BIOMECHANICS OF THE INSIDE AND OUTSIDE LEG WHEN SPRINTING ALONG FLAT CURVES

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Introduction

For outdoor track events such as the 200 and 400 m sprint, over half the race is completed along a flat curve. Curve sprinting requires an athlete to produce vertical and centripetal ground reaction forces (GRF) to support body weight and accelerate the body towards the inside of the curve [1]. Specifically, curve sprinting maximum velocity (v_{max}) can be described by $mv^2r^{-1} = GRF_c$, where v is a function of an athlete's mass (m), curve radius (r), and centripetal GRF (GRF_c).

Track athletes navigate different curve radii depending on lane assignment and track design, but previous studies have investigated leg-specific (inside vs. outside) GRFs on flat curves with radii smaller than those experienced by track athletes (1-6 m) [2] or only one curve radius [3]. Additionally, leg-specific GRFs may change with curve radius, as the inside leg produces greater GRF_c than the outside leg on a 37.72 m radius curve [3] but smaller GRF_c than the outside leg on 1-6 m radii curves [1]. Determining leg-specific GRFs when sprinting on curve radii typical for track athletes may also provide opportunities to improve curve sprinting performance.

We measured centripetal and vertical GRFs of the inside and outside leg during counterclockwise (CCW) and clockwise (CW) sprinting on curves with 17.2 m and 36.5 m radii, representative of the innermost lanes for a 200 m and 400 m athletics track. We hypothesized that: 1) v_{max} would decrease by ~5% from a 36.5 m to 17.2 m curve radius according to Greene [4], 2) the inside leg would produce greater GRF_c than the outside leg for both curve radii, and 3) the outside leg would produce greater vertical GRF than the inside leg for both curve radii.

Methods

9 experienced sprinters (8 M, 1 F; 200 m Personal Best (PB): 22.60 ± 2.39 s, 400 m PB: 47.76 ± 1.49 s; 74.6 ± 9.5 kg; 1.83 ± 0.10 m; 21 ± 1 yr) completed a randomized series of 40 m sprints on a flat indoor track. Athletes were instructed to perform maximal effort sprints CCW and CW along curves with radii of 17.2 m and 36.5 m. Athletes sprinted over two force plates embedded in the ground and covered with an indoor track surface that was level with the surrounding surface. Force plates and motion capture cameras were located halfway along the curve and athletes adjusted their starting position backwards to allow them to reach v_{max} in the capture volume.

We measured lower body 3D kinematics (200 Hz) and calculated v_{max} using markers on the pelvis and averaged over the capture volume (5 m). We measured 3D GRFs (1000 Hz) and transformed them so that the mediolateral axis was oriented relative to the athlete to determine GRF_c. We combined data from CCW and CW directions and calculated stance-average centripetal and vertical GRF of the inside and outside leg for both curve radii. We applied the Bonferroni correction method to each family of comparisons and set statistical significance at $\alpha = 0.05$.

Results and Discussion

On average, athlete v_{max} decreased by 7.2 ± 2.4% (0.66 ± 0.05 m/s) from the 36.5 m to 17.2 m radii curve ($p<0.01$), which was significantly different ($p<0.01$) than the 5.0 ± 0.8% change predicted by Greene [4]. The inside leg produced greater stance-average GRF_c than the outside leg on the 36.5 m radius curve ($p<0.01$), but not on the 17.2 m radius curve (Fig. 1A). Previous research suggests the inside leg produces less GRF_c than the outside leg when running on curves with a small (1-6 m) radius [1], but the opposite occurs on curves with a larger (37.72 m) radius [3]. We found a significant interaction ($p=0.03$) between curve radius and GRF_c produced by each leg, indicating that the inside and outside leg are affected differently by curve radius. v_{max} may decrease with curve radius due to the inside leg's inability to meet the increased GRF_c requirement.

The outside leg produced greater stance-average vertical GRF than the inside leg on 36.5 m and 17.2 m radii curves (both $p<0.01$; Fig. 1B). These findings indicate the inside leg may be responsible for redirecting the body's center of mass to the inside of the curve and the outside leg may be responsible for generating vertical GRF during curved sprinting. However, we found a significant interaction ($p<0.01$) between curve radius and stance-average vertical GRF for each leg, where the difference between legs increased as radius decreased from 36.5 m to 17.2 m.

Changes in the ankle's frontal plane kinematics and plantarflexor moment generation may be responsible for changes in centripetal and vertical GRF production during maximal effort sprinting [2]. We intend to investigate the ankle's frontal plane kinematics as a potential mechanism that modulates the ability of plantarflexors to produce the necessary centripetal and vertical GRF during curve sprinting.

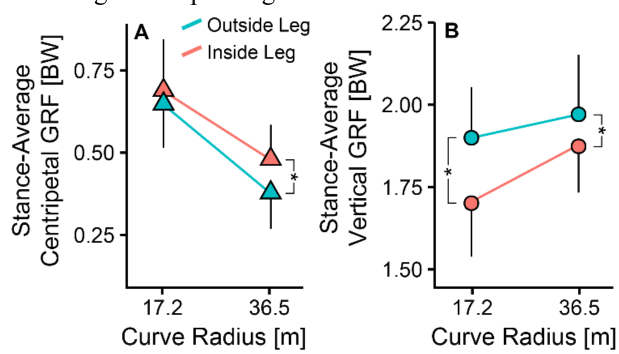

Figure 1. A) The inside leg had greater stance-average centripetal ground reaction force (GRF) on the 36.5 m radius curve (*$p < 0.01$), but not on the 17.2 m radius curve ($p = 0.3572$) compared to the outside leg. B) The outside leg had greater stance-average vertical GRF for both curve radii compared to the inside leg (*$p < 0.01$).

Significance

The inside and outside legs exhibit different biomechanics when sprinting at v_{max} along curve radii typical for track athletes. Considering the relationship between centripetal GRF and curve v_{max}, athletes could improve performance by increasing the inside leg's centripetal GRF and the outside leg's vertical GRF on a flat curve. This could be accomplished by strengthening the plantarflexors under various degrees of ankle eversion/inversion.

References

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