TECHNICAL CHANGES IN HURDLE CLEARANCES AT THE BEGINNING OF 110 M HURDLE EVENT – A PILOT STUDY

Aki I.T. Salo
Department of Sport and Exercise Science, University of Bath, Bath, United Kingdom

Practically in all hurdle studies, the analysis has been carried out over a single hurdle. The purpose of this study was to investigate individual differences in hurdle clearances at the first 4 hurdles. Two male athletes were videotaped and 3D analysis was carried out. Athlete A showed a more consistent pattern than athlete B in over a range of variables. Athlete A was also able to increase the mean horizontal velocity from hurdle to hurdle. From a coaching point of view the main issues for athlete A are to avoid drifting too close to the first hurdle and to try to take-off more aggressively forward. Subject A's lead leg worked very well before and after the hurdle. Subject B has most problems around the lead leg, i.e. it is not bent enough at the take-off and it is not working effectively at the landing contact.

KEY WORDS: hurdling, 3-dimensional, variability.

INTRODUCTION: Understanding of critical points of athletes' technique can help the coach and athlete in preparation for better performance. Thus, there is interest to biomechanically analyse different sport events. This is also the case for sprint hurdles which has attracted several 2-dimensional and 3-dimensional analysis over the years. Practically in all studies, the analysis has been carried out over only one hurdle. Further, there has been a large variation in the hurdle selected for investigation - e.g. 1st hurdle by Schlüter (1981), 4th or 5th hurdle by McDonald and Dapena (1991), and 9th hurdle by Mann and Herman (1985). Consequently, there is lack of information on how hurdle clearances develop over different hurdles within the athlete's own performance. Thus, the purpose of this pilot study was to investigate individual differences in hurdle clearances at the beginning of the 110 m hurdle event.

METHODS: Two male sprint hurdlers were videotaped at the start of the indoor season in a normal training situation. The height of subjects was 1.88 m and 1.71 m and both had run 110 m hurdles under 13.85 s during the 2001 outdoor season. Videotaping was carried out with two Sony DCR-TRV900E digital video camera recorders operating at 50 fields per second. Four different hurdle clearances (one clearance from each of the first four hurdles of the race - H1, H2, H3 and H4, respectively) were videotaped for each subject. The normal competition hurdle height (1.067 m) and hurdle distances (9.14 m) were set. Camera views were restricted to 3.7 m before the hurdle and 3.0 m after the hurdle, with the midpoint 0.35 m before the hurdle at the middle of the running lane. Two video camera recorders were located symmetrically sideways at 45° to the line of running at a distance of 25.3 m from the midpoint for the first hurdle. The respective distance on the other hurdles was 22.1 m. This difference between the set ups was due to restrictions in the indoor facility used for this study. Only two video camera recorders were used for measurement. Consequently, this meant that hurdle 1 was videotaped first, then camera recorders were re-located for hurdle 2 etc. Iris was set at F2 and the shutter speed was 1/625 s for both camera recorders. A standard Peak Performance™ 25 point calibration frame was located at the above mentioned midpoint and videotaped for each hurdle. Additionally, a Laveg LDM 300-C Sport speed gun (Jenoptik Laser, Optik, Systeme GmbH) was located 23.05 m behind the starting line and was manually aimed at the lower back of the subjects during their runs. Subjects performed a series of trials after their own normal warm-up procedure. All trials were manually digitised on Peak Motus™. Digitising started 4 video fields before the start of the take-off contact and finished 4 video fields after the landing contact. Synchronisation of the digitised views was carried out to one millisecond by determining the offset between asynchronous camera recorders using a specific LED light procedure described in Kerwin and Trewartha (2001). Quintic spline processing was carried out for smoothing purposes of the raw data. Selected variables in line with previous hurdle studies (e.g. Salo et al., 1997B) were subsequently analysed.

RESULTS: The mean horizontal velocity over the hurdle ranged from 7.6 m/s to 8.2 m/s for subject A (table 1). The respective range for subject B was from 7.5 m/s to 7.8 m/s.

Table 1. Centre of mass (CM) mean horizontal velocities over the hurdle, take-off and landing distances, total hurdle clearance stride lengths and hurdle clearance times for the subjects on different hurdles.

	CM mean horizontal vel.	Take-off Distance	Landing Distance	Total stride length	Hurdle clearance time
	[m/s]	[m]	[m]	[m]	[s]
A_H1	7.6	2.12	1.15	3.26	0.34
A_H2	8.0	2.38	1.17	3.55	0.34
A_H3	8.1	2.48	1.19	3.67	0.36
A_H4	8.2	2.40	1.20	3.60	0.36
B_H1	7.5	1.98	1.77	3.75	0.42
B_H2	7.7	1.92	1.88	3.80	0.42
B_H3	7.5	2.01	1.85	3.86	0.42
B_H4	7.8	2.00	1.80	3.80	0.42

The vertical velocity of CM at take-off stayed lower in the first two hurdles for both subjects than for hurdles 3 and 4 (Figure 1A). The maximum value was 2.4 m/s for both subjects on hurdle 3. The highest point of the centre of mass above the hurdle varied without any clear pattern from 0.27 m to 0.31 m and 0.25 m to 0.29 m for subjects A and B, respectively (Figure 1B).

