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Effects of an active prosthetic ankle during ambulation on stairs and ramps

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Introduction

Conventional prosthetic ankle foot systems are commonly not able to adapt to different conditions, e.g. stairs and ramps. Walking on inclined surfaces or stairs is therefore a particular challenge for a prosthetic user [1]. So the amputee is forced to compensate the deficits of his prosthesis by adapting the kinematics and kinetics of the proximal and the contra lateral joints [2].

The Proprio-Foot™ (Ossur) shall be able to reduce these compensating mechanisms as a result of an adaptive microprocessor controlled ankle [3].

Methods

Twenty non vascular transtibial amputees (49 ± 12 years) underwent a conventional 3D gait analysis (VICON & Kistler) [4]. Kinematics and kinetics of the lower limbs were analyzed during ambulation on an instrumented stair with five steps and an instrumented ramp with an incline of 7.5°. The condition of the adapted ankle was compared to the non-adapted ankle.

For a preliminary analysis, mean values of knee kinematics and kinetics across the gait cycle was calculated (MatLab) and verified by an ANOVA for repeated measurements with SPSS 14.0 ($p < 0.05$) (Table 1). Ultimately, the results will be compared to those of twenty young healthy controls.

Results

Preliminary data of ten participants show significant changes in kinematics and kinetics for the knee in the involved side during ambulation with the adapted compared to the non-adapted prosthetic ankle foot system.

Particularly during ramp and stair ascend, the adaptation leads to a significantly reduced knee extension ($p < 0.05$) and to significantly reduced knee extensor moments in the prosthetic side ($p < 0.02$).

Similar results could be partially found for the knee kinematics when descending the stair ($p < 0.05$). Although patients reported a broad benefit during ramp descend, only a small but not significant difference for the maximum knee extension could be found in the involved side ($p = 0.358$).

Conclusion

The preliminary findings suggest that the prosthetic ankle adaptation leads to more physiological knee kinematics and kinetics in the involved limb during walking on stairs and ramps.

For a final conclusion, complete results of twenty patients in the involved and the contra lateral sides and normal reference data have to be taken into account.

Table 1: Average data (mean± std) of knee extension and knee extensor moments during ambulation on the stair and the ramp for N = 10

	Adaptation	Stair ascend	Stair descend	Ramp ascend	Ramp descend
Knee extension [deg]	ON	0.2 ± 7.9 *	-10.7 ± 4.9 *	-14.2 ± 5.4 **	-13.0 ± 3.2 *
	OFF	2.9 ± 9.7 *	-7.5 ± 5.9 *	-18.2 ± 4.1 **	-13.7 ± 4.1 *
(p-value)		(p < 0.05)	(p < 0.05)	(p < 0.002)	(p = 0.358)
Knee extending moments [Nm/kg]	ON	0.3 ± 0.2 *	0.0 ± 0.2 *	0.6 ± 4.2 *	-0.2 ± 0.1 *
	OFF	0.4 ± 0.2 *	0.1 ± 0.2 *	0.8 ± 2.2 *	-0.2 ± 0.2 *
(p-value)		(p < 0.002)	(p = 0.194)	(p < 0.02)	(p = 0.158)

Level of significance = p < 0.05; * = maximum value; ** = mean value

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