GROUND REACTION FORCES BETWEEN RUNNING SHOES, RACING FLATS AND DISTANCE SPIKES IN RUNNERS

Suzanna Logan, Iain Hunter, Brent Feland, Ty Hopkins, Allen Parcell

Brigham Young University, Provo, UT, USA
E-mail: iain_hunter@byu.edu Web: http://biomech.byu.edu

INTRODUCTION

During distance running, ground reaction forces (GRF) of more than two times a person's body weight are typical. Attenuation of GRF has been a major concern for shoe designers and manufacturers, as one of the primary roles for running shoes is to provide shock absorption. Additionally, in competitive shoes such as racing flats and spikes, the weight of the shoe has been reduced to improve performance. In comparison to most regular running shoes, spikes and racing flats have less cushioning and a thinner heel.

Several studies have looked at the reduction of GRF in running shoes, but there is a lack of data on the GRF in competitive footwear. Studies comparing barefoot and shod running have found significantly increased loading rates and greater vertical impact peaks in the barefoot condition (De Wit, 2000).

The objective of this study was to compare how GRF are influenced while running in training shoes, racing flats and spikes at a given speed, and therefore provide meaningful information that could influence the timing and frequency of the use of competitive footwear in runners.

METHODS

Twenty subjects (10 male, 10 female) from the Brigham Young University track/cross-country teams ran across a Kistler force plate (Type 9287BA, Amherst, NY) embedded into the track at 6.7m/s for males, and 5.7m/s for females. Two valid trials were obtained for each subject in each of three types of shoes – training shoes (Nike® Air Pegasus™ 2005), racing flats (Nike® Zoom Waffle Racer™ 2005), and distance spikes (Nike® Zoom Miler™ 2005). Forces were normalized to body weight in Newtons.

Only subjects who had a heel strike were included in the data analysis (n=18). Impact peak (BW), loading rate (BW/s), peak braking and propulsive force (BW), peak vertical force (BW), stance time (s), and vertical stiffness (BW/m) were subjected to a repeated-measures ANOVA and Tukey's post-Hoc test ($p<0.05$).

RESULTS AND DISCUSSION

Impact peak and vertical stiffness significantly increased between running shoes and spikes. Differences between stance time and loading rate approached significance with trainers being lower (Table 1). Loading rate and impact peak in the flats and spikes were expected to be higher, given similar results from previous studies comparing barefoot and shod running (DeWit, 2000), and could be explained by the decreased cushioning in flats and spikes, which would affect the negative acceleration of the foot at impact. The increased vertical stiffness is attributed to the decreased cushioning in the spikes causing a greater

negative vertical acceleration at ground contact.

Higher vertical stiffness is usually correlated to increased peak forces coupled with smaller lower extremity excursions, which leads to increased loading rates (Butler, 2003). Increases in these variables have been associated with potential increased risk of bony injuries (Ferber, 2002; Williams, 2004).

Whether or not increased GRF raises injury risk has been a topic of debate in research. In this study, the amplified loading rate, stiffness, and impact peak demonstrate that running in spikes and flats produces a greater external load on the body. The initial impact between the foot and the ground are directly transmitted to the leg and can potentially be an influential factor in injury risk (Hewett, 1999). However, there may also be an osteogenic effect when wearing the less-cushoined shoes.

Stance time in spikes and flats bordered on being significantly lower than in training shoes. The importance of decreased stance time is mostly from a performance standpoint, as shorter stance times have been correlated with higher running speeds (Munro, 1987). The lighter shoe should also improve running economy.

SUMMARY/CONCLUSIONS

The external load placed on the body during running is significantly increased in competitive footwear compared to regular running shoes. The differences are evident in the larger impact peak and vertical stiffness (in the spikes condition), as well as in the shorter stance time. These data can be used to better inform competitive runners, coaches, and trainers of the risks and performance benefits, when determining the frequency and duration of the use of competitive footwear in training.

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Table 1: Results where significant differences were observed (mean± SD). Superscripts (A,B,C) denote differences between groups $p < 0.05$ for impact peak and vertical stiffness. Superscripts (A,B,C) denote differences approaching significance between groups $p < 0.10$ for loading rate and stance time.

Condition	Impact Peak (BW)	Loading Rate (BW/s)	Stance Time (s)	Vertical Stiffness (BW/m)
Trainers (A)	2.3 ± 0.44^{BC}	151 ± 56.9^{BC}	0.162 ± 0.013^{BC}	63 ± 26.4^{C}
Racing Flats (B)	2.7 ± 0.71^{A}	206 ± 113.3^{A}	0.156 ± 0.008^{A}	101 ± 77.3^{A}
Spikes (C)	2.9 ± 0.51^{A}	214 ± 131.8^{A}	0.156 ± 0.01^{A}	138 ± 106.7^{A}