EFFECT OF CURVE AND SLOPE ON INDOOR TRACK SPRINTING

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INTRODUCTION: In 200 meter indoor sprinting it is generally accepted that the lane assigned to the athlete and the construction of the track can determine performance and results in a significant way. While running on a curve, the contact foot is subject to high centripetal forces. The centripetal forces are determined by the body mass (m), the squared running velocity (v) of the athlete, as well as by the Radius (R) of the curve: $Fc=(m*v^2)/R$. This results in a smaller reduction of running velocity for the athletes sprinting in the outer lanes. Even on a standard 400 meter track, time differences up to 0.4 s were noticed between the inner and outer lanes (Jain, 1980; Alexandrov, & Lucht, 1981; Greene, 1985). This is a substantial handicap in an event that often is decided with differences in the order of 0.01 seconds. The problem even emerges dramatically in the sharp curves of a 200 m indoor track. Therefore the curves of these indoor tracks are normally constructed by means of lateral slopes to reduce the centripetal forces acting on the contact foot of the sprinter. This slope enables the athlete to reach rather normal sprint velocities in the sharp curves. The more the athlete's body- and foot position remains perpendicular to the running surface, the less he will have to cope with lateral forces. A secondary effect of the slope is that it implies uphill and downhill running when entering or leaving the curve respectively. This latter effect gradually increases from the inner to the outer lane when the inclination axis lies on the inner line of the track. This creates a new problem regarding the equal chances of the different sprinters in competition.

It was the aim of this study to analyze the differences in time, stride length and stride rate among 200 meter sprint performances in lane 2, 4 and 6 on the 'Flanders Expo Track' that will host the European Indoor Championships in the year 2000. This track consists of a unique construction, as the inclination axis of the lateral slope is situated in the middle of lane 2. This specific construction implies reduced uphill running in lanes 3 to 6 when entering the curve, but at the same time this includes downhill running in lane 1. When leaving the curve it is just the opposite. Only the athlete in lane 2 runs a 200 meter flat course.

METHODS AND PROCEDURES: Five national level male sprinters performed a 120 m all-out sprint from starting blocks in lanes 2, 4 and 6 of the Flanders Expo Track. A comparable group of six sprinters performed a 120 m sprint, running full speed through the second curve of the 200 m track in lane 2, 4 and 6. The order of running the different lanes was randomized. Over the 200 meter distance 15 different intervals were distinguished by taking into account the gradual changes in the radius of the curve and the changes in the slope of the track (Table 1)

Table 1: Slope and curve characteristics of 15 different intervals

	curve 1			curve 2	
interval	**curve - straight**	**slope - flat**	**interval**	**curve - straight**	**slope - flat**
1	large radius (R)	uphill (U)	1	straight line	flat
2	decreasing R	steep U	2	large radius (R)	uphill (U)
3	smallest R	flat	3	decreasing R	steep U
4	smallest R	flat	4	smallest R	flat
5	increasing R	steep D	5	smallest R	flat
6	large radius	downhill (D)	6	increasing R	steep (D)
7	straight line	flat	7	large radius	downhill
8	= see interval 1 of curve 2		8	straight line	flat

Infrared sensors and an electronic timing system by *Intersoft Electronics* enabled the recording of the mean running speed (V) in each of the 15 intervals (Table 1).
Surface electrodes were used to record the muscle activity of three thigh muscles: m. rectus femoris, m. vastus medialis, m. vastus lateralis. During the sprint the EMG-recordings were stored on a portable computer in a backpack. The extra weight the subject had to carry was 1.8 kg. The EMG-data were used to determine the duration of each stride cycle and to calculate mean stride rate (SR) per interval. Intra- and inter-observer reliability for the determination of the stride cycle duration was r=0.98, determined on the basis of 245 analyses. The average stride length (SL) per 5 meter-interval was calculated as follows: SL=V/SR.
The total 200 m-performance was reconstructed by combining the data of both groups of subjects.

RESULTS AND DISCUSSION:
Table 2: Average velocity per curve and final 200 m-time recorded in lanes 2, 4 and 6 of the Flanders Expo Track.

	Velocity in curve 1	Velocity in curve 2	200 m-time
Lane 2	9.07 m/s	9.01 m/s	22.13 s
Lane 4	9.15 m/s	9.09 m/s	22.00 s
Lane 6	9.27 m/s	9.13 m/s	21.90 s

The results of this study indicate that at the end of a 200 m run lane 6-runners have a mean advantage of 0.23 s and 0.10 s compared to lane 2 and lane 4 respectively. Based on the formula of the centripetal force ($Fc=(m*v^2)/R$), the largest differences in running speed were predicted to be found in the second curve, because a higher running velocity was expected in that curve. Surprisingly in all lanes the average velocity was higher in the first compared to the second curve (Table 2).

