INTERACTIVE EFFECTS OF RUNNING SPEED AND WEIGHT SUPPORT ON METABOLIC COST AND GROUND REACTION FORCES

Alena M. Grabowski and Rodger Kram
University of Colorado, Boulder, CO, USA
E-mail: alena.grabowski@colorado.edu
Web: www.colorado.edu/intphys/research/locomotion.html

INTRODUCTION

Training at fast running speeds can enhance cardiovascular function due to increased metabolic demands and may also enhance neuromuscular function, thereby improving running performance (Daniels, 2005). Yet, running fast likely increases the risk of over-use injury due to greater peak ground reaction forces (GRFs) (Hreljac, 2000). Weight support decreases peak GRFs (Chang et. al, 2000), but also demands less metabolic power (Farley and McMahon, 1992) than normal weight running.

Our goal was to determine running speed and weight combinations that demand the same metabolic power, but differ in peak vertical impact and active GRFs. We predicted that running at fast speeds with weight support would decrease peak vertical GRFs, yet demand the same metabolic power compared to running at slower speeds with normal weight.

METHODS

We used a novel device called the G-trainer, created by Alter-G, Inc., to acutely reduce body weight (Fig. 1). The G-trainer is an enclosed treadmill body-weight-support system that uses a small increase in air pressure around the user's lower body to create a lifting force approximately at the person's center of mass. The controlled air pressure (less than 10.3 kPa or 1.5 psi) can support up to 100% of body weight. The G-trainer is comfortable, easily adjustable, and allows runners to retain normal mechanics, unlike water running.

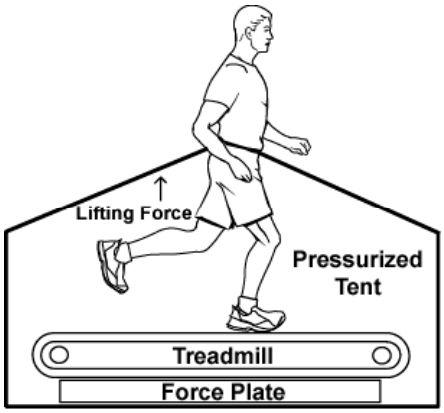

Figure 1. G-trainer (Alter-G, Inc.)

10 healthy recreational runners volunteered [7 M, 3 F, 64.4 ± 7.4kg (mean ± s.d.)]. Subjects completed 12 trials during 2 experimental sessions on a force-measuring treadmill. Trials were 7 minutes with at least 3 minutes rest given between. Subjects began each day with a standing trial at 100% body weight (BW). We randomly assigned the order of the other trials. Subjects ran 3.0 m/s at 1.0, 0.75, 0.50, and 0.25 BW, 4.0 m/s at 1.0, 0.75, 0.50, and 0.25 BW, and 5.0 m/s at 0.50, and 0.25 BW.

We measured rates of oxygen consumption and carbon dioxide production during minutes 4-6 of each trial and calculated net (gross-standing) metabolic power (Brockway, 1987). We measured GRFs at 1000 Hz during 10 strides.

We used repeated measures ANOVAs with Tukey HSD follow-up tests when warranted

($P < 0.05$). We used linear least-squares regression equations to compare body weight and net metabolic power and to compare body weight and peak GRFs.

RESULTS AND DISCUSSION

We found multiple running speed and weight combinations that demanded the same net metabolic power, but resulted in different peak vertical impact and active GRFs. Running at faster speeds with weight support decreased peak vertical GRFs in most cases, yet maintained the same metabolic power demand as running at slower speeds with normal weight.

For example, running 3 m/s at 1.0 BW, 4 m/s at 0.83 BW, and 5 m/s at 0.43 BW all demand the same net metabolic power of 9.95 W/kg (Fig. 2).

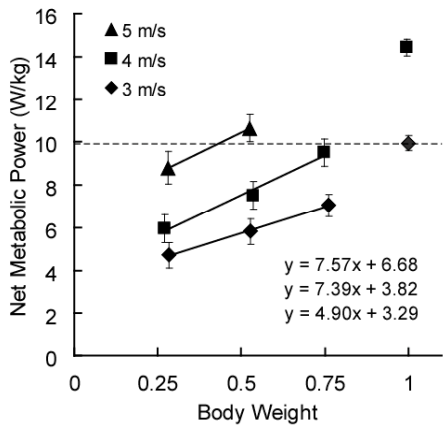

Figure 2. Metabolic demand during normal and weight supported running. (n=10) means ± s.e.m.

Peak impact and active GRFs running 3 m/s at 1.0 BW were 941 N and 1480 N, respectively (Fig. 3). Running 4 m/s at 0.83 BW, peak impact GRF increased to 1170 N and peak active GRF decreased to 1398 N. Running 5 m/s at 0.43 BW both peak impact and active GRFs decreased to 910 N and 955 N, respectively. Therefore, a person who normally runs 3 m/s could run 5 m/s in the G-trainer at 0.43 BW and reduce their impact GRF by ~3% and active GRF by ~35%.

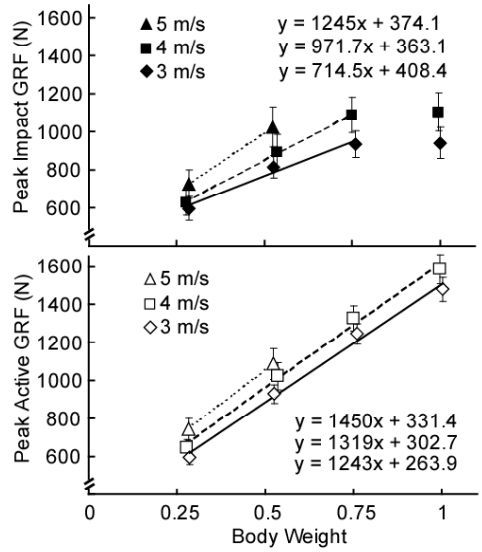

Figure 3. Peak vertical GRFs during normal and weight supported running (impact n=6, active n=10) means ± s.e.m.

SUMMARY/CONCLUSIONS

The G-trainer is a unique lower-body positive pressure system that can assist runners in training and rehabilitation. By running at faster speeds with weight support, runners can achieve the same aerobic intensity while decreasing peak vertical GRFs.

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