INTERLIMB ASYMMETRIES DURING STAND TO SIT AND SIT TO STAND TASKS IN TRANSTIBIAL AMPUTEES

[1]Abbie E. Ferris, [1]Jeremy D. Smith, [2]Cory L. Christiansen and [1]Gary D. Heise
[1]School of Sport & Exercise Science, University of Northern Colorado, Greeley, CO
[2]Interdisciplinary Movement Science Lab, University of Colorado, Anschutz Medical Campus, Denver, CO
Email: abbie.ferris@unco.edu; website: http://www.unco.edu/nhs/ses/

INTRODUCTION

Patients with unilateral, transtibial amputation (TTA) often exhibit functional asymmetries that clinicians, researchers, and patients often attempt to minimize. Compared to traditional surgical techniques transtibial osteomyoplastic amputation (Ertl) has been suggested to lead to improved functional outcomes following amputation [1]. Using a "bone bridge", the Ertl technique connects the tibia and fibula and seals the medullary canal. In addition the anterior and posterior musculatures are sutured together. This technique commonly results in a healthier residual limb through reduced bone spurs, increased venous return, and reduced incidence of ulcers [1, 2]. It has also been suggested that those who undergo an Ertl compared to a traditional amputation have enhanced "end-bearing" capability of the residual limb [3].

Important to activities of daily living, are sitting and standing tasks. It has been estimated that people with TTA sit-to-stand (STAND) roughly 50 times per day [4, 5]. To date, there has only been one biomechanical study of STAND following TTA [6]. Agrawal et al. found patients with TTA produced 27% more vertical ground reaction force (VGRF) with the intact limb during a STAND movement compared with the prosthetic side. Non-amputee controls, however, exhibited less than 10% asymmetry in vertical ground reaction force during the same movement.

While inter-limb asymmetries have been shown to exist during the STAND task, it is unclear if these asymmetries persist in people who underwent an Ertl amputation. Additionally, to our knowledge no study has evaluated the stand-to-sit (SIT) task in a TTA population regardless of surgical technique. The purpose of this study was to evaluate inter-limb asymmetry in persons who have undergone an Ertl amputation during SIT and STAND tasks.

METHODS

Six persons with unilateral Ertl TTA volunteered (78.9±18.9 kg, 1.75±0.08 m). All participants wore an elastic response prosthetic, had been wearing the same prosthesis for at least 6 months, and were considered K3 or above in functional classification.

Participants performed a five times STAND task as fast as possible. Participants were not allowed to push off with their hands during the task. Seat height was adjusted to the height of each individual's intact fibular head height from the ground during standing. The seat was placed in front of two force plates (2000 Hz) embedded into the ground and each foot was placed on a force plate. Of the five cycles, only the middle three were analyzed to avoid any issues with starting and ending the task. SIT and STAND phases were analyzed separately.

VGRFs were low-pass filtered using a recursive, 4th order Butterworth filter (50 Hz cut-off frequency). Peak VGRF, impulse (Imp), symmetry indices (SI), percent net impulse contribution (PC), and task time were calculated for each task/limb. SI was calculated using the methods of Agrawal et al. [6]:

$$SI = 100 - 100 * \frac{I - P}{(I + P)}$$

The SI indicates the distribution of forces between the limbs, it does not indicate the contribution of each limb to the overall movement. PC was computed using:

$$PC = \frac{Imp_{limb}}{Imp_{int} + Imp_{pros}} * 100$$

where Imp_{limb} is the impulse of the limb being compared; Imp_{int} and Imp_{pros} are the impulses of the intact and prosthetic limbs, respectively.

Between limb differences were evaluated using a MANOVA (SPSS 19.0). A paired t-test was used to evaluate differences in time during the STAND and SIT tasks. Statistical significance was set at $p<.05$.

RESULTS

Amputees took longer to stand up than to sit down (1.05 s vs. 0.87 s, $p=.006$). VGRFs during quiet standing were not significantly different between limbs; however, significant asymmetries were found during SIT and STAND (see Table 1, Figure 1). Impulse SI for both SIT (76%±7%) and STAND tasks (82%±5%) indicated an asymmetry towards increased loading of the intact limb. The PC of the intact limb to the total impulse was significantly greater than the prosthetic limb for sitting (16.4% $p=.008$) and standing (17.5%, $p<.001$) (Figure 2).

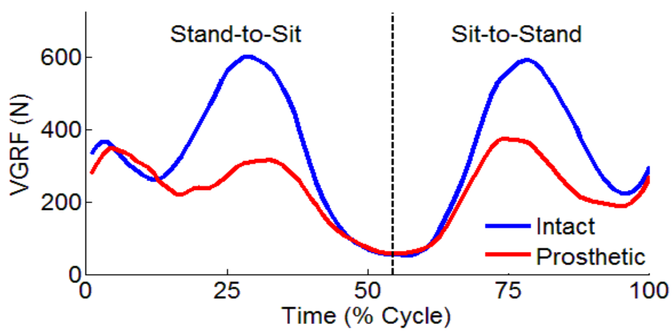

Figure 1. Mean VGRF for the complete trial.

DISCUSSION

During periods of non-movement (Figure 1: 0%, 55%, 100%), loading asymmetry was minimal between limbs. As movement progressed, loading asymmetries increased with more reliance on the intact limb for total force production. The current finding of 76% SI during the STAND task was similar to the results reported by Agrawal et al. [6] (~72-76% during STAND phase). From a force perspective, 62% of the total VGRF was produced by the intact limb in our study. These force discrepancies lead to a functional asymmetry in impulse with the intact limb contributing ~18% more of the total impulse during STAND.

This was the first study to evaluate inter-limb asymmetries during the sitting task in patients with TTA. VGRF asymmetries were similar between STAND and SIT tasks. Even though no significant asymmetries were observed during quiet standing, once movement began, subjects relied on the intact limb for a greater portion of the force production.

Results of our study indicated a significant functional asymmetry during SIT and STAND tasks in persons who received an Ertl amputation. In regards to the number of times this task is completed on a daily basis further understanding of the functional consequences of this loading asymmetry is needed.

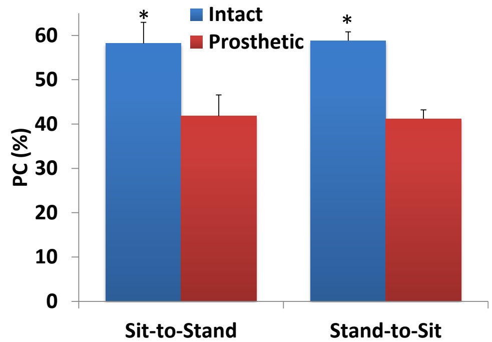

Figure 2. Percent contribution to the task. *Significantly different from prosthetic $p>.05$

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Table 1. Peak VGRFs and Impulse

	Peak Vertical Ground Reaction Force (N)			VGRF Impulse (Ns)	
Limb	STAND	SIT	Quiet Standing	STAND	SIT
Intact	667.5±198.6*	663.0±179.9*	403.9±107.9	341.9±113.5*	290.7±77.9*
Prosthetic	398.1±82.8	458.1±104.9	360.5±85.3	241.6±72.9	201.6±45.9

Note. *Significantly different from prosthetic $p<.05$