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Force Characteristics in Different Shoe Designs

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Abstract

Women's shoes are known to be constructed from the same parameters as men's shoes but on a smaller scale. However, foot and gait characteristics are different between genders The purpose of this study was to determine if mid-sole design has an effect on ground reaction force characteristics during running, cutting and jumping motions. Twenty-two apparently healthy female (73.8±8.4 kg; 1.74±0.06 m) and seven male (73.5±5.3 kg; 1.68±0.02 m) current or recently graduated NCAA Division III athletes voluntarily participated in this study. Subjects wore four shoes with different mid-sole designs while performing five different actions: running, cutting, shuffling, back cut and plyometric jumping. In the locomotive portion of the study, no differences were found between the shoes or gender in both the vertical and medial/lateral forces. In females, jumping data showed that the D3O shoe yielded less contact time with less velocity. Prototype shoes seemed to effect GRFs while landing from a jump but did not alter GRF characteristics during running and agility movements.

Background

Women's shoes are known to be constructed from the same parameters as men's shoes but on a smaller scale. However, foot and gait characteristics are different between genders (Ferber, Davis & Williams, 2003; Ford, Myer, Toms & Hewett, 2005). In running, females are observed to have more hip frontal plane negative work than males, which increases eccentric demand on hip adductors (Ferber et al., 2003; Jacobs, Uhl, Mattacola, Shapiro & Rayens, 2007). When adding an agility-type motion, i.e. cutting, females also exhibit greater knee inversion/eversion range of motion and knee abduction angles (Ford et al., 2005). These kinematic changes were noticed to varying degrees in different sports; suggesting a potential sport-specific training effect (Cowley, Ford, Myer, Kernozek & Hewett, 2006). In landing, females are known to land more erect, thus absorbing more of the force in the lower extremities of the leg rather than the upper extremities (Jacobs et al., 2007; Luethi, Frederick, Hawes & Nigg, 1986; Russell, Palmieri, Zinder & Ingersoll, 2006). Females also generate energy through different mechanisms than males. Because males have greater muscle mass, they are able to generate more immediate velocity while females use body momentum to maximize their strength (Barfield, Kirkendall & Yu, 2002). This implies that females execute the loading phase of their motions at higher velocities than males, which could put them at an increased injury risk.

Purpose

The purpose of this study was to determine if mid-sole design has an effect on ground reaction force characteristics during running, cutting and jumping motions.

Method

Twenty-two apparently healthy female (73.8±8.4 kg; 1.74±0.06 m) and seven male (73.5±5.3 kg; 1.68±0.02 m) current or recently graduated NCAA Division III athletes voluntarily participated in this study. Apparently healthy was defined as having no leg injury or repercussion from injury within the past year and is currently active in their respective sport with full capabilities.

Before starting trials, subjects were asked to warm-up on a stationary bike for five minutes at a self-selected workload. Subjects wore four shoes with different mid-sole designs while performing five different actions: running, cutting (Figure 1), shuffling (Figure 2), back cut (Figure 3) and plyometric jumping. Each movement was done while crossing a force plate (AMTI 1000).

Subjects performed the jumps from box heights of 60.0 cm, 30.5 cm and 21.6 cm. Subjects stepped off the box and immediately prepared and executed an explosive jump. Subjects stepped off the box and landed with their right foot on the force plate and their left foot on the ground. For all box heights, a second box (60 cm) was placed on the opposite side of the force plate for subjects to land on.

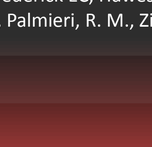

Figure 1: Cut

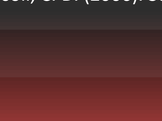

Figure 2: Shuffle

Figure 3: Back Cut

Locomotion:

