RUNNING SPEED ON CURVED PATHS IS LIMITED BY THE INSIDE LEG

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INTRODUCTION

In nature, animals rarely sprint along straight trajectories. Rather, prey species try to evade faster predators with high-speed small radius locomotor maneuvers (Alexander, 1982). Sprint performance along curves is also critical in many sports like baseball, soccer, and basketball. In track, it is well established that the radius of curvature of the lanes affects performance (Harrison and Ryan, 2000; Jain, 1980).

Greene (1985) proposed a model for curve running performance based on the assumption that the maximal effort leg extension force is a physiological upper limit to running speed. His data generally supported this theory. However, he noted a significant degree of scatter to [the] data, and thus it is...possible that other theoretical models can predict the data as successfully. Furthermore, Greene did not measure ground reaction forces to validate his assumption nor do these data currently exist.

The primary goal of this study was to test directly whether an upper limit to leg extension force limits sprint velocity along curved paths.

METHODS

Five recreationally fit men (29.4 – 5.2 yrs., 80.7 – 9.0 kg, mean – SD) gave informed consent to serve as subjects. They sprinted along a straight track and along circular tracks of 1, 2, 3, 4, and 6 m radii. Curve sprinting was performed normally and with a tether. The tether attached a harness worn about the waist to a vertical pole at the center of each track. Speeds were determined from high-speed video analysis. Ground reaction forces (GRFs) were recorded from a force platform mounted flush with the running surface. Tether forces were recorded from an in-line force transducer.

RESULTS AND DISCUSSION

Sprint velocity decreased with radius, but less so with the tether (Fig. 1). At the 3 m radius, velocity decreased by 42% for normal curve sprinting, but only 33% with the tether.

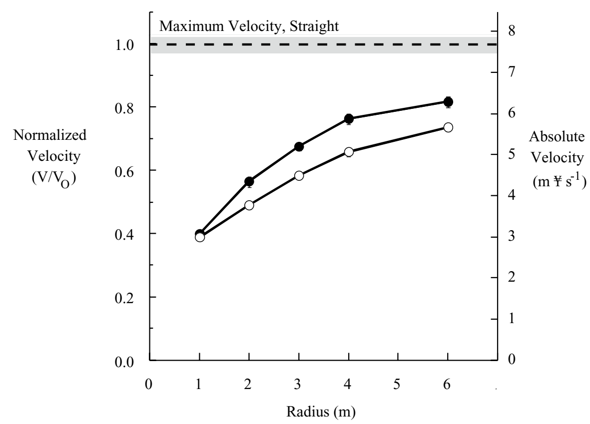

Figure 1. Maximum sprint velocity as a function of track radius for normal (unfilled circles) and tethered (filled circles) sprinting. Data are means – SE. Dashed line indicates average straight path maximum velocity – SE.

The outside leg produced significantly more force than the inside leg during normal curve sprinting (Fig. 2A). In contrast, outside and inside legs generated nearly the same peak resultant GRFs during tethered curve sprinting (Fig. 2B).

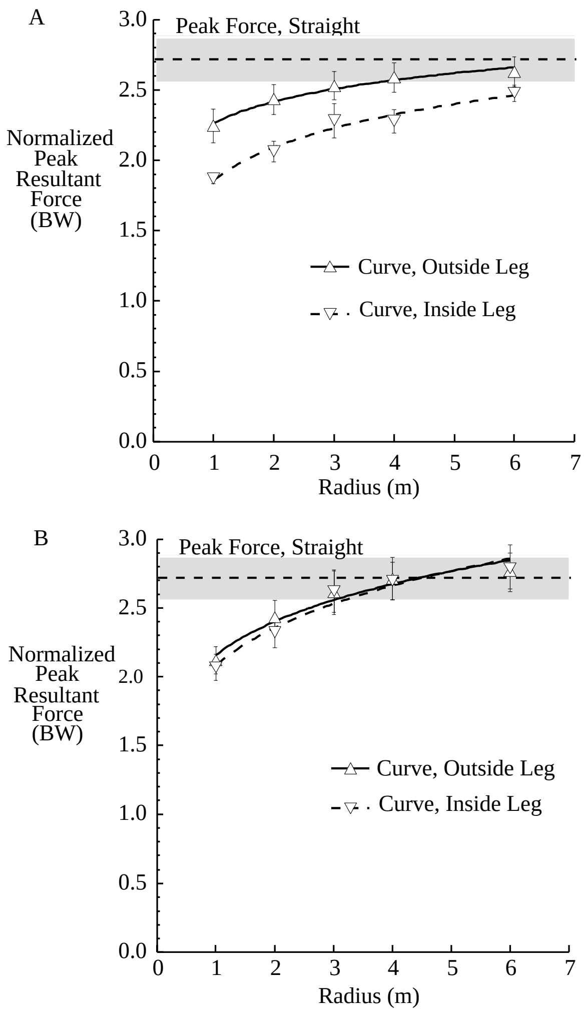

Figure 2. Normalized peak resultant GRFs for outside (triangles) and inside (inverted triangles) legs as a function of radius during (A) normal and (B) tethered curve sprinting. Data are means – SE. Dashed line indicates average straight path GRFs – SE.

Our direct measurements show that peak resultant GRFs decreased at smaller radii is strong evidence against Greene s primary assumption that the physiological limit of leg force is generated at all radii. We found that the tether provided approximately 50% of the needed centripetal force. According to Greene s hypothesis, supplying 50% of the centripetal force at a given radius is equivalent to normal curve sprinting at twice that radius, and velocities should thus also be equivalent. However, despite having the same peak resultant GRFs, velocities at the 2 and 3 m radii with the tether were significantly slower than velocities at 4 and 6 m radii without the tether, respectively.

An implicit assumption that Greene made was that the legs act symmetrically. In contrast, we found that the inside leg generates smaller peak resultant GRFs during curve sprinting. Weyand et al. (2000) recently correlated maximum straight path sprint velocity with GRFs. If this is the case, the inside leg appears be limiting the sprint speed on curved paths. This is consistent with data for cutting maneuvers (Ohtsuki et al., 1988).

Curve sprinting velocity is not determined by a general physiological leg extension force limit. Instead, we find that curve running performance is specifically limited by the ability of the inside leg to generate GRFs and thus change the direction of the momentum vector.

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