Step and Spin Turning in Transtibial Amputees: Functional Effects of a Rotational Unit in a Prosthetic Foot

Merkur Alimusaj
Heidelberg University Hospital

Summary
Ten transtibial amputees were investigated during change of direction indicated by a visual cue after passing a photoelectric switch. A blinded comparison of two conditions with and without full functional rotational unit was performed using a 3D motion capture system.

Introduction
Turning is a mandatory task to move freely within the environment. It has been shown that approximately 50% of the steps indoors can be recognized as a turning manoeuvre [1]. The aim of this study was to evaluate if transtibial amputees (TTA) benefit from a rotational adapter integrated in a prosthetic foot (i.e. Variflex XC Rotate; Össur, Iceland) during a randomized, cued turning task. Repeated measurements with two feet similar in appearance, geometry, category, size and alignment except for a rotational adapter (one foot with fully functional adapter [FA] and one foot with a mechanically blocked „placebo“ adapter [PA]) were conducted to identify differences.

Method (1000)
10 unilateral TTA (45y±17; 178cm±8; 76kg±12) were investigated using the PA and FA foot while turning in a 45° angle, randomly defined either to the left or the right. All TTA were provided with the FA foot, not knowing about the features of the adapter and had two weeks to accommodate prior to measurement. After data collection, the PA foot was additionally fitted. The sequence of PA and FA measurements was randomized and TTA were blinded for the foot investigated. Kinematics and kinetics were collected by means of conventional instrumented gait analysis using a 12 camera system (Vicon) [3]. A photoelectric switch triggered a visual signal indicating randomly the turning direction while walking. In a preliminary study the protocol was validated and data of 10 unimpaired subjects (33y±10y; 179cm±9; 72kg±17) was collected [4]. The protocol of the turning test is based on the work of Kuni et al. [5]. Statistical significance was tested by using Wilcoxon-Signed-Rank test (p<0.05).

Results
The turning manoeuvres were performed either in a step-turn or a spin-turn strategy as previously described in the literature [6]. TTA showed relevant changes in the lower limb positioning while turning when compared to reference subjects. When step-turning they showed a pronounced internal foot rotation. When spin-turning they showed a pronounced external foot rotation while pelvic positioning was not different compared to reference group. The rotational adapter showed significant motion during the turning manoeuvre in both, the spin and the step-turn (p<0.05). This motion led to possibly relevant knee rotation and knee rotation moments. However, no statistical significance was found in the small sample group. Nevertheless, the users feedback for torsion functionality of the FA foot was positive.

Conclusion
To our knowledge there is only one study which had a similar approach but only collected subjective feedback of subjects [2]. Results of the presented study indicate only few statistically significant changes between the PA and the FA foot. However, the changes indicate a slightly reduced rotational motion between socket and stump in FA condition. Relevant changes in gait strategy could be observed comparing TTAs with the non-impaired reference group. It is hypothesized that patients try to position the prosthetic foot towards the turning direction independent of the turning strategy in order to avoid high rotational moments onto the knee and consequently onto the stump-socket interface. A prosthetic component which leads to a reduction of rotational moments at the proximal segment might therefore be beneficial. Results of the FA showed a tendency towards such an effect. Further data analysis has to be done for better understanding of patients’ feedback and the observed effects.

References