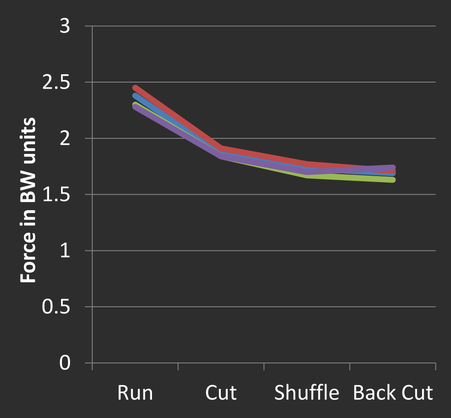

Figure 4: Women Maximal Vertical Force by Shoe

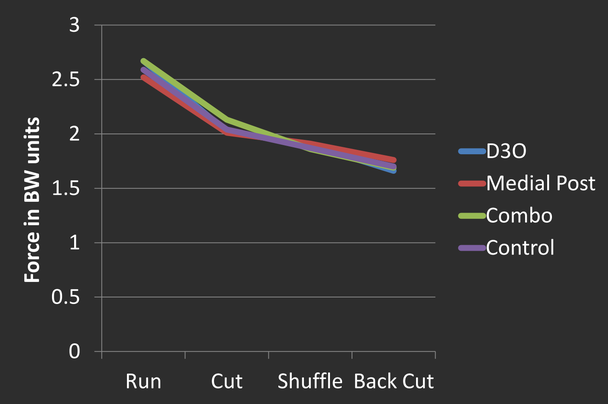

Figure 5: Men Maximal Vertical Force by Shoe

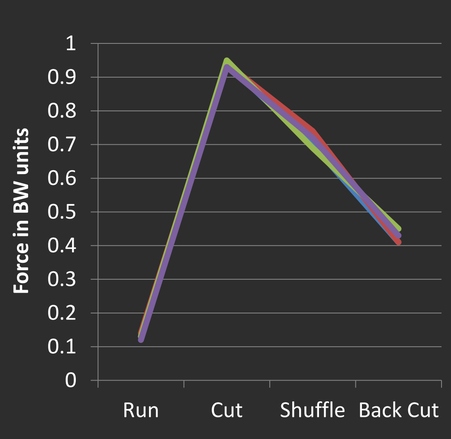

Figure 6: Women Maximal Medial/Lateral Force

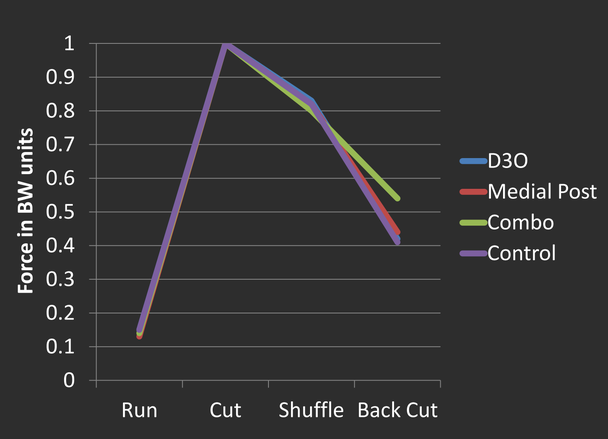

Figure 7: Men Maximal Medial/Lateral Force

Jump:

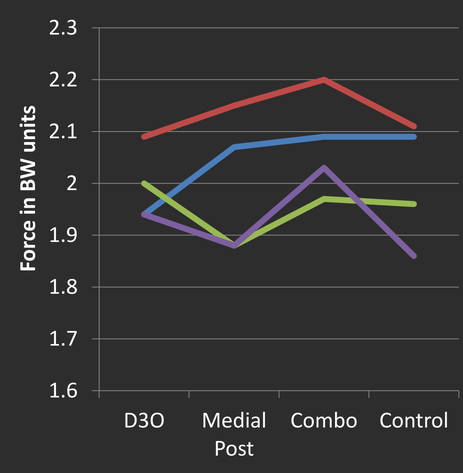

Figure 8: Maximal Vertical Force

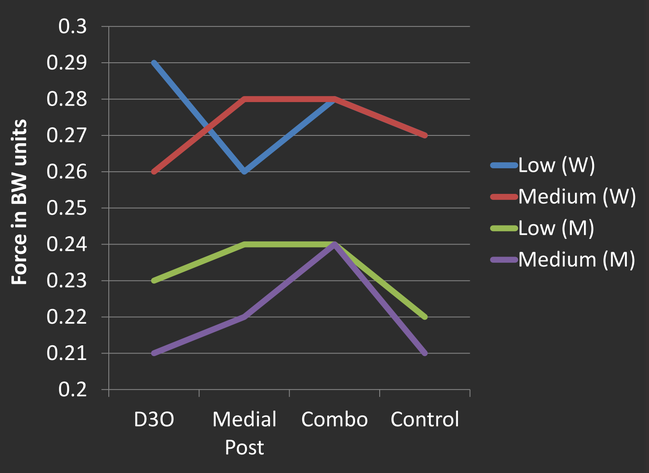

Figure 9: Maximal Medial/Lateral Force

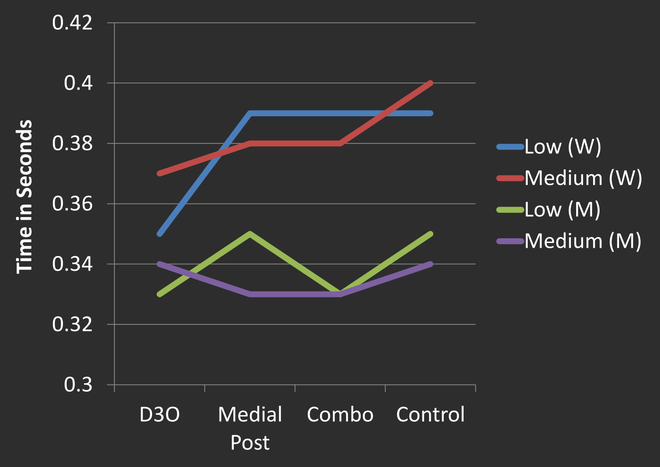

Figure 10: Total Contact Time

Shoes:

Four different shoes were used in this experiment. All shoes were made in Women's size ten (Men's size eight). Prototype shoes are made in only one size to reduce preliminary overhead on projects. The four shoes were:

- **Control**: a typical *Nfinity* volleyball shoe currently on the market
- **Medial Post**: a shoe with a constructed mid-sole to reduce valgus
- **D3O**: a shoe with a mid-sole contructed to increase jumping capabilities
- **Combo**: a shoe with a combination of both the Medial Post and D3O shoes

**Due to signing of non-disclosure agreement, specifications of shoes cannot be discussed*

Discussion

Ground reaction forces (GRF) provide insight into the amount of stress and impact placed on the lower body during activity. In the locomotive portion of the study, no differences were found between the shoes or gender in both the vertical and medial/lateral forces. However, during the jumping portion, significant gender differences were observed in contact time and medial/lateral forces. In females, jumping data showed that the D3O shoe yielded less contact time with less velocity. Although this is counterintuitive, it could suggest that the D3O shoe allows athletes to jump quicker and with less force while attaining the same performance standards. The Medial Post shoe controlled the increased medial/lateral forces that are generated from increased female valgus at the knee. When considering both the locomotive and jumping results together, it could suggest that the shoes work in their respective ways while maintaining normal GRFs during running and agility type activities.

Conclusion

Prototype shoes seemed to effect GRFs while landing from a jump but did not alter GRF characteristics during running and agility movements.

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Acknowledgements

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