ACTIVE DORSIFLEXING PROSTHESIS MAY REDUCE TRIP-RELATED FALL-RISK

INTRODUCTION
A considerable amount of research has focused on reducing falls in older adults, yet little has been directed at reducing falls in amputees. This is not trivial, given that amputee fall at higher rates than their able bodied peers1. For transtibial amputees (TTA) the absence of ankle dorsiflexion muscles may specifically increase the risk of tripping, thereby increasing overall fall-risk. During the swing phase, ankle dorsiflexion muscles act to increase minimum toe clearance (MTC) which is typically small (1-2 cm)2. With decreasing MTC the probability that the swing foot will catch an unseen obstacle increases1, increasing the likelihood of a fall. The likelihood of falling after a trip further increases with walking speed3. The active swing phase dorsiflexion provided by the ProprioFoot® is intended to increase MTC during normal walking4. The ProprioFoot® also provides adaptive dorsiflexion during inclined surface ambulation. Initiating swing from a more flexed position should additionally aid MTC on inclines. The hypotheses tested were that, regardless of speed or incline the ProprioFoot® would: 1) significantly increase MTC and 2) significantly decrease the likelihood of tripping on an unseen obstacle.

METHODS
Ten unilateral TTA subjects, all level K3/K4 ambulators, participated (49.0±12.1 yrs; 93.0±23.1 kg; 1.74±0.10 m). Nine subjects were existing users of conventional prosthetic feet without active dorsiflexion (control subjects) and one used the ProprioFoot®. Four control subjects were tested, then fit with the ProprioFoot® and allowed four weeks to accommodate to it before testing again, for a total of five ProprioFoot® subjects. During testing subjects walked on a treadmill at 0% grade (level) and 5% grade (incline) at three speeds each: preferred and 20% faster and slower than preferred, all while wearing a harness. Subjects walked for at least two minutes at each condition. An 8-camera motion capture system (Motion Analysis) tracked the movements of markers placed on the extremities. Prior to data collection, subjects were allowed to acclimate to treadmill walking and choose their preferred speed (mean across conditions and groups: 0.87±0.20 m/s). For those participating in both groups, speeds were matched for each condition.

MTC was calculated from marker data as the vertical distance between the antero-inferior aspect of the shoe and the treadmill at the instance the swing limb passed anterior to the stance limb, and toe clearance reaches a local minimum. For each subject the mean MTC for each condition was determined. Individual, across-condition averages of these six values were compared between groups using an independent-sample t-test (one value per subject). For hypothesis two, a Likelihood of Tripping Curve was calculated based on the distribution of all MTC values for that group (Figure 2). The coefficients of the best fitting lines were statistically compared to determine if the curves were different from each other.

RESULTS
Across all conditions and speeds, the average MTC for the ProprioFoot® group was significantly greater than that of the control group (Figure 1; 28.5±10.3 mm vs. 16.7±7.4 mm, respectively; p=0.03). The Likelihood of Tripping Curves were significantly different with the ProprioFoot® curve shifted to higher MTC values, indicated reduced likelihood of tripping.

DISCUSSION
Our results support our hypotheses that the ProprioFoot® would significantly increase MTC and decrease the likelihood of tripping on an unseen obstacle. Several studies have suggested a benefit for Propriofoot users during stair and ramp ambulation5,6. However this is based on knee kinetics and kinematics. Our study is the first to suggest increased safety through reduced trip-related fall-risk. It should be noted that interpretation of Figure 2 assumes an obstacle is both unseen and present at the instance of MTC. Given that MTC increases to avoid expected obstacles8, the true likelihood of tripping should account for the probability that an obstacle is unseen and present at MTC. As this would likely influence the groups equally, it should not alter the conclusions drawn from Figure 2. Continuing work will, larger sample sizes and prospective tracking of community based falls. In conclusion the ProprioFoot confers increased safety upon its users.

REFERENCES