Older Adult Metabolic and Mechanical Energetics Across Slopes with Increased Footwear Bending Stiffness

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Summary

We examined whether increasing footwear bending stiffness via carbon fiber shoe insoles altered older adult metabolic and mechanical energetics during walking across slopes relevant to everyday activities. Our preliminary results suggest a potential slope-dependent effect of footwear stiffening on older adult net metabolic power and highlight mechanical mechanisms that may underly metabolic power reductions.

Introduction

Older adults walk with greater metabolic costs than younger adults [1]. This has been proposed to arise at least in part from ankle joint specific deficits in older adults leading to a shift of energy generation from the ankle joint to the hip [2]. We have previously demonstrated that carbon fiber insoles (CFI) that increase footwear bending stiffness improve ankle joint and muscle mechanics in younger adults [3]. These CFI may therefore be well-suited for counteracting the metabolic and mechanical energetic deficits characterizing older adult gait.

The purpose of this preliminary analysis was to examine how altering footwear stiffness influences older adult gait energetics across slopes relevant to walking in everyday environments. We hypothesized that walking with increased footwear bending stiffness via CFI would reduce older adults' net metabolic power. Given that individuals generate relatively less energy at the ankle joint when walking on slopes compared with level ground [4], we hypothesized that reductions in net metabolic power would be diminished when walking at a decline and incline compared with level ground.

Methods

To date, seven participants (5F/2M, 65.8±3.3 yrs, 66.8±11.8 kg) walked at 1.2 m/s in three footwear stiffness conditions: Shoe Only (NewBalance 880), Shoe+1.6 mm CFI, and Shoe+3.2 mm CFI on three slopes: 5° decline, level, and 5° incline. Net metabolic power was computed using gas exchange rates. Joint work was estimated by time integrating six degrees of freedom joint mechanical power. Differences in net metabolic power and mechanical work (positive and negative) were evaluated using two-way repeated measures ANOVAs and Bonferroni-adjusted post-hoc comparisons.

Results and Discussion

Older adult net metabolic power and joint mechanical work were sensitive to walking slope and footwear stiffness (Fig 1). Despite a non-statistically significant interaction (p=0.124), our preliminary data suggest that increased footwear stiffness may have a slope-specific effect on net metabolic power (Fig 1A). Footwear stiffness also increased the magnitude of negative work performed about the ankle and decreased the magnitude of negative work about the hip (Fig 1B and 1D). Changes in both distal and proximal lower-limb joint mechanics may underlie the preliminary differences seen in metabolic energetics with increased footwear stiffness.

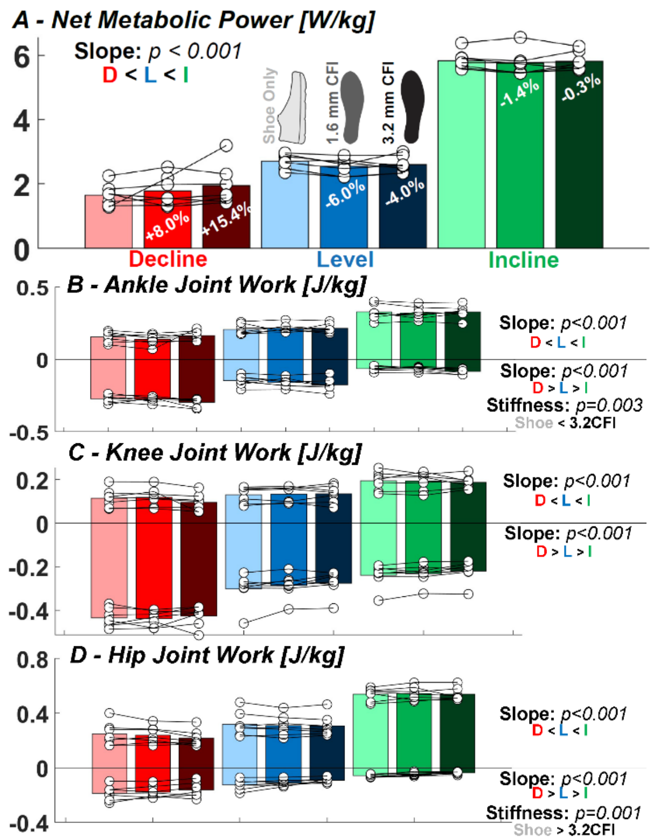

Figure 1: Net metabolic power (A) and joint mechanical work (B-D) during walking at 1.2 m/s on a 5° decline, level, and a 5° incline with increasing footwear stiffness via carbon fiber insoles (CFI). Significant main effects and pairwise differences are presented.

Conclusions

Our preliminary results suggest that increasing footwear stiffness can reduce metabolic costs during level walking in older adults and may therefore help improve older adult gait.

Acknowledgments

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