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 midsole design has an effect on ground reaction force characteristics during running, cutting, and jumping. Subjects participated in a prospective, randomized, single-blind study. Subjects were 18 healthy female (73.6±7.5 kg, 1.67±0.08 m) or 18 healthy male (79.5±7.3 kg, 1.83±0.02 m) current or recently graduated NCAA Division III athletes voluntarily participated in this study.

Subjects wore shoes with different midsole designs while performing five different actions: running, cutting, shuffling, back cut and plyometric jumping. No significant differences were found between the shoes or gender in both the vertical and medial/lateral forces. In females, jumping data showed that the D30 shoe yielded less contact time with less velocity. Prototype shoes seemed to affect GFRs 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 et al., 2003; Ford, Myers, & Hewett, 2003). 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, Myers, Kornzeke & 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; Lueth, Frederick, Hayes & Nigg, 1989; Russelli, Palmeir, 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 midsole design has an effect on ground reaction force characteristics during running, cutting and jumping motions.

Method

Twenty-two apparently healthy female (73.6±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 repercussions 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 midsole 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 with the foot laterally placed and stepped off the box with the 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.

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 D30 shoe yielded less contact time with less velocity. Although this is counterintuitive, it could suggest that the D30 shoe allows athletes to jump quicker and with less force while attaining the same performance standards.

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 infinity volleyball shoe currently on the market
- Medial Post: a shoe with a constructed midsole to reduce valgus
- D30: a shoe with a midsole contracted to increase jumping capabilities
- Combo: a shoe with a combination of both the Medial Post and D30 shoes

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

Conclusion

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