KINEMATIC ANALYSIS OF 100M HURDLE RACE IN FIRE SPORT

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Fire sport is a discipline based on maximal movement velocity and optimal muscle-nerve co-ordination during the implementation of supporting movement activity. One of the most attractive disciplines is the 100m running event with various hurdles. The conclusive moment for passing a beam-hurdle is the way of starting towards the board. For analysis of this activity we used four video cameras and photocells to measure time parameters. According to efficiency we divided the monitored file (n=22, average age 24.37 years) into three groups. There is a trend, in order to maintain the velocity in the group of the best runners during the start, towards getting over the hurdle by executing the take off from the board is managed from a more forward position. In subjects with lowest efficiency there is a lowering of the ankle position during the runner's contact with a rising board manifested via the braking rate.

KEY WORDS: fire sport, kinematic analysis, start towards the hurdle.

INTRODUCTION: Fire sport is a specific sport event characterised by close relation between high championship status and the professional duty of an integrated rescue system. Fire sport has a short history in comparison to other sport disciplines, which has thus far lasted for about 40 years. In 1966, this sport earned its entry into the international competition programme through the auspices of the CTIF Committee. The fire sport disciplines contain various movement skills that the firefighters have to manage as a part of their job – passing all sorts of hurdles, working at high and several levels of team co-operation. Since 2001, women have also entered the fire sport competitions of CTIF. Championships and competitions are super effort shows at the highest sport level.

One of the disciplines is the 100m hurdle race, which we can regard as a technical-sprinter discipline analogous to other hurdle races. The sports effort is determined mainly by high velocity and strength ability as well as the short runs, it is very demanding on muscle-nerve co-ordination (Millerova et al., 2001). The final time is concerned with starting reaction, acceleration and the adopted hurdle race technique (Coh, 2002).

For this hurdle race there is a 2 m wide and 2 m high barrier at a distance of 23 m from the starting block. Each runner places 2 x C-52 water hoses (2.5 kg, 20 m) at a 5 m distance behind the barrier. Ten meters further to the water hoses begins the second fixed hurdle start up board – beam. The start-up boards on each beam are 25 cm wide and 2 m long. A typical beam comprising 3 supports is 1.2 m high, 8 m long and 18 cm wide. In the start-up phase towards the beam, the subject of this study, we differentiate between the take off phase in the direction of the hurdle, contact with start-up board in the immediate following period, take off from the start-up board period, the flight period (this period is replaced by a step in some runners) and the contact beam period.

The manner of overcoming the second hurdle depends upon, besides running velocity, the minimisation of velocity loss through contact with start up-board. The athlete has to overcome a demanding load through foot contact, maintain high velocity and simultaneously direct his or her angular momentum vector in the required direction (Perttunen et al., 2000, Costa & McNitt-Gray, 1999, Seyfarth, Blickhan, & Val Leeuwen, 2000). The size of the ground reaction force through foot contact greatly exceeds the walking load in athletic jumping disciplines. Maximal values are more than 14 times higher than the gravitational force value (Perttunen et al., 2000, Ramey & Williams, 1985).

For the decelerating phase the completion of high knee extensor muscle activity and plantar flexor muscle activity is necessary. Solutions to this situation are connected with and increase in the demands on CNS. Muscle activity is differs in the way of support of foot contact (Hay, 1999). Eccentric and concentric contraction combinations have a positive

impact on the follow up take off performance. Concurrently, the role played by stretch shortening cycle concerned in the muscle activity of the mm. vasti and m. triceps surae does not contribute significantly to the enhancement of vertical velocity (Hay, 1999). Stored elastic energy utilisation increases muscle activity efficiency, the impact of which on the high jump is not so noticeable (Anderson & Pandy, 1993). The optimal drop high before successive take off is 0.20-0.40 m (Bobbert, Hujing & Van Ingen Schenau, 1987).
The aim of this study is to provide a kinematic analysis of lower limb movements involved at the start of overcoming a hurdle in the 100m hurdle race in fire sport and to compare the manner in which runners approach the hurdle at various levels of efficiency.