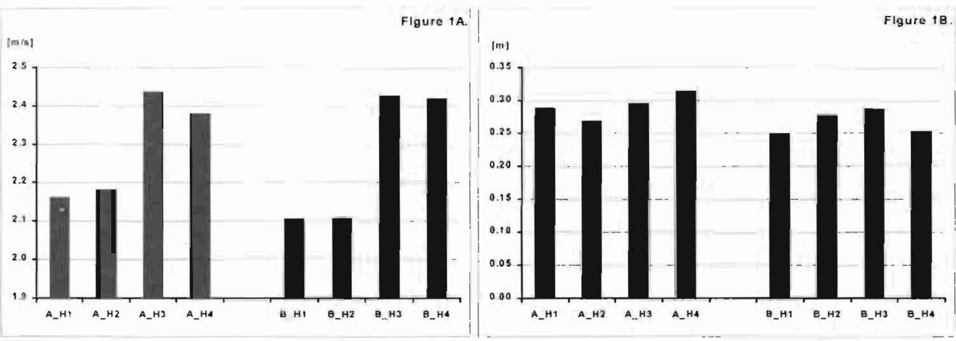

Figure 1. Vertical velocities of the CM at the moment of take-off (1A) and the maximum heights of the CM above the hurdle during the clearance (1B) for both subjects in different hurdles.

Figure 2A shows the minimum angle of the lead leg knee during the take-off contact. Subject A had lower value in each hurdle clearance (range 31-38°) than subject B (range 41-61°). Figure 2B presents the values for the angular velocity of the leading leg hip angle at the moment of landing. Subject A gained higher values in each run (range 816-913 °/s) than subject B (range 340-658 °/s).

DISCUSSION: It is noted that the analysed hurdles are from different runs. Thus, it is possible that subjects could have performed differently on different clearances on separate runs. However, it was not possible to obtain 8 camera recorders to carry out the analysis from each hurdle at the same run. Further, speed data from Laveg radar gun provides evidence of similar speed propagation over the different runs. Mean horizontal velocities for centre of mass showed that subject A was able to increase his running velocity from hurdle to hurdle.

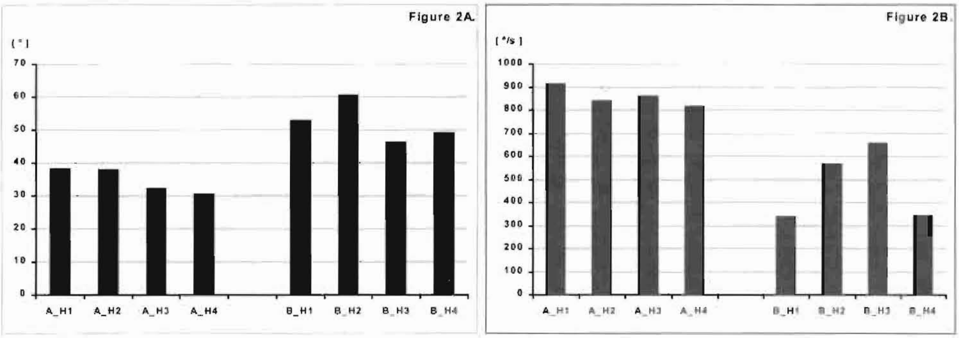

Figure 2. Minimun knee angles of the lead leg knee (2A) and the angular velocities of lead leg hip angle at the moment of landing (2B) for both subjects in different hurdles.

