INTERACTION OF STEP LENGTH AND STEP RATE DURING SPRINT RUNNING

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INTRODUCTION

Sprint running horizontal velocity (SV) is the product of step length (SL) and step rate (SR). When training to improve one of these factors, it is crucial that the other is not negatively affected to the extent that SV decreases. From this point forward, we will refer to the negative effect of SL on SR, and vice versa, as a ‘negative interaction’. The purpose of this study was to quantify this negative interaction, determine its likely sources, and investigate the effects of manipulation of the interaction.

METHODS

To investigate the sources of the negative interaction between SL and SR, eight pairs of athletes who regularly performed sprint running were paired according to the following criteria: same gender, similar SV (difference < 0.05 m/s), similar leg length (difference < 6.0 cm), and notably different SR (difference > 0.15 Hz). Mean ± SD for age, height, and body mass were 24 ± 5 yrs, 1.76 ± 0.08 m, and 73 ± 9 kg, respectively. The athletes performed sprints, 25 m in length, from which video (240 Hz) and ground reaction force data (960 Hz) were collected at the 16 m mark. Paired t-tests were performed to determine differences in the determinants of SL and SR.

A simple simulation was performed to investigate the effects of manipulation of the negative interaction. Using data from the fastest sprinter as a starting point, the flight determining parameters (velocity, angle, and height of takeoff) were individually altered and the effects on SL, SR, and SV were calculated using...

\[ SV = SL \times SR = (D_S + D_F) \times (T_S + T_F)^{-1} \]

…where \( D_S \) and \( D_F \) are the horizontal distance the centre of mass travels during the stance and flight phases, and \( T_S \) and \( T_F \) are the durations of the stance and flight phases. \( D_S \) and \( T_S \) were assumed to remain constant for small changes in \( D_F \) and \( T_F \). \( D_F \) and \( T_F \) were calculated from the relative height, and horizontal and vertical velocities of takeoff, using equations provided in Hay (1994).

RESULTS AND DISCUSSION

For the entire group of 16 athletes there was evidence of a significant negative interaction between SL and SR (Pearson \( r = -0.70, P < 0.01 \)). The paired t-tests revealed that the athletes with a longer SL had a longer flight distance, achieved via a longer flight time. This was the product of a greater vertical velocity of takeoff, and, in turn, a greater net vertical ground reaction impulse per body mass. There were no significant differences in horizontal velocity or relative height of takeoff. Although the longer flight time had a positive effect on SL, it also had a negative effect on SR. In brief, vertical velocity of takeoff (determined largely by vertical ground reaction impulse) was the source of the negative interaction between SL and SR.

The simulation results are shown in Figure 1. When vertical velocity, angle, or relative height of takeoff were increased, SL increased, SR decreased, and SV barely changed. When horizontal velocity of takeoff was increased, SL increased, SR did not change, and SV increased.

\[ SV = D_S \times SL \times SR = (D_S + D_F) \times (T_S + T_F)^{-1} \]

Figure 1: The effects - on SL, SR, and SV - of changes in flight determining parameters. A: Effects of changes in either vertical velocity (□) or horizontal velocity (●) of takeoff (original magnitudes of 0.41 and 8.91 m/s, respectively, and are indicated at point 0.0 m/s). B: Effects of changes in the angle of takeoff (original magnitude = 2.6 degrees). C: Effects of changes in the height of takeoff (original magnitude = 1.6 cm).

SUMMARY

Increasing SL by increasing angle, relative height, or vertical velocity of takeoff will have a negative effect on SR, and little effect on SV. A long SL and high SR combination, typical of elite sprinters (e.g. Kivi, 1999), is likely to be achieved by use of a low vertical velocity, and high horizontal velocity of takeoff.

REFERENCES


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