Reference	Thomas Schmalz, Bjoern Altenburg, Michael Ernst, Malte Bellmann, Dieter Rosenbaum. Otto Bock Healthcare GmbH, Hermann-Rein-Straße 2a, 37075, Göttingen, Germany.

Lower limb amputee gait characteristics on a specifically designed test ramp: Preliminary results of a biomechanical comparison of two prosthetic foot concepts

Gait and Posture 68 (2019) 161-167; DOI: 10.1016/j.gaitpost.2018.11.017

Products

Meridium vs. current ESR feet vs. Non-Amputee control group

Major Findings

The results show the advantages of MPF (Meridium, Ottobock) compared to ESR feet and the non-amputee control group:

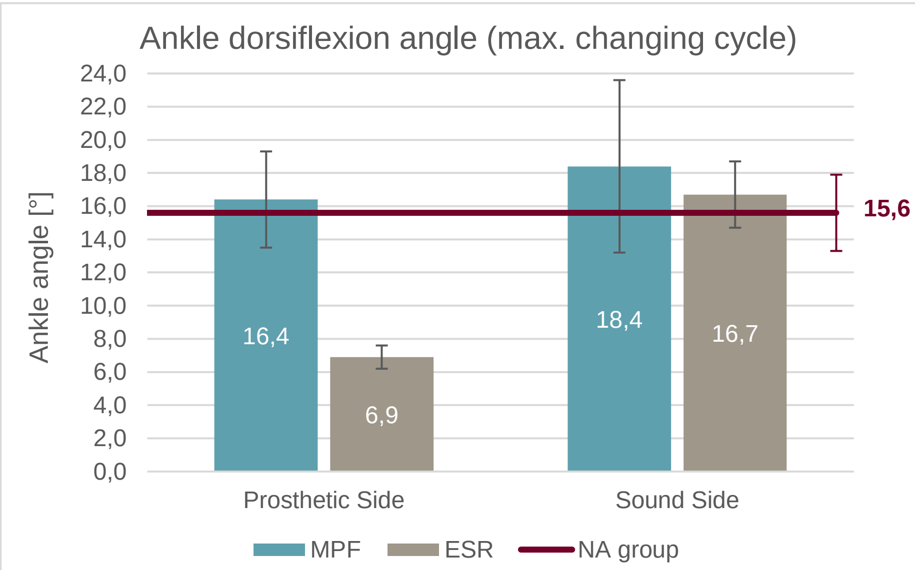
→ **MPF show significant decreased maximal knee extension moment during the changing cycle compared to ESR**

Max. knee extension moment: MPF: 0.42±0.12 [Nm/kg]; 0.71±0.13 [Nm/kg]

→ **MPF show significant increased ankle dorsiflexion angle during the changing cycle compared to ESR**

Max. ankle dorsiflexion angle during changing cycle: MPF: 16.4±2.9°; ESR: 6.9±0.7°

Ankle dorsiflexion angle of MPF is comparable to dorsiflexion angle of NA-group (15.6±2.3°).

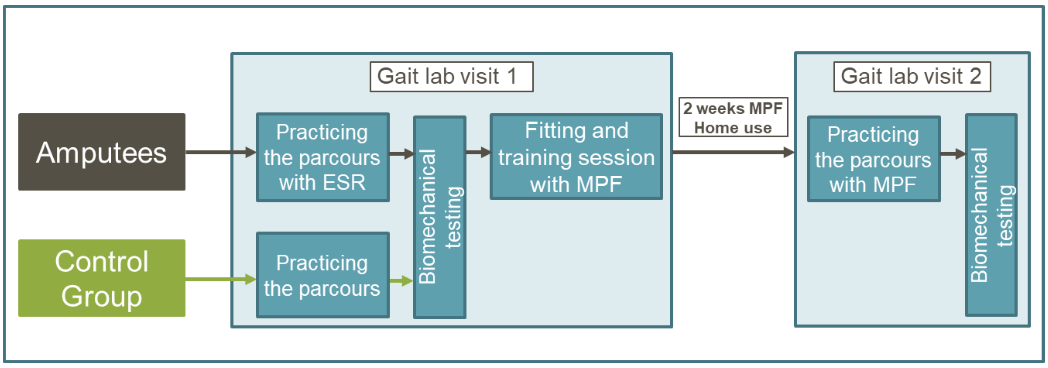


Population

Subjects:	4 male TT amputees; 10 non-amputees as control group (6 males, 4 females)
Previous TT prostheses:	Ottobock prosthetic feet: 1C30 Trias, 1C60 Triton, 2x 1C40 C-Walk
Amputation causes:	trauma (N=3); peripheral arterial disease (N=1)
Mean age:	Amputees: 56±12 years; Control group: 23±3 years
Mean time since amputation:	16.5 ±13.4 years
MFCL:	K3

Study Design

Monocentric prospective interventional study:



The biomechanical measurement took place on a specific ramp to simulate uneven ground. The ramp consists of a "3m downhill (10°) walkway followed by specific uphill and downhill elements with opposite inclination angles of 10°." Kinematic and kinetic gait parameters were measured via a motion capturing system and a force plate which is integrated in the uphill walkway element. Each subject has to repeatedly walk down the ramp until 8 trials with contacting the force plate with the prosthetic side and 8 trials with contacting the force plate with the sound side were measured. In the same way the non-amputee control group performed 16 measurements (8 per side). The last step before the uphill walkway is called preparing cycle (=PC) and the step on the force plate is called changing cycle (=CC).

