Older Adults Who Redistribute Joint Work Proximally During Walking Are More, Not Less, Metabolically Efficient

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Summary

The "distal-to-proximal shift," an age-related redistribution of propulsive gait kinetics away from the ankle toward the hip, has been suggested to contribute to a greater metabolic cost of walking (CoW) in older adults. This study compared CoW between young adults, older adults who exhibit a distal-to-proximal redistribution (O_R), and older adults who do not (O_{NR}). CoW for O_R was not different than young, while O_{NR} had significantly greater CoW compared with young.

Introduction

A greater CoW is well-documented in older compared with young adults [1] and is likely a catalyst for age-related mobility loss. Proximal redistribution of joint work during gait has been suggested as a contributor to greater CoW in aging [1,2]. However, evidence to support this link is limited and no prior work has investigated CoW in older adults while stratifying by lower extremity work distribution during gait. This study aimed to assess CoW differences between young adults, O_{NR}, and O_R during a 30-minute treadmill walk (30MTW). We hypothesized that O_R would display significantly increased CoW during the 30MTW, compared to young and O_{NR} groups.

Methods

Forty participants provided informed consent and were included in this study (Table 1). Overground gait analysis was performed prior to a 30MTW at preferred walking speed. The 30MTW included three one-minute challenge periods (3% incline) at minutes 7, 14 and 20.

Table 1: Descriptive Data. Preferred walking speed - PWS; Redistribution ratio - RR; mean ± SD.

	n	**Age** years	**PWS** $m \cdot s^{-1}$	**RR** ratio
Young	11 (3F)	35.6 ± 3.4	1.42 ± 0.23	0.56 ± 0.18
O_{NR}	15 (11F)	73.7 ± 3.4	1.46 ± 0.12	0.66 ± 0.10
O_R	14 (8F)	73.4 ± 3.1	1.41 ± 0.13	1.03 ± 0.24

Lower-extremity kinematics from five overground walking trials were calculated using the point cluster marker technique. Joint moments during stance were calculated using inverse dynamics. Kinetic and kinematic data were used to calculate total positive joint work at the hip and ankle during stance. Joint work was used to calculate the redistribution ratio (RR), a ratio of ankle positive work minus hip positive work/(ankle + hip positive work) [2]. Older participants were placed in the O_R group if RR > 0.8, and in the O_{NR} group if RR ≤ 0.8, similar to prior work [2].

The primary outcome variable of this study was average net CoW during the final two minutes of the 30MTW. Net CoW ($mL \cdot kg^{-1} \cdot m^{-1}$) was calculated by subtracting the cost of standing from gross CoW, measured by indirect calorimetry (ParvoMedics TrueOne 2400 Metabolic Cart, Salt Lake City, UT), and normalizing to body weight. One-way ANOVA with post hoc Tukey's test ($\alpha = 0.05$) was used to assess main and groupwise effects, respectively.

Results and Discussion

48% of our sample of older adults were classified as O_R. There was a main effect of group on CoW [$F(2,37) = 5.33$, $p < 0.01$]. Post hoc Tukey's tests indicated that CoW was greater in O_{NR} (0.11 ± 0.02 $mL \cdot kg^{-1} \cdot m^{-1}$) than young ($0.09 \pm 0.01$ $mL \cdot kg^{-1} \cdot m^{-1}$, $p < 0.01$), with no difference in CoW between young and O_R (Figure 1). Thus, in contrast to our hypothesis, the distal-to-proximal shift did not increase CoW in older relative to young adults.

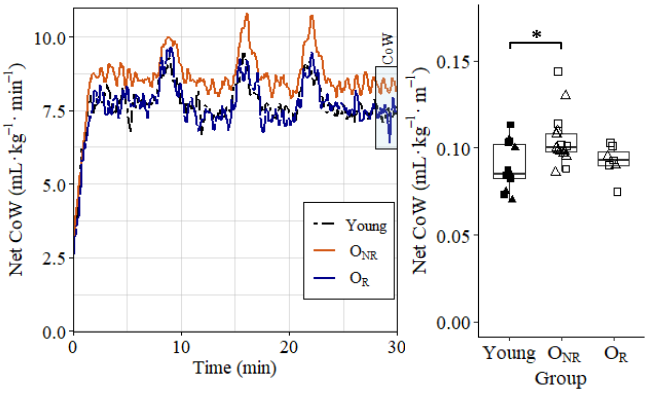

Figure 1: (Left) Group mean net CoW during 30MTW. Box denotes data used for discrete CoW calculation. (Right) Boxplots comparing discrete measures of net CoW. Squares = male, triangles = female, open = young, and closed = older. *post-hoc Tukey's test significant ($p < 0.05$).

Conclusions

This novel analysis revealed that the metabolic CoW is greater for older adults who *do not redistribute* propulsive joint kinetics proximally compared with young adults during a 30MTW. In contrast, older adults who exhibited the distal-to-proximal shift did not have a difference in CoW compared with young adults. These findings challenge current notions regarding the effects of the distal-to-proximal shift on CoW in aging [1,2].

Acknowledgments

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References

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