

HORIZONTAL IMPULSE GENERATION CHARACTERISTICS DURING THE SPRINT START ARE INFLUENCED BY SHANK SEGMENT CONTROL

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INTRODUCTION

The goal of the first step of a sprint start is to increase the forward horizontal momentum of the body as quickly as possible. Change in horizontal momentum of a system requires that a net horizontal impulse be applied in the desired direction. Previous investigations have found that faster horizontal running velocities are associated with shorter ground contact times, larger net horizontal ground reaction forces, and faster times to peak horizontal ground reaction force, compared to slower horizontal running velocities (Henry, 1952; Bobbert & Van Zandwijk, 1999; Weyand et al., 2000; Kuitunen et al., 2002). The purpose of this investigation was to test the hypothesis that increased rate of horizontal force development (HRFD) produces larger net horizontal impulse during the first foot contact of sprint start. Understanding impulse generation strategies during the first step of the sprint start will facilitate horizontal momentum generation early in the race, leading to an improvement in overall sprint performance (Mero, 1988).

METHODS

National level multi-event athletes (1 heptathlete, 11 decathletes) volunteered to serve as subjects in accordance with the Institutional Review Board. Each athlete performed a series of sprint starts out of starting blocks during a pre-season training

camp session (United States Olympic Training Center, Chula Vista, CA). During the sprint start, two-dimensional, sagittal plane kinematics (NAC C²S, 200Hz) and three-dimensional reaction forces (Kistler, Amhurst, MA, 0.6x0.9m, 1200Hz) were collected during the first step out of the starting blocks. Body segment landmarks (22) (Zatsiorsky and Seluyanov, 1983; de Leva, 1996) were manually digitized (Motus, Peak Performance, Inc., Inglewood, CO) during the time between touchdown (TD) and take-off (TO) of the first step of the sprint start. Digitized x and y coordinates of body landmarks were individually filtered, interpolated (1200 Hz) and synchronized with reaction force data at the time of TD. Net joint forces (NJF) and net joint moments (NJM) of the ankle, knee, and hip of the stance leg were determined using Newtonian mechanics. Changes in center of mass (CM) horizontal and vertical velocity during the contact phase were determined by integrating the net horizontal and the net vertical force-time curves normalized by body mass from TD to TO. Rate of horizontal force production was calculated as the average slope of the horizontal reaction force-time curve from minimum braking force to maximum propulsive force.

RESULTS AND DISCUSSION

Contrary to the hypothesis, an increase in HRFD did not consistently result in larger net horizontal impulse during the first foot

contact of a sprint start. Athletes were found to generate similar net horizontal impulse with different horizontal force-time characteristics (e.g. high ΣF_h over short Δt , or low ΣF_h over long Δt ; figure 1). Across subjects, net horizontal impulse generated during the first step ranged from 1.08-1.48m/s over a period of 0.166-0.265s.

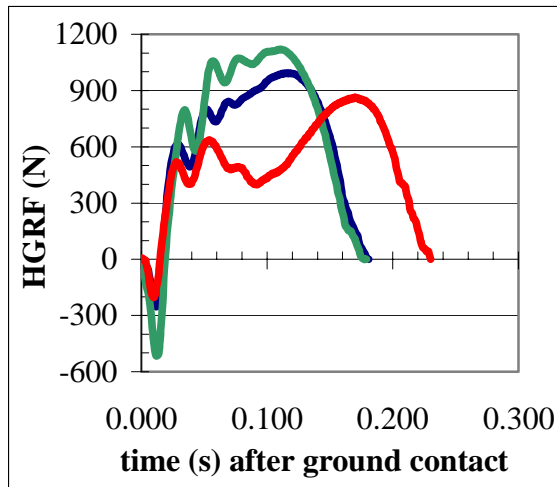


Figure 1. Horizontal ground reaction force-time curves plotted for 3 athletes who generated equal net horizontal impulse ($\Delta V_h = \Sigma F_h \Delta t / m = 1.29\text{m/s}$) during the first step of a sprint start from starting blocks. These data demonstrate that equal net horizontal impulse magnitudes may be generated with different HRFD.

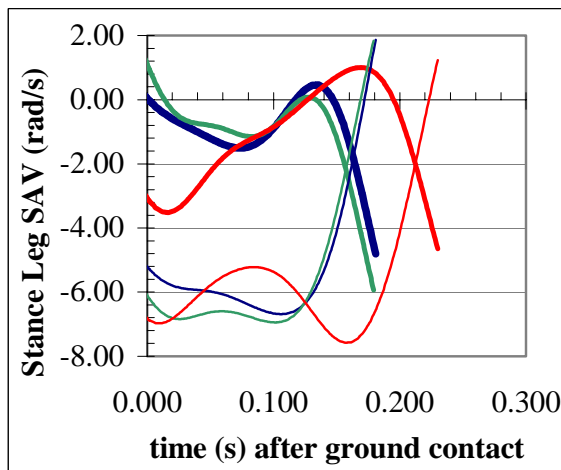


Figure 2. Support leg shank (thick lines) and thigh (thin lines) segment angular

velocity (SAV)-time curves plotted for the same 3 athletes as shown in figure 1. These kinematic data suggests horizontal impulse generation characteristics may be associated with lower extremity segment control during ground contact. Specifically, trials with greater shank SAV during the impact phase, tended to have greater thigh SAV during the post-impact leading to a delay in HGRF generation. Whereas, trials with lower shank SAV during impact appeared to provide a base for quicker thigh rotation over the knee thereby contributing to a quicker generation of HGRF.

SUMMARY

Rate of horizontal force development was not found to be directly related to horizontal impulse generation during the first step of a sprint start. Individual horizontal impulse generation characteristics (e.g. large ΣF_h over short Δt , or small ΣF_h over long Δt) appears to be related to lower extremity segment control at touchdown and during ground contact phase.

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ACKNOWLEDGEMENTS

USOC C&SS, USA Heptathlon, USA Decathlon

