COMPARISON OF GROUND REACTION FORCES BETWEEN MALES AND FEMALES DURING DROP LANDINGS FROM DIFFERENT HEIGHTS WITH ANKLE SUPPORT

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INTRODUCTION
Landing technique has been suggested as a possible basis of the epidemiological data indicating a male to female difference in the frequency of knee injury during physical activity (Kirkendall & Garrett, 2000). Vertical ground reaction forces (vGRF) are increased when landing from higher heights (Dufek & Bates, 1990) and by the use of prophylactic ankle support commonly worn to prevent inversion ankle sprains (McCaw & Johnson, 1992). Loading rate is a measure of the rate of increase in the vGRF and has been implicated with various lower extremity injuries. The purpose of this study was to compare loading rate between males and females during drop landings from two heights using three common ankle supports.

METHODS
Nine females [21.7 ± 1.9 y; 169 ± 6 cm; 62 ± 6 kg] and 13 males [22.0 ± 2.9 y; 181 ± 5 cm; 83 ± 10 kg] volunteered as subjects. All subjects were free of lower extremity injury for two years and participated on a weekly basis in recreational activities involving landing. Subjects signed informed consent. After a general warm-up consisting of jogging, stretching, and 5 bent knee jumps, subjects performed two-legged soft landings (unrestricted knee flexion) in the two height (30 cm & 60 cm) and three support (no support, lace-up (Mueller Sports Medicine, Inc), and mechanical stirrup (ActiveAnkle Systems, Inc)) conditions. Subjects performed 5 trials in each height by support condition (total = 30 landings) by stepping off platforms set at the two heights. Height conditions were randomized within each randomized support condition. vGRF data were collected (960 Hz) from under the right foot and normalized to units of BodyWeight (BW). Based on a pilot study, loading rate was calculated as the slope of the vGRF curve as it rises from 25N to BW/2 + 25N following initial ground contact (Munro et al, 1987). Each subject's 5-trial mean value for each ankle support/height condition was entered into a 2x(3x2) mixed factor ANOVA [sex {between subjects factor} by (support by height) {within subjects factors}]. When needed, the Tukey b post hoc test was used to determine the source of a significant F ratio. A significance level of 0.05 was used for all statistical tests.

RESULTS AND DISCUSSION
The mixed factors ANOVA revealed no interaction effects or main effect of sex on loading rate magnitudes during drop landings (Figure 1). However, there was a significant support by height interaction (Figure 2). The post hoc test revealed that loading rate was greater when landing from 60 cm than from 30 cm, but only when using the lace-up support. Loading rate was significantly lower during the no support condition compared to both the lace-up and stirrup support conditions when landing from 30 and from 60 cm. There was no significant difference in loading rate between the lace-up and stirrup support conditions at 30 cm, but this difference was significant when landing from 60 cm. Effects of higher landing height (McNitt-Gray, 1991, 1993; Dufek & Bates, 1990) and ankle support (McCaw & Johnson, 1992) on discrete values describing the vGRF have previously been reported. We report loading rate because it is a primary factor associated with both beneficial (Frost, 1998) and deleterious (Grimston & Zernicke, 1993) bone remodeling. However, since the threshold of the loading rate magnitude to initiate osteogenesis in human bone is unknown (Nigg & Wakeling, 2001), we cannot determine if any of our mean values represent an increased risk for injury during landing activity. With respect to this limitation, results of this study allow us to conclude that there is no difference between males and females in loading rate during drop landings. Loading rate is higher when wearing ankle supports compared to the non-supported condition, and the lace-up support may further increase loading rate when landing from a higher height.
**Figure 1:** Loading rate magnitude for males and females in three support conditions between the 30 cm (white bars) and 60 cm (black bars) height conditions.

**Figure 2:** Loading rate magnitude collapsed across males and females in three support conditions between the 30 cm (white bars) and 60 cm (black bars) height conditions.

**REFERENCES**


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