METHODS:
Characterization of the Subjects: Twenty-two subjects were examined (mean age of 24.37 years, mean weight of 79.60 kg, mean height of 183.66 cm). According to personal records we divided subjects into three groups (performance level): A – 17.50 s, B – 18,20 s, C – 20,50 s). Among runners in group A were also included members of the Czech Republic's representation contingent.

Instrumentation: We used 4 video cameras to record the start towards the beam. Using photocells we ascertained time values to determine movement velocity before and after the start towards the hurdle. Figure 1 shows the location of cameras and the photocells' setting.

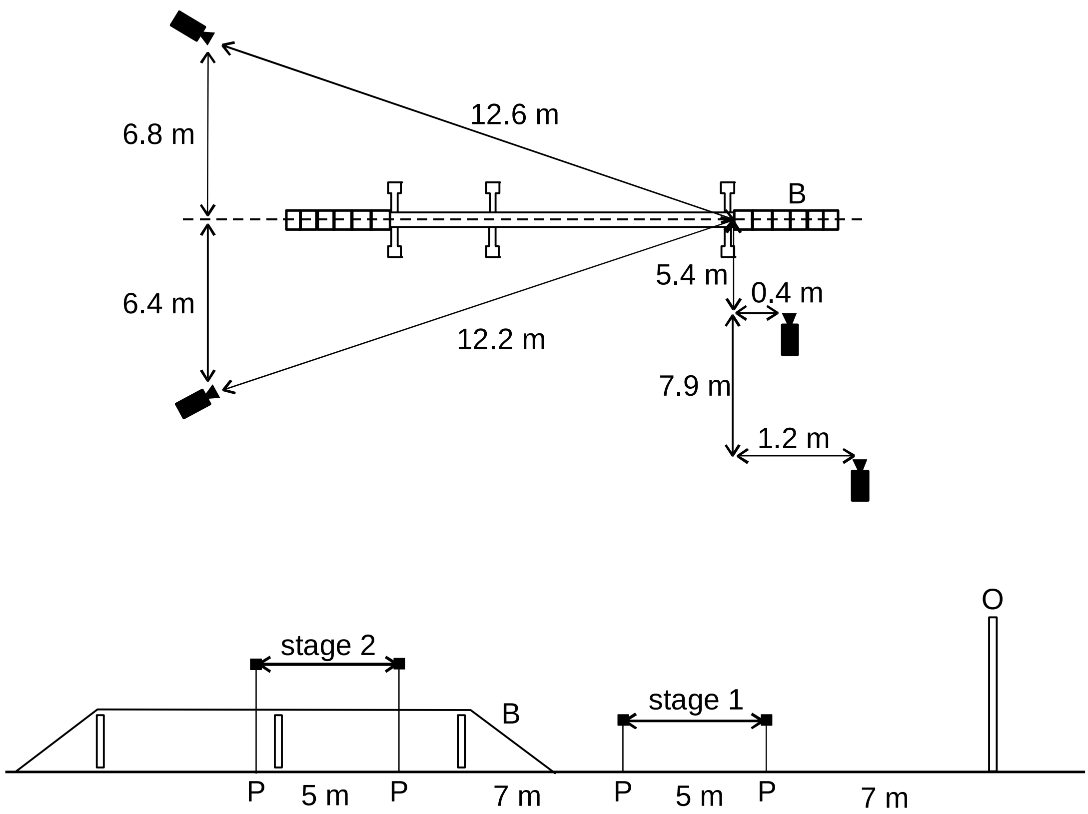

Figure 1: Video cameras' location and photocells' setting while data recording (B – beam, O – obstacle, P – photocell)

Each data recording was preceded by 2-3 trials following individual warm-up and trial attempts at overcoming the obstacles. For the needs of this study, runners first successfully passed through a 50m obstacle course (two trials with the equipment and accessories commonly used in races) where they had to pass in accordance with the rules two fixed hurdles. In between both experiments, there was a sufficient rest period determined on the basis of individual demands for adequate adaptation.
On the human body we marked eleven selected points. For the needs of this study we assessed (APAS) in three successive steps – the last step before the take off towards the

board, the take off towards the board and the take off step from the board. For comparison of the three performance levels we used basic angular and metric parameters on the lower limbs, the velocity value and their changes in the monitored sector. For statistical data analysis we used Statistica 6.0 (ANOVA with repeated measures, Fisher's LSD).