Results

Functions and Activities						Participation			Environment
Level walking	Stairs	Ramps, Hills	**Uneven ground, Obstacles**	Cognitive demand	Metabolic Energy Consumption	Safety	Activity, Mobility, ADLs	Preference, Satisfaction, QoL	Health Economics

Category	Outcomes	Results for MPF, ESR and NA-Group	Sig.*
Uneven Ground, Obstacle Course	Walking speed [m/s]	MPF: 1.00 ±0.03 ESR: 1.03 ±0.05 NA-Group: 1.19 ±0.04	0
	Stance phase duration during force plate contact [% gait cycle]	MPF: 61.8 ±1.4 ESR: 61.0 ±1.2 NA-Group: 61.4 ±0.03	0
	Ankle dorsiflexion angle [max. CC °]	**Prosthetic side:** MPF: 16.4 ±2.9 ESR: 6.9 ±0.7	++
		Sound side: MPF: 18.4 ±5.2 ESR: 16.7 ±2.0 NA-Group: 15.6 ±2.3	0
	Knee flexion angle [stance CC°]	**Prosthetic side:** MPF: 9.8 ±6.1 ESR: 11.5 ±6.6	--
		Sound side: MPF: 22.7 ±1.6 ESR: 20.7 ±4.9 NA-Group: 21.3 ±4.2	0

Category	Outcomes	Results for MPF, ESR and NA-Group	Sig.*
	Hip extension angle [max. CC °]	**Prosthetic side:** MPF: 17.4 ±3.1 ESR: 10.5 ± 3.4	++
		Sound side: MPF: 11.3 ±5.3 ESR: 9.3 ±3.6 NA-Group: 10.9 ±3.4	0
	Vertical ground reaction force 1st peak [% body weight]	**Prosthetic side:** MPF: 102 ±10 ESR: 106 ±18	0
		Sound side: MPF: 128 ±5 ESR: 127 ±12 NA-Group: 124± 10	0
	Anterior-posterior ground reaction force (min) [% body weight]	**Prosthetic side:** MPF: 13 ±6 ESR: 16 ±9	0
		Sound side: MPF: 19 ±3 ESR: 21 ±3 NA-Group: 18± 4	0
	Anterior-posterior ground reaction force (max) [% body weight]	**Prosthetic side:** MPF: 9 ±4 ESR: 14 ±4	0
		Sound side: MPF: 18 ±6 ESR: 17 ±3 NA-Group: 22± 4	0
	Ankle dorsiflexion moment (max) [Nm/kg]	**Prosthetic side:** MPF: 1.49 ±0.13 ESR: 1.36 ±0.10	0
		Sound side: MPF: 1.56 ±0.31 ESR: 1.46 ±0.08 NA-Group: 1.39± 0.09	0
	Knee flexion moment (max) [Nm/kg]	**Sound side:** MPF: 0.51 ±0.28 ESR: 0.67 ±0.42 NA-Group: 0.52± 0.19	0
	Knee extension moment (max) [Nm/kg]	**Prosthetic side:** MPF: 0.42 ±0.12 ESR: 0.71 ±0.13	--
		Sound side: MPF: 0.46 ±0.12 ESR: 0.38 ±0.08 NA-Group: 0.36± 0.07	0

Category	Outcomes	Results for MPF, ESR and NA-Group	Sig.*
	Knee adduction moment (1st peak) [Nm/kg]	**Prosthetic side:** MPF: 0.28 ±0.19 ESR: 0.29 ±0.19	0
		Sound side: MPF: 0.59 ±0.14 ESR: 0.59 ±0.18 NA-Group: 0.43± 0.10	++ (MPF and ESR compared to NA-group)

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)
CC=changing cycle; PC=preparing cycle

Author's Conclusion

"The results of the present study show that the MPF can facilitate partly normalized walking biomechanics in TT amputees on terrain with changing inclination conditions compared to regular ESR feet. The real-time adaptable ankle joint motion of the MPF seems to be the crucial functionality for a more natural motion pattern and a reduction in sagittal knee joint loading on the prosthetic side. However, the typical increase in knee loading in the medial compartment of the sound side of TT amputees does not appear to be affected by the MPF." (Schmalz, 2019)