AGE EFFECTS ON LATERAL STABILITY DURING STEPPING

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INTRODUCTION

Stepping is a common balance recovery strategy that has been studied extensively in the literature. Age-related changes in the stepping strategy have been investigated using a variety of balance perturbation methodologies; however, age effects on lateral stability appear to be consistent across testing paradigms. Specifically, older adults often take steps designed to preserve lateral stability, as evidenced by large components of medial-lateral step length [1,2] and center of mass displacement [3]. Similar results have also been reported during quiet stance and gait activities [4,5]. These studies and others focus on kinematic features of lateral stability; however, there has been little work done to investigate lateral stability from a kinetics perspective, particularly during the strength-intensive landing phase of a protective step. Therefore the purpose of this study was to investigate age effects on kinetic as well as kinematic measures during the landing phase of a balance-restoring step response. We hypothesized that an age-related tendency to use steps more optimized for lateral stability, as quantified by increased peak lateral ground reaction forces and lateral components of step length, would be observed.

METHODS

Participants. Twelve young (YA) and thirteen older (OA) adults participated after providing written informed consent. All participants were free from recent lower extremity fractures, head injury, or neurological disease.

Procedure. All participants performed balance recovery maneuvers facilitated by release from a forward-leaning configuration. The lean magnitude was large enough to ensure all participants required a forward step to regain balance. Participants were instructed to take a single step with the right leg following release. Each participant completed a total of seven trials of the stepping task.

Measurements. Height and weight were recorded for each participant. Foot-floor reactions were captured from the landing location of each stepping trial using a force platform (AMTI, Watertown, MA, USA). Kinematic data was captured from a reflective marker placed on the second metatarsal using a motion capture system (Vicon, Los Angeles, CA, USA). Force and motion data were synchronized and captured at sampling rates of 1000 Hz and 120 Hz, respectively.

Data Analysis. Outcome variables included peak landing phase medial ($F_{\text{Medial}}$) and lateral ($F_{\text{Lateral}}$) ground reaction forces; and medial-lateral ($L_{\text{ML}}$) and anterior-posterior ($L_{\text{AP}}$) components of step length. Peak medial and lateral ground reaction forces were defined as the extreme positive and negative values, respectively, of medial-lateral force recorded after the step foot landing event. Step lengths were defined as the net medial-lateral (ML) and anterior-posterior (AP) distances traveled by the step foot metatarsal marker between liftoff and landing events. To correct for differences in participant size, force and step length outcome variables were normalized to participant body weight and height, respectively. All data were processed with MATLAB (The MathWorks, Natick, MA, USA).

Statistical Analysis. Independent samples t-tests were performed on participant aggregates, using a Bonferroni correction to compensate for multiple comparisons. Significant age group
differences were identified by Bonferroni-corrected p-values ≤ 0.05.

RESULTS AND DISCUSSION

Independent samples t-tests revealed significant age-related increases in $F_{\text{Lateral}}$ (Figure 1; corrected p<0.05) and $L_{\text{ML}}$ (Figure 2; corrected p<0.05).

Our first result suggests an age-related tendency to use a balance-restoring step response characterized by larger laterally-directed peak ground reaction forces. This finding supports our first hypothesis that older adults would configure their landing phase kinetics for optimal lateral stability. This finding is also consistent with previous studies demonstrating an age-related tendency to preserve lateral stability [2,3]. Our second finding demonstrating an age-related increase in $L_{\text{AP}}$, but not $L_{\text{ML}}$, is inconsistent with our hypothesis and with studies reporting larger lateral step lengths among OA [1,2]. This unexpected finding may be related to our requirement that all participants take single steps to restore balance. Since OA are more likely to use multiple steps [1], they may have used larger-than-natural AP step lengths to ensure successful balance recovery with a single step.

CONCLUSIONS

This study demonstrates an age-related increase in the lateral ground reaction landing force during a balance-restoring step response, suggesting a strategy used by OA to optimize lateral stability. The unexpected absence of age-related differences in ML step lengths is likely related to instructional constraints placed on the number of steps taken.

REFERENCES