THE USE OF MOTION ANALYSIS AS A COACHING AID TO IMPROVE THE INDIVIDUAL TECHNIQUE IN SPRINT HURDLES

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Biomechanical data are oflen presented as a group average, which may not always help individual athletes to improve their own performance. The purpose of this study was to analyse techniques in sprint hurdles within the athlete and find critical individual aspects, which influence performance. The hurdle clearance of three athletes (eight trials each) were videotaped with four video camera recorders and analysed three-dimensionally. There were several statistically significant correlations between the critical overall horizontal velocity and other variables, especially for one athlete. Such trends in individual performance presented ideas to coaches, athletes and also to researchers, regarding what happened in less successful runs and which technical points were worth individual attention in training.

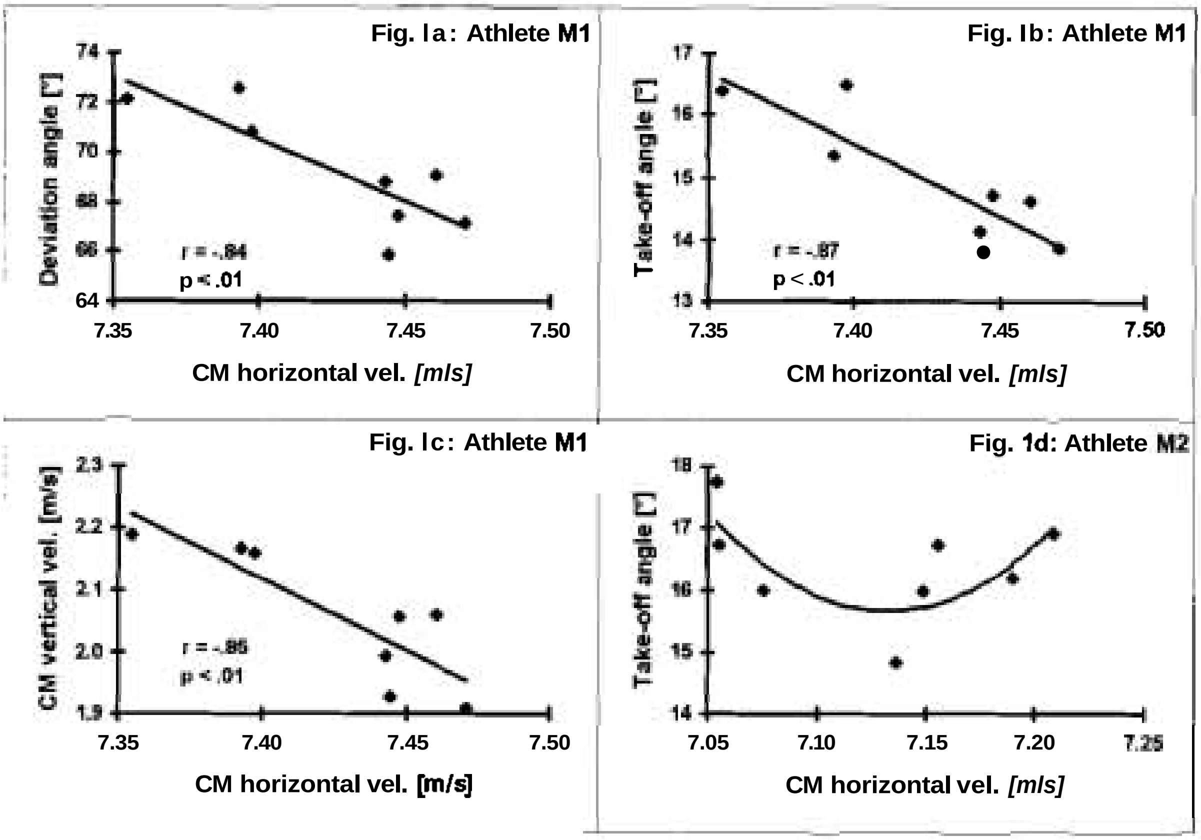
KEY WORDS: biomechanics, kinematics, three-dimensional, video, performance