It is clear that it is not possible to reach a high velocity phase by the first hurdle, thus the respective value is clearly lower than on other hurdles. Subject B had a similar pattern of horizontal velocities except for hurdle 3. Speed gun data showed that the subject could not utilise the steps effectively between the hurdles in this run. The take-off distance showed that subject A took off very close to the first hurdle causing an exceptionally short hurdle clearance stride in comparison to the other hurdles. Although part of this is due to lower horizontal velocity at this hurdle (with lower horizontal velocity you have to take-off closer to the hurdle to make the clearance), it is concluded that this take-off is too close to the hurdle hampering the subject's efforts to attack the hurdle horizontally and to maintain horizontal speed. This is a common problem for taller hurdlers who take eight steps to the first hurdle. The set approach distance of 13.72 m for the first hurdle gives a dilemma for athletes who are drifting too close to the hurdle. Two possible solutions are either to change to seven step approach or to move the starting blocks backwards. The former means that the front leg in the starting blocks needs to be changed and this may not be possible due to long term learning and co-ordination of having blocks the other way around. The latter means that at the starting signal the athlete is already behind the others by 0.20-0.30 m, which is psychologically difficult to overcome especially when top level athletes regularly comment that it is important to be first on the first hurdle in order to dictate the race. Subject B had more consistent patterns on take-off and landing distances and hurdle clearances. However, the range of horizontal mean velocity of the centre of mass was smaller than for subject A. Although subject A was taller than subject B, subject A could not utilise this advantage fully. The vertical velocities of CM at the take-off were similar between the subjects (or even slightly higher for subject A). As subject A's initial take-off position is higher due to height advantage, this meant that the highest point of the centre of mass was higher above the hurdle than for subject B (figure 1B). There is no obvious reason for this and these two figures emphasise that subject A gets himself to an 'up & down' pattern over the hurdles as already commented in relation to the take-off distance on the hurdle 1. All the unnecessary effort in the vertical direction detracts from the horizontal movement, which is the main point of any running related competition. The vertical velocity values in this study were higher than in McDonald and Dapena (1991) or in Salo et al. (1997A). Horizontal velocity values showed that these subjects performed about the same level as Salo et al. (1997A) athletes, whilst the McDonald and Dapena (1991) subject group performed at a higher level (mean horizontal velocity value was 8.57 m/s) than these two subjects. The minimum knee angle of the lead leg during the take-off contact is an important variable in the context that the smaller the knee angle the quicker the lead leg can be swung forward. Subject A showed very good values in this variable (all trials $\leq 38°$). Also, the knee is bent more when the velocity increases. It is impossible to determine the causal relationship between these two variables in this study. However, when running velocity increases generally all actions happen quicker. The determination, whether the more bent lead leg knee is a conscious technical change by the athlete or whether it is subconscious alteration for the increased velocity, requires more analysis. Subject B's lead leg during the take-off contact was straighter than subject A's (minimum knee angle was between 41° and 61°). Qualitative analysis of hurdling shows often that smaller athletes have a straighter lead leg during the last contact phase. It may be that the smaller athletes use this to increase vertical momentum to gain enough vertical velocity to clear the hurdle. This, however, requires further analysis with various subject groups of different heights. One important factor in the hurdle race is to run well off the hurdle. Athletes in sprint hurdles have only three steps between the hurdles to accelerate after their velocity has decreased over the hurdle. One indicator for this is the action of the lead leg at landing. The angular velocity of the lead leg hip describes how well the lead leg is coming down to the ground after the hurdle. Subject A had angular velocity values between 816 °/s and 913 °/s, thus showing a consistent pattern. Subject B, on the other hand, had clear difficulties, as variability between the runs was large (340-658 °/s) and the absolute values were noticeably lower than for subject A. This very active lead leg allowed subject A to get into a good landing position and run off the hurdle well. This was also evident from the fact that the subject was able to increase the horizontal velocity from hurdle to hurdle. From a coaching point of view the main issues for subject A are to avoid drifting too close to the first hurdle and to try to take-off more aggressively forward. Lead leg worked very well before and after the hurdle. Subject B has most problems around the lead leg, i.e. it is not bent enough at the take-off contact and it is not working effectively at the landing contact. This study has shown that some variables were consistent from hurdle to hurdle whilst there were large variations without any clear pattern in other variables. It was also evident that some variables were velocity dependent. This was interesting as hurdle literature has concentrated on comparisons between studies in absolute technical terms and debated whether the clearances should be analysed at the start, maximum running (hurdling) phase or at the end of the race. Perhaps, this discussion and the associated comparisons should be made in line with the horizontal velocities. Luhtanen and Komi (1978) showed how the step characteristics in flat running are velocity dependant. The same may also be the case for clearance characteristics in hurdles.

REFERENCES:

Kerwin, D.G., & Trewartha, G. (2001). Strategies for maintaining a handstand in the anterior-posterior direction. *Medicine and Science in Sports and Exercise*, **33**, 1182-1188.

Luhtanen, P., & Komi, P.V. (1978). Mechanical factors influencing running speed. In: Asmussen, E., & Jørgensen, K. (eds.). *Biomechanics IV-B, Proceedings of the Sixth International Congress of Biomechanics*, 23-29. Baltimore: University Park Press.

Mann, R., & Herman, J. (1985). Kinematic analysis of Olympic hurdle performance: Women's 100 meters. *International Journal of Sport Biomechanics*, **1**, 163-173

McDonald, G., & Dapena, J. (1991). Linear kinematics of the men's 110-m and women's 100-m hurdles races. *Medicine and Science in Sports and Exercise*, **23**, 1382-1391.

Salo, A., Grimshaw, P.N., & Marar, L. (1997A). 3-D biomechanical analysis of sprint hurdles at different competitive level. *Medicine and Science in Sports and Exercise,* **29**, 383-389.

Salo, A., Grimshaw, P.N., & Viitasalo, J.T. (1997B). Reliability of variables in the kinematic analysis of sprint hurdles. *Medicine and Science in Sports and Exercise,* **29**, 231-237.

Schlüter, W. (1981). Kinematische Merkmale der 110-m-Hürdentechnik. *Leistungssport,* **11**, 118-127.