RESULTS: In the measured data assessments, we compared six files (two trials at three various performance levels). We did not note statistically significant differences ($p<0.05$) between performance at various trials in groups of similar efficiency level.
Movement velocity determined by photocells is the highest in group A in both monitored sections, while being minimal for group C. The difference between group A and B increases following the start towards the beam. Differences before the starting phase are due to the absolute running velocity, but also relate to other performance skill techniques – water hose collection, and passing over barriers. Differences between runners of various performance levels in the second section are attributable to the manner of start towards the beam. Only in the best runners did we find change in growth velocity between both monitored sections. For the two remaining groups this parameter decreases (table 1). Step length is minimal for group C before the start towards the beam and after passing over the board.

Table 1: Velocity values ($m.s^{-1}$) and velocity difference development during the performance of the start towards the beam

	Stage 1			Stage 2 – Stage 1		
Group	**Mean**	**SD**		**Mean**	**SD**	
A1	6.11	0.14	A1-C1*	0.019	0.14	DNS
A2	6.17	0.14	A1-C2**	0.039	0.14	
B1	5.90	0.13	A2-C1*	-0.204	0.13	
B2	5.92	0.13	A2-C2**	-0.155	0.14	
C1	5.55	0.18		-0.289	0.17	
C2	5.49	0.18		-0.275	0.18	

Legend
A, B, C – performance levels, 1, 2 – trials, *p<0.05, **p<0.01

There are considerable inter-individual differences between runners of the same performance level in the take off phase. We did not find significant differences between groups with various efficiencies. During contact with the board, there is a false ankle engagement in group C. This is apparent in insufficient braking to stop the movement and the subsequent need of heel participation in take off. The best group of runners performs the transfer by loading via the ankle joint with minimum decrease. This is followed by take off towards the beam, which is managed more to the front with lower shin angle and a smaller angle in the knee joint of both the take off and the swing limb phases. Movement is characterised by smaller centre of gravity enhancement and minimisation of velocity loss.

CONCLUSION: Runners with the best efficiency reach towards greater velocity even before the start towards the beam. Differences are further pronounced after contact with the board following the start towards the board and start in the direction of the beam. The take off following the start towards the board is managed in a more forward position by this group. In less efficient sports persons, there is complete change in treading and movement deceleration upon contact following start towards the board.

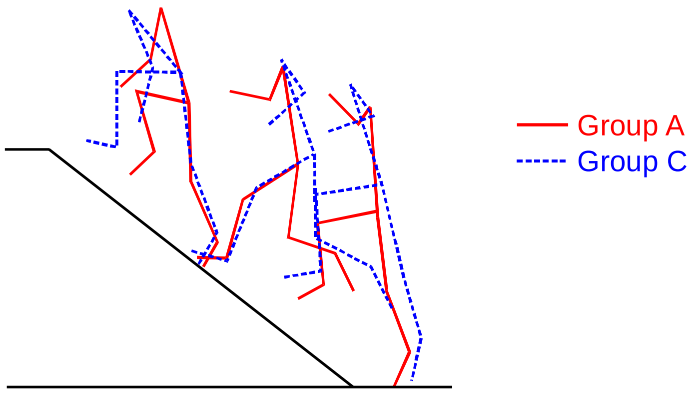

Figure 2: Graphic comparison of start towards a hurdle at various levels of efficiency by runners

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