ASYMMETRIC STABLITY MARGIN OF POSTURAL RESPONSES TO PERTURBATION IN UNILATERAL TRANSTIBIAL AMPUTEES

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INTRODUCTION

Falling is an important clinical problem in amputee population. Among community living people with lower extremity amputation (average age 62 ± 15.7 years), 52% have fallen in the past 12 months (Miller 2001). In unilateral transtibial amputees, increased postural sway in quiet standing and asymmetric EMG reactions in anticipatory postural adjustments to rapid arm raises have been previously identified (Fernie and Holliday 1978, Aruin et al. 1997, Isakov et al. 1992, Hermodsson et al. 1994, Buckley et al. 2002, Aruin et al. 1997).

However, there have been no prior studies of examining dynamic postural responses to perturbations in the amputee population. Reactions to support-surface perturbation have been a useful tool in advancing our understanding of basic postural control mechanisms, as well as for quantifying postural control deficits in various clinical populations such as Parkinson's disease (Horak et al. 2005).

The goal of this study is to quantify directional deficits in postural control in individuals with unilateral transtibial amputation. We used the concept of *stability margin*, which is the difference of peak center of pressure (COP) and center of mass (COM) displacement, to characterize directional stability in response to multiple directions of support-surface perturbations in the horizontal plane.

METHODS

Four subjects with unilateral, traumatic, transtibial amputation and four able-bodied subjects as a control group we recruited. Subjects were instructed to stand quietly with their arms crossed on the perturbation platform and were presented with a randomized set of support surface perturbation in the horizontal plane. We collected five replicates of each of the 8 perturbation direction (0º, 45º, 90º, 135º, 180º, 225º, 270º, 315º). Kinematic, kinetic and EMG data were recorded.

CoP and CoM trajectories were calculated from kinematic and kinetic data. For each subject we found the average peak CoP and CoM for each perturbation direction. Stability margin for each subject was computed as the difference of the peak COP and COM in each direction. Data from right-side amputees group was reflected, so that the left side could be considered the amputated side for group analyses.

RESULTS AND DISCUSSION

We found no significant difference between the peak COP or COM in the amputee vs. the control group in all directions ($p > 0.19$).

However, an asymmetric stability margin was found in amputee group. The stability margin of the control group is symmetric and round shape (Figure 1A); however, stability margin of amputee group is asymmetrical (Figure 1B).

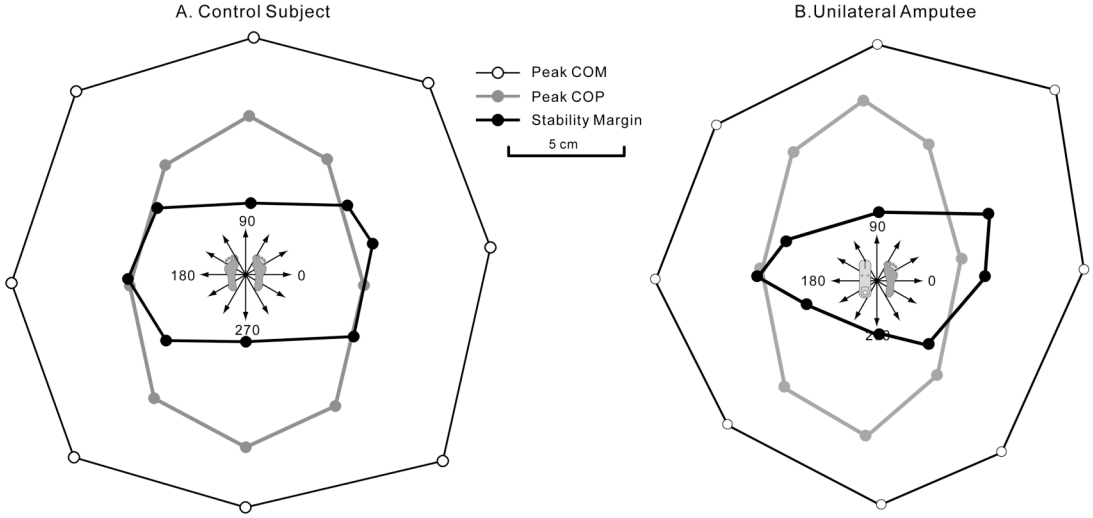

Figure 1: Peak CoP, Peak CoM, and stability margin of an individual in the A) control group and B) unilateral transtibial amputee group

Surprisingly, the stability margin in anterioposterior and mediolateral directions in amputee group was not significantly different from controls. However, stability margin was significantly reduced in the diagonal directions when the amputated side was loaded (Figure 2, 45° and 315° perturbations, $p < 0.05$).

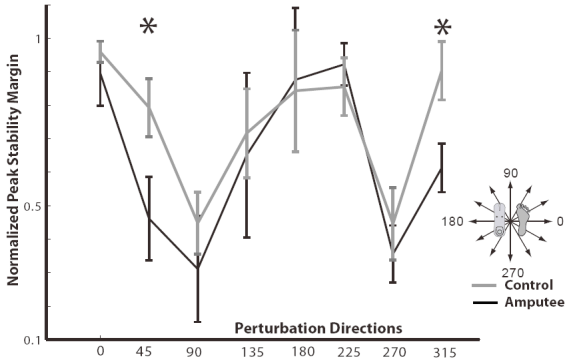

Figure 2: Stability margin as a function of perturbation direction for control group (gray lines) and amputee group (black lines). Stability margin in significantly les in the diagonal perturbation direction where the amputated side is loaded (45º, 315º, *p<0.05)

CONCLUSIONS

Our results show that the stability margin in amputees is reduced in diagonal directions where the amputated side in loaded and the intact side is unloaded. This reveals directions of postural instability which may be important in the fitting and training patients with prostheses. Surprisingly, we also showed that stability margin was not significantly reduced in the anterior-posterior or medial lateral directions.

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