INTRODUCTION: The biomechanical analysis of different events can help to understand the critical points of the technical performance, thus helping coaches and athletes in their preparation. One event with a very high technical demand is sprint hurdles. There are several studies about hurdle clearances in the biomechanical literature both in the training and competition situations. Important factors influencing the hurdle performance are e.g. overall horizontal velocity, vertical velocity at the take-off and the shape of the centre of mass (CM) path (Mann and Herman, 1985; McDonald and Dapena, 1991; Salo et al., 1997). These studies, however, contain mainly data at the average group level and/or include one trial per subject, as do most of the biomechanical studies about sport techniques. The presentation of average results clearly reveals general trends and highlights some fundamental principles within the sport. However, as each athlete's style may differ greatly from the average performance, such results may not always assist in improving individual techniques. In addition, with average performance, the end result is also average.
Thus, the purpose of this study was to analyse individual techniques within athletes and bring a scientific service closer to coaches and athletes by finding critical individual components which influence performance.

METHODS: A typical training session of Finnish National level athletes in sprint hurdles was videotaped in an indoor hall approximately two weeks before the outdoor competition season. One female (F) and two male athletes (M1 and M2) volunteered as subjects and signed an informed consent form before videotaping, giving permission to use their data for research purposes. The female athlete was 20 years old (1.70 m and 65 kg) with a personal best of 14.08 s. The respective information for the male athletes was 23 years, 1.81 m, 80 kg and 14.68 s for M1 and 23 years, 1.69 m, 67 kg and 14.83 s for M2.
The training procedure followed the typical sprint hurdles training pattern. Each athlete performed a total of eight trials (2 sets of 4 trials) over the four hurdles from their own start using starting blocks. Recovery times were approximately 4 and 15 minutes between the trials and the sets, respectively. The hurdle heights and intervals were the same as in the normal competition, i.e. hurdle heights 0.840 m and 1.067 m and hurdle intervals 8.50 m and 9.14 m for the female athlete and the male athletes, respectively.
Four video camera recorders were located symmetrically around and 29.0 m away from the midpoint of the third hurdle, from which the hurdle clearances were analysed. The cameras and lenses used for this study were as follows: cameras in the front side of the hurdle, JVC GY-X2 (with Canon macro TV zoom lens (13x7.5) f: 1:1.4 17.5-97.5 mm); and cameras to

the rear side, JVC GY-X1 (with JVC HZ-714 zoom lens (14x7) f: 1:1.4 / 7-98 mm). The cameras were genlocked by an external black burst synchronisation from the Sony SEG-2000P pulse generator. The cameras, which were set at a height of 1.48 m above the floor, operated at the rate of 25 frames per second. This enabled the analysis to be carried out with a sampling rate of 50 fields per second. The shutter speed was set to 11500 s, lens iris was 1.4 and the gain of 9 dB and 6 dB for the camera pairs in the front and rear, respectively, was used to compensate for indoor lighting conditions.
The camera views were strictly restricted to the third hurdle clearance (3.7 m before the hurdle and 3.0 m after the hurdle for the female athlete). Additionally, a Peak Performance Technologies Inc. 24-point calibration frame was located 0.50 metres before the hurdle. For the actual calibration purpose, 16 balls (inner and outer) out of 24 were used. After the female athlete had performed the whole session the camera views were expanded by 0.3 m in both directions (before and after the hurdle). This was due to male athletes generally having longer clearance strides than female athletes (e.g. McDonald and Dapena, 1991; Mero and Luhtanen, 1986). The calibration procedure was repeated accordingly.
One operator digitised all camera views of each trial from each athlete (i.e. 3 athletes, 8 trials and 4 camera views). T his was carried out utilising the Ariel Performance Analysis System version 6.91, using a 14-segment body construction model. Additionally, the comers of hurdle frame were digitised giving the reference of the hurdle position. The digitising cursor was moved on the 17" screen with the pixel matrix of 640 x 480. Consequently, calibration and digitisation information was reconstructed using Direct Linear Transformation (Abdel-Aziz and Karara, 1971).
Three-dimensional co-ordinates of each data set were smoothed using a quintic spline algorithm with the error factors obtained by the software. Randomly selected digitised fields in each camera view were re-digitised and the system automatically calculated smoothing factors in x-, y- and z-directions based on the differences between the two digitisations. This was carried out on one trial of each subject and accordingly the other trials of the same subject were smoothed using these values. A total of 28 kinematic variables (including linear and angular displacement and velocity and timing variables) were analysed. Data values for the variables were collected using the Excel macros and further calculation were carried out using Excel 5.0 software. Pearson Product Moment correlation was used for the statistical analysis within the athletes (SPSS 7.5.1 package for Windows).

