



IMPACT FORCES DURING RUNNING IN A NOVEL SPRING BOOT

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INTRODUCTION

It has been reported that runners generally select a running style that optimizes oxygen cost of running but not impact magnitude (Hamill et al., 1995). Since impact magnitudes have been hypothesized to be related to running overuse injuries (Hreljac et al., 2000), it seems reasonable to suspect that if the impact magnitude can be reduced, the risk of overuse injuries could be reduced. Recently, a spring-boot (SB, Kangoo Jumps.) has been developed for general exercise use. Based on boot construction, a purpose of the SB is to reduce impact magnitudes during activities such as running. Since runners can change their running style (e.g. change stride length), and since running style affects impact attenuation (Hamill et al., 1995), it is not known if impact magnitudes are attenuated during SB running. Therefore, the purpose of this study was to determine if impact magnitudes are affected while running with Kangoo Jumps (Spring Boots).

METHODS

Seven healthy subjects (age: 23 ± 2.5 years, height: 168 ± 8 cm, mass: 62 ± 11 kg; male: $n=4$, female: $n=3$) were recruited from a university population. Informed consent was obtained prior to data collection. Subjects ran at three different velocities (2.2 , 3.1 , and $4.0 \text{ m}\cdot\text{s}^{-1}$) during two shoe conditions: 1) running shoes

(RS, laboratory shoe); 2) Spring Boot (SB, Kangoo Jumps). The order of shoe and velocity conditions were counterbalanced among subjects. All running trials were completed along a 20m runway with the right foot contacting a force plate (Kistler) mounted in the middle of the runway. GRF data were collected (1000Hz) for five acceptable trials for each shoe-speed condition. An acceptable trial was defined as the right foot entirely contacting the force platform with no obvious modification of stride (e.g., lunge or stutter-step), and velocity within $\pm 5\%$ of the target velocity. Velocity was monitored using sensors placed 3m before and 2m after the center of the force platform. Prior to testing, ample time was allowed for subjects to become comfortable with SB running. Impact magnitude ($F1$), active force peak ($F2$), average vertical force (F_{avg}), and contact time were each analyzed using repeated measures ANOVA with linear contrast follow-up testing (SPSS, version 10.1).

RESULTS AND DISCUSSION

An impact peak was observed in 15% of the trials during SB running, compared to 96% of the trials during RS running. Table 1 reports the percent of trials in which $F1$ was observed per condition.

Table 1: Percent of trials that impact peak was observed.



Velocity (m/s)				
Condition	2.2	3.1	4.0	Total
RS	89%	100%	100%	96%
SB	3%	6%	37%	15%

Mean for F1 was not calculated across subjects since only a small number of trials contained an impact peak. However, one subject who had at least one F1 per condition, F1 magnitude ranged from 1.0-1.6 BW during RS and 1.5-2.0 BW during SB running. This suggests that for this user, impacts were not attenuated but for the majority subjects F1 was attenuated. The observation that frequency of F1 occurrence increased as velocity increased indicates that the effectiveness of the boots to attenuate impact peak was related to velocity.

F2 increased linearly across velocity for both RS and SB conditions (Figure 1, $p < 0.05$) with F2 increasing $0.28 \text{ BW/m}\cdot\text{s}^{-1}$ during RS but only $0.17 \text{ BW/m}\cdot\text{s}^{-1}$ during SB. However, F2 was not different between shoes collapsing across velocity ($p > 0.05$).

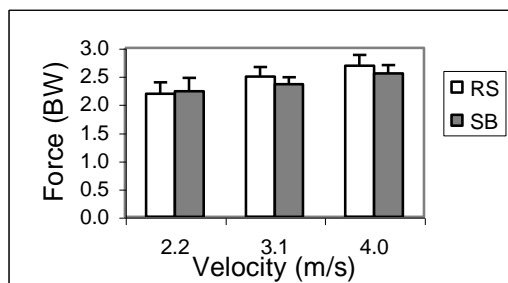


Figure 1: F2 during SB and NS running.

F_{avg} increased linearly across velocity during RS ($0.20 \text{ BW/m}\cdot\text{s}^{-1}$) and SB ($0.13 \text{ BW/m}\cdot\text{s}^{-1}$) running (Figure 2, $p < 0.05$). The F_{avg} increase during RS was similar to the $0.21 \text{ BW/m}\cdot\text{s}^{-1}$ increase across similar velocities reported by Munro et al. (1987). Mean F_{avg} was 6% greater during SB than RS across velocity (Figure 2, $p < 0.05$).

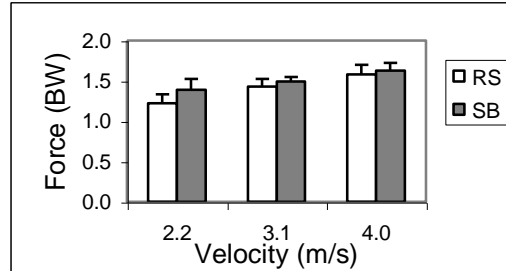


Figure 2: F_{avg} during SB and RS running. Contact time was not different between RS and SB running ($p > 0.05$) but did decrease linearly across velocity for both conditions ($p < 0.05$). There is evidence indicating that runners adjust lower extremity stiffness to surface stiffness. Ferris et al. (1999) reported that runners adjusted lower extremity stiffness inversely proportional to the surface stiffness. They also reported that contact time and peak forces were similar during running across surfaces with different stiffness when runners adjusted lower extremity stiffness to the surface. Hardin et al. (2000) also reported that lower extremity stiffness was modified to surface-shoe changes. In the present study, the similarity in contact time and F2 between shoes across velocity suggests that subjects adjusted lower extremity stiffness to SB stiffness.

SUMMARY

Running with SB reduced the frequency of occurrence of F1 compared to RS, but F2, F_{avg} and contact time remained similar between conditions across velocities tested. It is suggested that subjects were able to adjust lower extremity stiffness to the novel spring surface with the impact cost of running significantly reduced.

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