FOOT ELEVATION AND WHOLE BODY MEDIAL-LATERAL SWAY IN ELDERLY PATIENTS WITH BALANCE DISORDERS

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INTRODUCTION

Falling to the side has been found to be an important risk factor for hip fracture (Greenspan et al., 1998). Additionally, imbalance and tripping over obstacles have been confirmed as two of the most common causes of falls in the elderly (Tinetti et al., 1989). An increased understanding of the factors influencing falls in the elderly should help reduce the risk of falls, thereby limiting the number of debilitating injuries suffered later in life.

Imbalance of the whole body during obstacle crossing may cause inappropriate movement of the lower extremities or misplacement of the swing foot, which can consequently lead to a foot-obstacle contact and result in a fall. Anterior-posterior and vertical displacements of the whole body center of mass (COM) were shown to increase in young adults while negotiating obstacles of increasing height (Chou et al., 2001). However, no significant increases in medial-lateral (M-L) displacement (sway) and peak velocity were noted, possibly indicating a successful control strategy used to maintain M-L balance during obstacle crossing. This suggests that differences in M-L motion of the COM while negotiating obstacles might serve as an effective indicator to distinguish individuals at risk for sideways falling from healthy individuals. Therefore, the purposes of this study were to determine if elderly patients with balance disorders display greater M-L sway and peak M-L velocity of the COM as compared to healthy elderly while negotiating obstacles and whether increases in M-L sway and peak velocity are influenced by foot elevation during obstacle crossing.

METHODS

Eleven subjects, including five healthy elderly adults (mean age, 70.4 years) and six elderly patients with imbalance (mean age, 75.7 years), were recruited for this study. Whole body kinematic data were collected from each subject using a six-camera ExpertVision™ system (Motion Analysis Corp., Santa Rosa, CA) during unobstructed level walking and when stepping over an obstacle of height corresponding to 2.5%, 5%, 10%, or 15% of the subject’s height. All trials were conducted at a comfortable self-selected walking speed while barefoot. The order of obstacle height was randomly selected.

A 13-link biomechanical model of the body was used to compute the kinematics of the whole body’s COM. The 3-D trajectory of the whole body’s COM was computed from the weighted sum of the segmental COMs. Linear velocities of the whole body’s COM were computed using the GCVSPL algorithm (Woltring, 1986). Correlation analyses were performed between foot elevation (vertical position when toe crosses
obstacle, relative to ground), M-L sway of the COM, and between foot elevation and peak M-L velocity of the COM. A two-way ANOVA with repeated measures of obstacle height was used to test for group differences for these variables.

RESULTS AND DISCUSSION

Group differences were identified in both M-L sway and peak M-L velocity (p=0.025 & p=0.02, respectively) across all obstacle heights. Patients with imbalance demonstrated greater sway and peak velocity while crossing obstacles of all heights, indicating higher risk for M-L instability. M-L displacement (sway) and peak M-L velocity of the COM did not show significant increase for either group when obstacle height increased.

Significant group mean differences (p=0.04) in toe-obstacle clearance of the leading limb (normals=12.9cm, patients=16.0cm) were found. Mean toe-obstacle clearances of the trailing limb were also greater in the patient group (normals=15.0cm, patients=16.7cm), but not significantly. Toe-obstacle clearances of both limbs did not differ significantly across obstacle heights. Increased toe-obstacle clearance as exhibited by the patient group may indicate a risk-avoidant strategy in which the patient attempts to ensure obstacle clearance by increasing foot elevation.

With increased foot elevation of the leading limb, M-L sway and peak M-L velocity of the COM also increased for both groups combined (see Figure). Although these correlations were not significant, the trends of increasing M-L sway (p=0.065) and peak M-L velocity (p=0.12) with foot elevation indicate a potential for significance, with increased sample size.

SUMMARY

The finding that COM M-L sway and peak velocity were significantly greater in the patients with imbalance than the healthy group provides insight into identification of dynamic instability. Results from this study indicate a trend of M-L sway and peak velocity increasing as the foot is progressively elevated to cross obstacles. As more elderly gait is analyzed using this protocol, a distinction between healthy elderly subjects and those at risk for falling may become more evident.

REFERENCES


Figure. M-L COM sway and peak velocity as functions of leading foot elevation.