RESULTS AND DISCUSSION: In the most simplified form, the only thing which matters in sprint and sprint hurdle events is how quickly athletes can get their centre of mass from the start to finish line. Thus, the horizontal velocity of an athlete is the crucial variable for performance, as also suggested by Mann and Herman (1985). Therefore, the main results in this study concentrates on the relationship between the CM horizontal velocity and other variables.
The overall horizontal velocity revealed a statistically significant correlation between two, five and two variables for the F, M1 and M2 athletes, respectively. Naturally, one of the limiting factors in this study has been that data contains only eight trials per athlete, which makes it difficult to achieve statistical significance. Despite this, there were very clear relationships between the CM horizontal velocity and several variables on the athlete M1 as can be seen in Figures 1a-c. All three figures are from the take-off phase representing the deviation angle (angle of the imaginary line from the CM to the toe in contact against the track), take-off angle (the angle of CM movement against the horizontal plane) and CM vertical velocity at the moment of take-off. These figures clearly show that for this athlete it is very important to lean forward, approach the hurdle at a flatter take-off angle with a low vertical velocity. Similar conclusions have been done with group level results (Mann and Herman, 1985; Salo et al., 1997), thus this is not a particularly new finding. However, such strong trends within one athlete and graphical presentation of data are a very clear indicator to coaches and athletes.



Figures Ia-d - Selected variables against centre of mass (CM) horizontal velocity on athletes M1 and M2.

The same take-off angle variable as mentioned for athlete M1 revealed very different results for the other male athlete (M2 in Figure Id). The relationship between the take-off angle and CM horizontal velocity is parabolic. This seems unusual, as the lowest take-off angle does not occur at the highest velocity. The possible explanation for this could be related to athlete's height (1.69 m). At intermediate running velocities, the athlete is quite comfortable on his approach to the hurdle (lowest take-off angle). However, this athlete has a tendency to come closer to the hurdle for the take-off as the velocity increases. Thus, he needs to raise the CM from the lower position over the hurdle in a shorter distance than would taller athletes. This consequently requires more vertical lift resulting in increased take-off angle. With the lower CM horizontal velocities, the athlete also requires more lift, as the take-off distance is longer. The CM parabola across the hurdle needs more emphasis, as the initial position of the athlete's CM is lower than it is for taller athletes. Otherwise the CM parabola would not take him over the hurdle. Although higher vertical lift was linked with the higher horizontal velocity, this cannot be recommended, as vertical lift wastes energy. Thus, for this athlete, it would be important to control the steps between the hurdles even when the running velocity increases. This would enable the athlete to have a better take-off distance, which would consequently allow a flatter take-off angle. Hence, the athlete could produce more horizontal velocity, which would make him even faster.

CONCLUSIONS: The main aim of this study was not to find statistically significant results, but to study individual athletes and find trends in their performance. As several trials per athlete were analysed, the results have produced ideas for coaches, athletes and researchers, as to how runs differ from each other. Additionally, information has been obtained, about what has happened in less successful runs and which technical points are worth concentration in a training situation. Further advantages would be achieved if such an analysis could be carried out on a regular basis, which would enable the potential changes in individual techniques to be carefully monitored.

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