INTRODUCTION

Balance during walking is of high importance to transtibial amputees (Legro, 1999) and its assessment is a fundamental consideration in prosthetic rehabilitation.

The margin of stability (MOS) is a measure of dynamic balance, adapted from traditional static base-of-support measures to account for center of mass (COM) motion during movement (Hof, 2004) via the addition of an inertial term, the Extrapolated Center of Mass (XcoM).

We hypothesized that changes in balance over a 3 week adaptation period with a new prosthesis would differ in the mediolateral (MOSML) and anteroposterior (MOSAP) depending on the individual’s prescribed Medicare functional level. Specifically, improvements in balance would be exaggerated when adapting to a foot of a lower activity level than that of the person’s correct functional level.

METHOD

Subjects: 21 unilateral transtibial amputees (27-76 yrs; 1.78 (0.81) m; 100.6 (18.8) kg; etiology traumatic (n=13), vascular (n=5), other (n=3)) participated in a randomized crossover trial. All subjects were previously categorized as K3 or K4 and appropriately wore high activity feet with their personal prostheses.

Procedures: Participants were tested on two foot components rated ‘higher activity’ (HA) (i.e. energy-storage-and-return type feet) and ‘lower activity’ (LA) (e.g. SACH) with order of provision randomized. A new foot component was provided and aligned by a certified prosthetist at the initial session (V1) after which participants immediately undertook baseline gait assessment. Retroreflective markers on the lower limbs and pelvis were recorded during ten traverses at self-selected walking speed using a 12-camera motion capture system (60 Hz; Motion Analysis Corp.). After 3 weeks, participants returned for a repeat assessment (V2). The foot component was then swapped for the other category foot and the repeat assessment (V2). The foot component was then swapped for the other category foot and the repeat assessment (V2). The foot component was then swapped for the other category foot and the repeat assessment (V2).

Data analysis: Pelvis and foot markers were used to estimate COM (Hak, 2012) and base of support respectively. MOSML was defined as the minimum distance between the XcoM and the lateral margin of the base of support during movement (Hof, 2004) while MOSAP was the maximum distance that the XcoM was allowed to progress past the base of support prior to heel strike of the contralateral limb. MOSML and MOSAP were examined using a three way repeated measures ANOVA (leg x prosthesis x visit) with Fisher’s LSD post hoc tests.

RESULTS

MOSAP was greater on the sound limb compared to the prosthetic limb for the LA foot. There were significant increases in MOSAP for both limbs from V1 to V2 for the HA foot (Figure 1a). Non-significant changes in MOSML for the HA foot resulted in the elimination at V2 of a significant interlimb difference previously recorded at V1. No such change was seen with the LA foot (Figure 1b).

DISCUSSION

Our hypothesis was not supported given the significant changes in both MOSAP and MOSML across visits that were greater on average for HA. The changes seen however resulted in a more symmetrical MOSML, which may suggest reduced favoring of the sound limb, and an increased MOSAP, possibly indicative of a greater balance confidence. Of clinical relevance, at the initial fitting only the LA foot had significant interlimb differences for MOSAP. Furthermore, at the 3 week period, in contrast to the HA foot, the LA foot showed asymmetries in both directions.

CONCLUSION

Dynamic balance, indicated by MOSML and MOSAP, improved over a 3 week adaptation period on a new prosthetic limb of the individual’s prescribed Medicare functional classification level.

CLINICAL APPLICATIONS

MOSAP may have value as an assessment tool at the initial fitting to determine appropriateness of a device. MOS in both directions may be a valuable assessment tool following 3 weeks of wear time.

REFERENCES


ACKNOWLEDGEMENTS

This work was supported by the Center for Research in Human Movement Variability of the University of Nebraska at Omaha, NIH (P20GM109090) and the Nebraska Research Initiative.