hurdle are presented in Table 3. Also, the body's COM position in respect to the foot at lean (take-off) and reach (landing) are presented.

Table 3 Horizontal distances at take-off, reach, hurdle stride length, COM position in respect to foot at lean and reach for current and proposed height hurdles.

Variable	Current Hurdle	Proposed Hurdle	Difference
Take-off Distance m	1.89∀.09	1.93∀.16	.04
Landing Distance m	1.03∀.09	1.02∀.10	.01
Hurdle Stride Length m	2.92∀.13	2.96∀.13	.04
COM Lean Position in respect to foot cm	30.24∀7.18	20.92∀5.32	-9.32 **
COM Reach Position in respect to foot cm	-16.38∀7.10	-9.40∀5.60	6.98 **

Note: n=4, * Indicates significance at " = .05, ** Indicates significance at " = .01

The statistical analyses found no differences in the hurdle stride lengths, take-off, and landing displacements between the current and proposed height hurdles. Salo and Grimshaw (1998) reported similar mean values for these variables. This study found the hurdler's COM lean displacement (take-off) was significantly further (9cm) in front of the foot at lean for the current hurdle height. Whereas, the hurdler's COM was closer to their take-off foot while negotiating the higher hurdle height. This was the result of a more pronounced penultimate step at take-off that lowered the COM while maintaining the hurdler's horizontal velocity. The higher hurdle height produced a significantly shorter displacement of the COM in respect to the foot at reach (6.98cm) than the current hurdle height. This resulted in the hurdler's COM being located closer to their foot at landing for the higher hurdle and thus experiencing less breaking action and a faster recovery from the hurdle stride and transition into the sprint phase between hurdles (McFarlane, 2001).

CONCLUSIONS: When hurdling the proposed height hurdle, the female athletes' COM was lower at take-off and higher at clearance. Although the hurdlers' COM peak height was higher when negotiating the proposed hurdle, the vertical displacement of the COM above the hurdle bar at clearance was less for the higher hurdle. This indicated that the hurdlers negotiated the higher hurdle more efficiently with a flattened body position through the clearance phase. No significant differences were found for the hurdle stride lengths, take-off and landing displacements from the two hurdles. This finding would indicate that no adjustments in the between hurdle distances would be necessary for the proposed hurdle height. Therefore, an increased women's hurdle height would require a degree of technical difficulty closer to that of the men's hurdle event and this would also place an increased emphasis on hurdle technique rather than foot speed. Additionally, it was found that the hurdlers' COM was closer to the ball of their foot at lean and reach, which would produce a more efficient hurdling technique that would result in less braking action during the take-off and landing phases and a faster transition to their sprint between hurdles.

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