THE ROLE OF SHOE SOLE DUROMETER ON JUMPING KINETICS

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INTRODUCTION

Insoles and shoe modifications have been used to enhance athletic performance. Adding carbon fiber insoles is the most common shoe modification (Gregory et al., 2018; Selish et al., 2015; Stefanyshyn & Nigg, 2000; Stefanyshyn & Fusco, 2016; Stefanyshyn & Wannop, 2016). Another modification that has been tested is the inclusion of elastic bands to the forefront of the shoe (Chen et al., 2014), or changes made by the manufacturer to the shoe itself. One example of this is the impregnation of thermoplastic polyurethane in between the midsole and outsole of the shoe (Tinoco et al., 2010).

Increasing the stiffness of shoes with carbon fiber insoles has been shown to improve sprinting times by 1.2 percent (Gregory et al., 2018). The stiffness of shoe soles has been linked to a 2.5 percent increase in jump height and reduced fatigue (Gregory et al., 2018). Additionally, increased shoe sole stiffness has also been shown to improve multi-directional sprints and cutting by up to 1.4 percent (Tinoco et al., 2010).

Durometers were used to assess the density of heel cushioning and how this property changes as the shoe ages (Cornwall & McPoil, 2017). A durometer was also used to evaluate the composition of the midsole and it's effect on ankle eversion (MacLean et al., 2009). However, no study has used a durometer to assess the ball and heel regions of the shoe or to assess the role of shoe sole density on jumping performance. Furthermore, no study has assessed or published data regarding the reliability of using durometers to assess shoe sole characteristics.

The purpose of this study was to investigate the relationship between heel sole density, toe sole density, and the GRF and RFD during the CMJ. This study also sought to assess the reliability of using a durometer to assess shoe soles.

METHODS

Twelve men (mean ± SD; age = 23.5 ± 3.9 years) volunteered for this study and provided informed consent. This study was approved by the Institutional Review Board. Additional subject information is shown in Table 1.

Subject heel sole density (HD) and toe sole density (TD) were assessed via durometer (Model 52-50546, Longacre, Booneville, IN, USA). Subjects wore the basketball or tennis shoe of their choice, resulting in shoe heel and toe durometer differences of 20.97% and 22.59%, respectively, across all of the subject's shoes. Subject's shoes included manufacturer's insoles and no aftermarket orthotic devices. Durometer values were obtained consistent with previously published methods (Cornwall & McPoil, 2017).

Subjects then performed two trials of countermovement jumps. The test exercises were performed on a force platform (BP 6001200, Advanced Mechanical Technologies Incorporated, Watertown, MA, USA), which was countersunk and mounted flush to the floor The force platform was calibrated prior to the testing session. Data were acquired at 1000 Hz and analyzed in real time with proprietary software (BP 6001200, Advanced Mechanical Technologies Incorporated, Watertown, MA, USA). The GRF and RFD were obtained from the take-off phases of the force-time record for each of the CMJ. These data were obtained and reduced based on previously published methods (Jensen & Ebben, 2007).

A Pearson's bivariate correlation analysis was performed using a statistical software (SPSS 26.0, International Business Machines Corporation, Armonk, New York) to determine relationship between HD, TD, GRF, and RFD. The trial-to-trial reliability of each dependent variable was assessed using average measures Intraclass correlation coefficients (ICC) and a repeated measures analysis of variance. Coefficients of variation were also calculated. The a priori alpha level was set at $p \leq 0.05$.

Table 1. Subject descriptive information (mean ± SD).

Mass (kilograms)	89.68 ± 10.66
Height (centimeters)	183.93 ± 8.58
Resistance training experience (number of days per week)	1.66 ± 1.61
Plyometric training experience (number of days per week)	0.58 ± 1.08
High school sports (total number of sports played)	1.41 ± 0.79
High school sport (years of participation)	5.33 ± 1.23
College intramural sport (years of participation)	3.00 ± 1.41
College varsity sport (years of participation)	0.41 ± 1.16

RESULTS

For the HD, no correlation was observed for GRF (r = -.22, p = .50) or RFD (r = -.14, p = .67). For the TD, no correlation was observed for GRF (r = -.29, p = .37) or RFD (r = -.28, p = .37). Average measure Interclass correlation coefficients for the heel and toe durometer were .95 (p = .69) and .92 (p = .53), respectively. Coefficients of variation for the heel durometer and toe durometer were 5.83% and 5.72%, respectively.

DISCUSSION

This is the first study to use a durometer to assess the density of the heel and toe regions of the shoe, and assess the relationship between sole density, GRF, and RFD, during the CMJ. Other studies have assessed the effects of shoe insoles on jump height, (Gregory et al., 2018; Selish et al., 2015; Stefanyshyn & Nigg, 2000; Stefanyshyn & Fusco, 2016; Stefanyshyn & Wannop, 2016) and the effect of shoe mid-sole durometer on lower extremity dynamics during running (MacLean, Davis & Hamill, 2009). Data from the current study shows that there is no relationship between HD and GRF or RFD, as well as TD and GRF or RFD.

Other research examining the role of shoe properties and modifications in improving performance has produced mixed results. Some research failed to find any advantage associated with different types of shoes or the addition of aftermarket insoles. For example, changes to shoe stiffness had no effect on jump height (Firminger et al., 2019). Other research demonstrated that commercially available insoles, compared to the control shoe condition, did not improve jumping performance (Selish et al., 2015).

In contrast to the aforementioned investigations and the current study, some evidence shows that shoe properties, or modifications of shoes, produce small improvements in performance. Rearfoot eversion velocity was lower in shoes with harder mid-soles (MacLean, Davis & Hamill, 2009). Other research demonstrated that the addition of carbon fiber insoles influenced shoe stiffness, which positively affected jump height during the CMJ (Gregory et al., 2018; Stefanyshyn & Nigg, 2000). Furthermore, carbon fiber insoles,, resulted in a 2.5% improvement in CMJ height, irrespective of gender (Gregory et al., 2018).

The current study demonstrated that the durometer is reliable for assessing shoe sole density. Previous research that used the durometer to assess the effect of shoe wear and endurance performance either did not assess reliability or did not report it (Cornwall & McPoil, 2017; MacLean, Davis & Hamill, 2009). Thus, the current study is the first to determine that the durometer is reliable for assessing shoe sole density.

Future research should further assess the role of shoe sole durometer on performance. This includes assessing shoe sole properties of other areas of the sole, and during other type of activities such as agility performance where a difference in the coefficient of friction may yield an advantage.

CONCLUSION

This study did not reveal any correlation between shoe sole durometer and the kinetics associated with the CMJ. Thus, jumping kinetics do not appear to be mediated by shoe sole density characteristics. Durometers such as the one used in this study are reliable for assessing shoe sole properties.

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