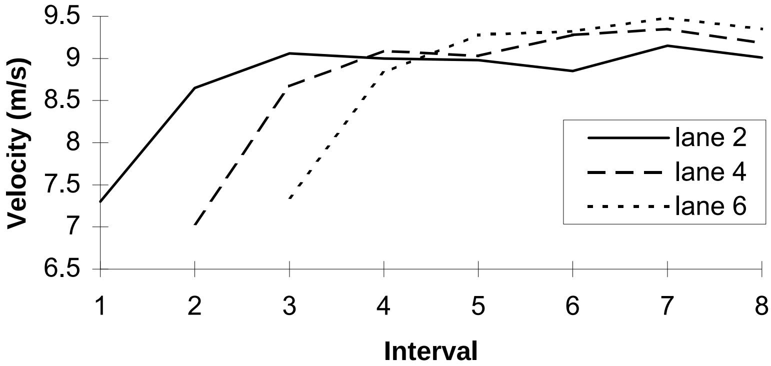

Figure 1 Average running velocity in intervals 1-8 of the first curve

When analyzing the changes in running speed in the first curve (Figure 1), it is clear that the higher running speed in lane 6 is mainly due to the forward starting position. In that lane the starting blocks are positioned in the third interval, hereby avoiding the uphill running part of the *first curve* (Table 1) and benefiting optimally from the downhill part at the end of the acceleration phase. The main problem in lane 4 is the uphill running in the first steps of the acceleration (interval 2), and a decrease in running speed at the end of the acceleration because of the small radius in interval 4 and 5. Lane 2-runners only have to cope with the very small radius of their curve. Their acceleration phase ends in the third interval, followed by a deceleration phase from interval 4 to 6. This early reduction in running velocity is caused by the small radius of the curve.
The effect of curve and slope characteristics becomes very clear in the second curve (Figure 2). In interval 2 of that curve the athletes reach their maximum velocity. This velocity is almost identical for all lanes, but lane 2-runners can only maintain this velocity during the third interval; on the other hand, a significant speed reduction is noticed in lanes 4 and 6. This is the only interval where the sprinter in lane 2 takes significant advantage of his flat course compared to the uphill running in lane 4 and in lane 6. From interval 4 to interval 8 the athletes run significantly slower in lane 2 because of the small radius. It is remarkable that in these intervals no significant difference in running speed among lane 6 and lane 4 was found. This indicates that the advantage of a greater radius in lane 6 disappears because of the steeper slope in that lane.

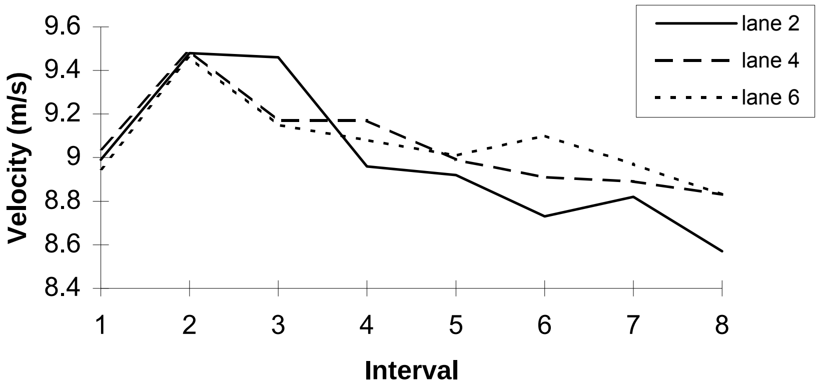

Figure 2 Average running velocity in intervals 1-8 of the second curve

CONCLUSIONS: It can be concluded that lane 6 takes advantage of lane 4 in the first curve and makes the difference with lane 2 in the first as well as in the second curve. The discriminating factor in sprint time between lane 4 and lane 6 is not the radius of the second curve but the slope and the forward position in the first curve. Analysis of stride characteristics shows that almost all significant differences in running velocity can be explained by differences in stride length. In general the dropping of the running velocity when entering the curve is caused by a drastic reduction of the stride length. Once the athlete is running in the curve the stride length remains constant, while the running velocity slightly decreases as a result of a normal and progressive reduction of stride frequency. When leaving the curve stride length increases again, but this does not assure an increase in running velocity, because of the further decrease in stride frequency.

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