THE EFFECTS OF INDOOR TRACK CURVE RADIUS ON SPRINT SPEED AND GROUND REACTION FORCES

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INTRODUCTION

Running on a curved path is an integral part of track and field events. Yet, running on a curved path compared to a straight path has been shown to be significantly slower [1,2]. This decrease in speed may be most apparent when considering indoor track designs. The International Association of Athletic Federations (IAAF) specifies that that a 200 m indoor track can have a radius ranging from 15 m to 19 m with 17.20 m being the “200 m standard indoor track” [3]. In the United States, amateur guidelines for track and field are set forth by the National Collegiate Athletic Association (NCAA). The NCAA specifies for indoor track championships that “the inside radius of the curves on a 200-meter track should be not less than 18 meters and not more than 21 meters” [4]. Depending on the level of competition, a runner could race on a track curve radius ranging from 15 m to 21 m.

Previous studies have attempted to identify the mechanism by which speed is attenuated when running on a curve [1,2]. In order to be continuously changing direction around the curve, medial/lateral (ML) ground reaction forces must be produced.

Decreased vertical ground reaction forces and increased ground contact time are primary components in decreased maximal running speed [5]. As the ML ground reaction forces increase, vertical forces are decreased which results in a loss of running speed.

While speed attenuation on the curve has been researched, previous studies have not focused on how differences in indoor track curve radii can affect sprint performance. In a race, average sprint speed over the length of the race will determine performance. It is unknown how differences in indoor track curve radii will affect sprint speed.

The purpose of this study was to determine the differences in running speeds, ground contact time, and ML impulse that are caused by the range of acceptable indoor track curves.

METHODS

Ten current intercollegiate male sprinters ages 18-25 were recruited as volunteers from the Brigham Young University track team. Subjects performed 45 m maximal sprints under three different conditions. The three sprint conditions were as follows:

- 45 m straight sprint
- 45 m sprint with a **21 m track curve** beginning at the 30m mark
- 45 m sprint with a **15 m track curve** beginning at the 30m mark.

Subjects were assigned sprint conditions using a randomized block design performing one condition on each testing day.

All trials were performed at maximal sprint speeds with at least 5 minutes rest between trials to avoid fatigue. The collegiate coach supervised all testing sessions to ensure maximal effort by the subjects.

In order to understand the differences between conditions, ground reaction forces were measured at the 37.5 m mark for each sprint condition using a Kistler force plate (Amherst, New York, USA). Sprinting speed was measured from 30 m to 40 m marks using Brower timing lights (Draper, UT). Mathematically, we rotated the axis of rotation of the force plate to account for the curved paths (Figure 1). Axial rotations for the 21 m and 15 m track curves were 21.6 and 28.6 deg, respectively. Ground contact time was determined from vertical ground reaction forces with a threshold of 100N.
We performed a mixed models analysis of variance blocking on subjects based on sprinting speed, ground contact time, and ML impulse. When we detected a significant effect, we performed a Tukey-adjusted post hoc test (P=.05).

RESULTS AND DISCUSSION

We found that sprinting speed was significantly slower as the radius of the track curve decreased. Runners were 2.6% and 4.7% slower for the 21 m and 15 m track curves respectively compared to straight (Table 1). Interestingly, we found that runners exhibit higher ML impulses and ground contact times on a 21m track curve compared to a 15m track curve. The reasoning for this remains unclear, but there is a difference ground forces between the two curves. This results in a difference in running speed that was expected.

The results of this study may help coaches and athletes to better understand how track conditions will affect sprinting speeds. If the average sprinter from our study were to run 200 m at maximum speed on the 21 m radius curve track in lane 1 the time would be 22.3 s. The same situation on a 15 m radius curve track would take 22.4 s. Sharper track turns result in slower maximum sprint speeds but give sprinters a high percentage of distance spent on straight-aways where maximum speed is higher. Based on our findings, differences in lane assignment may also play a significant role in race time and progression through heats. Although the difference in times between lanes is likely less than .1 s, this may be enough to affect finishing position.

In races longer than 200m, the different track designs lead to different strategies. Since all competitors runs in lane one after the first lap, tracks with wide turns and short straights make it more difficult to pass other runners effectively. So, while the overall time is not much different between the 15 and 21 m radius curves, the type of track may affect the style and outcome of the race.

REFERENCES


Table 1: Maximum velocity and corresponding contact times and ML impulses for each condition. Superscripts (A,B,C) indicate differences between groups at p<.05 in the Tukey post hoc analysis (i.e. a variable with a superscript denotes the variable is significantly different from the other superscripted variables).

<table>
<thead>
<tr>
<th></th>
<th>Straight (A)</th>
<th>21 m radius (B)</th>
<th>15 m radius (C)</th>
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</thead>
<tbody>
<tr>
<td>Speed (m/s)</td>
<td>9.12±.066^BC</td>
<td>8.88±.067^AB</td>
<td>8.69±.068^AC</td>
</tr>
<tr>
<td>Contact Time (s)</td>
<td>0.125±.003^BC</td>
<td>0.135±.003^AC</td>
<td>0.131±.003^AB</td>
</tr>
<tr>
<td>ML Impulse (Ns)</td>
<td>-0.39±2.47^BC</td>
<td>52.72±2.51^AC</td>
<td>38.40±2.59^AB</td>
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