Lower Extremity Joint Kinetics of Older Adults: A Comparison of Straight-Line Gait and Turn Strategies

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Summary

Turning while walking, a common activity of independent daily living also poses a fall risk for older adults. Lower-limb joint kinetics, specifically the net joint moments (NJM), vary between different turn strategies and walking straight. Compared to straight-line gait, step turns were associated with greater ankle external rotator and knee adductor NJM, whereas spin turns did not exhibit greater NJM.

Introduction

Turning while walking accounts for up to 50% of all steps [1], and falls during turns are ~8x more likely to cause hip fracture than straight-line gait (SLG) [2]. Thus, the purpose of this study was to characterize how healthy older adults modulate their lower extremity control during turns vs. SLG. We hypothesized that turns vs. SLG would be associated with greater frontal and transverse plane lower extremity NJM.

Methods

Healthy older adults (n=16; 70.9 ± 5.58 years) volunteered for this research in accordance with the IRB. Optical motion capture (Optitrack, 250 fps) and four hidden in-ground forceplates (Bertec, 1000 Hz) were used. Results are reported for the first three participants who had footfalls directly within a forceplate's boundaries (though efforts are ongoing to process additional existing participant data). Participants performed 12 SLG trials and 12 90-degree leftward turns. Turn "strategy" was determined by the footfall closest to the intersection [3]: if it was the left, it was a "spin turn," and if it was the right, it was a "step turn." Segment parameters were estimated using Dumas et al. [4]. NJMs are reported with an internal perspective, normalized to body mass, and expressed about each distal segment during the footfall closest to the intersection, from heel-strike to toe-off (**Figure 1**). A two-tailed paired sign test was used to evaluate the differences in maxima (max) and average NJM between SLG, Step, and Spin in each anatomic plane of the lower-limb joints (α=0.05).

Results and Discussion

Ankle: During step turns, there were significantly larger max (p=0.045) and average (p=0.041) external rotator NJM than SLG. In contrast, during spin turns, there were significantly smaller max (p=0.026) and average (p=0.015) external rotator NJM than SLG. Knee: There were significantly smaller max flexor NJM during step turns than SLG (p=0.006). In the frontal plane, there were larger max adductor moments during step turns than during SLG (p=0.001). This is sensible for a step turn, where the knee adductor NJM could facilitate body lean towards direction of the turn. Hip: Spin turns had smaller max flexor (p=0.034) and adductor (p=0.006) NJM than SLG. This smaller max hip adductor NJM could be associated with avoiding rightward translation of the COM during a left foot stance phase, as prior work demonstrated that spin turns exhibited smaller distances between the COM and lateral (left) edge of the left support foot during leftward turns [5].

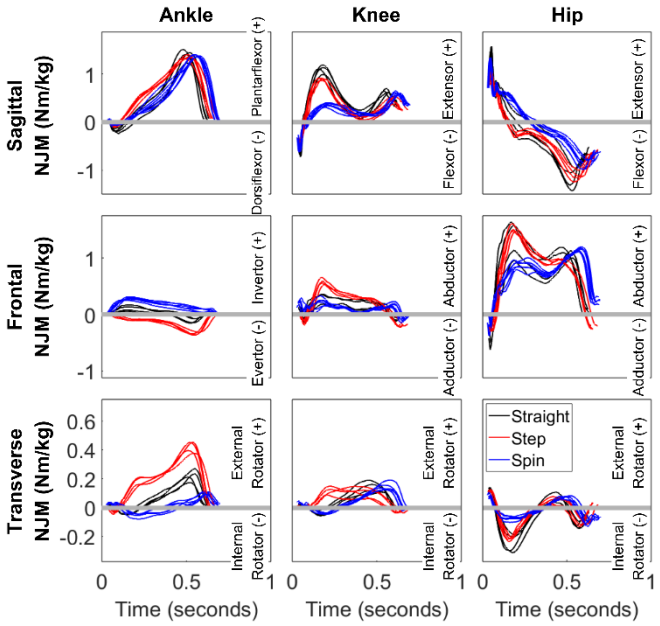

Figure 1: Time series of lower-limb internal NJM for SLG (black), step (red), and spin turns (blue) across trials for one participant.

There were no significant differences in the footfall duration across tasks. These findings are limited by the sample size. We will expand to include more participants and investigate contexts for altered NJMs (e.g., relate NJM to balance states, ground reaction force alterations, etc.).

Conclusions

Step turns were associated with greater ankle external rotator and knee adductor NJM vs. SLG. In contrast, spin turns were not associated with greater NJM vs. SLG in any joint or anatomic plane. Older adults control lower-limb joint kinetics differently in SLG, step, and spin turns, prompting further investigation of how older adults can safely utilize these turn strategies in daily life.

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