Reference

Marie Thomas-Pohl[1], C. Villa[2,3], J. Davot[2], X. Bonnet[3], J. Facione[1], E. Lapeyre[1], J. Bascou[2,3] & H. Pillet[3]

1) Service de Médicine Physique et de Réadaption, Hôpital D'Instruction Des Armées Percy, Clamart, France

2) INI, Centre D'étude et de Recherche Sur L'appareillage Des Handicapés (CERAH), Créteil, France

3) Arts er Metiers Institut de Biomécanique Humaine georges Charpak, Paris, France

Microprocessor prosthetic ankles: comparative biomechanical evaluation of people with transtibial traumatic amputation during standing on level ground and slope

Disability and Rehabilitation: Assistive Technology 2019, DOI: 10.1080/17483107.2019.1629112

Products

Meridium® vs Elan® vs ProprioFoot® vs ESR (usual prosthetic foot of each subject)

Major Findings

With Meridium compared to Elan and ProprioFoot and ESR (usual prosthetic foot of each subject (=UF)

→ **Meridium: significantly higher average dorsiflexion vs. Elan and UF**
The average dorsiflexion for Meridium was -6.2±0.2°.
The maximum dorsiflexion achieved with Meridium and ProprioFoot was 6.6°.

→ **Meridium: significant higher average plantarflexion vs. ProprioFoot and UF compared to the reference position during standing on negative slopes achieved**
The average plantarflexion for Meridium was 6.1±2.7°.
The maximum plantarflexion achieved with Meridium was 8.6° and 9.7 for Elan.

→ **Meridium: No significant increase of the knee moment between standing on level ground and standing on positive or negative slopes**
Increase of the knee moment (app. 10 times) for Elan, ProprioFoot and UF during standing on slopes compared to standing on level ground.

→ **Meridium: Only small increase (3%) of the CoP trajectory while comparing standing on level ground and standing on slopes**
The increase of the CoP trajectory for UF and ProprioFoot was 15% and 12% on positive and negative slopes. The Cop trajectory increased 20% on positive slopes and 12% on negative slopes for Elan (see Figure 1 below).

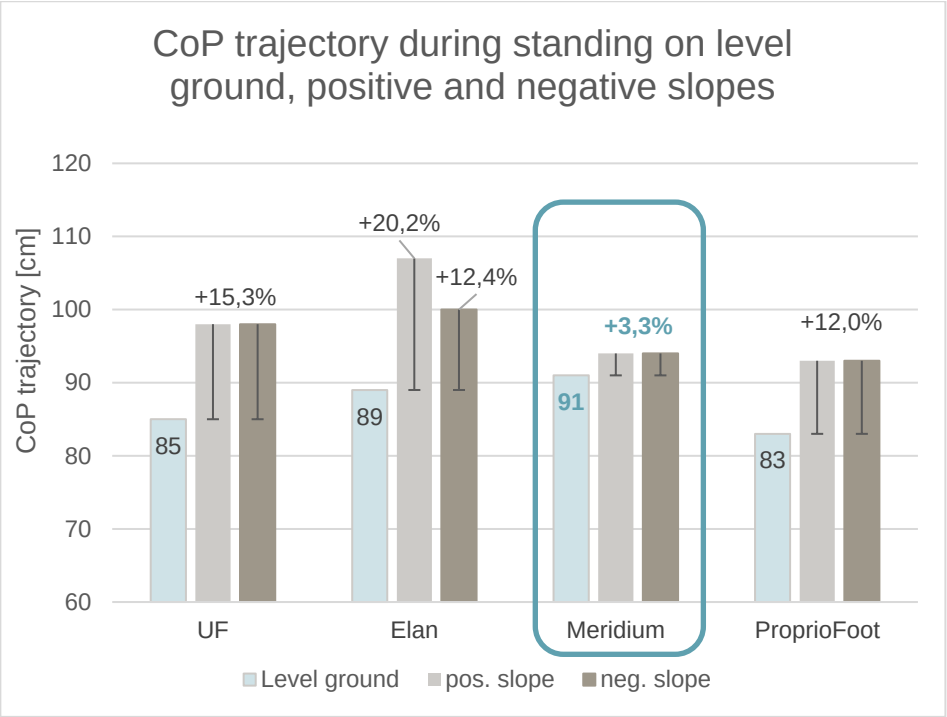


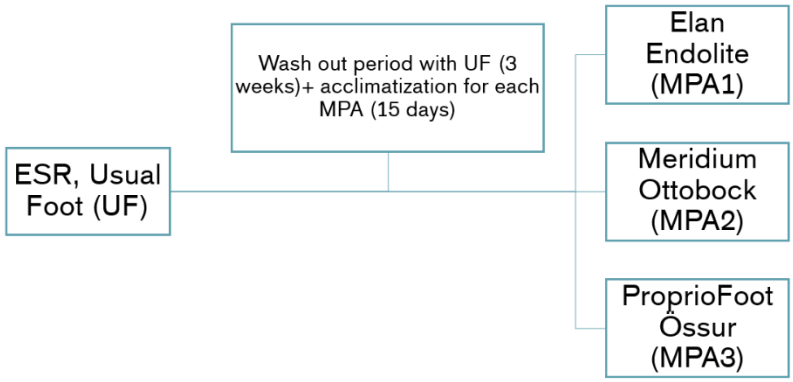
Figure 1: Average CoP trajectory [cm] and increase [%] during standing on level ground, positive and negative slopes with UF, Elan, Meridium and ProprioFoot

Population

Subjects:	6 unilateral, transtibial subjects (5 male, 1 female)
Previous prosthetic foot:	Non-MPF: Panthera (N=2), Variflex (N=2), Freedom (N=1), Echelon (N=1))
Amputation causes:	Traumatic reasons
Mean age:	36 ±13,9 years
Mean time since amputation:	45,5 ±22,5 months
MFCL:	n.a.

Study Design

Interventional, triple cross over study:



Before the testing with a new MPA the prosthetic alignment was validated and an acclimatization phase of 15 days duration took place. Information about the test order of the MPAs is not available.

Between the testing periods with the different prosthetic feet MPA1, MPA2 and MPA3 a wash out period with a duration of three weeks with the UF of each subject was performed.

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**

All results regarding angles depict the difference between an anatomical reference position, which was defined in a 2s trial before testing, and the measured angles during 20s trials on level ground, positive and negative slope.

MP1 = Elan; **MP2 = Meridium**; MP3 = ProprioFoot

Category	Outcomes	Results	Sig.*
Level Walking (Standing)	Flexion angle for ankle, knee, hip, pelvis and trunk	Difference to the reference position for all tested angles and prosthetic feet <2°	n.a.
	CoP trajectory	**UF:** 85±12cm; **MPA1:** 89±20cm **MPA2:** 91±13cm; **MPA3:** 83±11cm	n.a.
Ramps, Hills	Ankle dorsiflexion (DF) of prosthetic side on positive slope		
	Max angle UF & MPA1	3.9°	n.a.
	Max angle **MPA2** & MPA3	6.6°	n.a.
	Avg DF angle: **MPA2>MPA1** **MPA2>UF**	 **-6.2±0.2°>-2.36±1.3°** **-6.2±0.2°>-2.03±1.6°**	 **++** **++**
	Ankle Plantarflexion (PF) of prosthetic side on negative slope		
	Max angle UF & MPA3	4°	n.a.
	Max angle MPA1	9.7°	n.a.
	Max angle MPA2	8.6°	n.a.
	Avg PF angle: **MPA2>UF** **MPA2>MPA3** **MPA1>MPA3**	 **6.1±2.7° > 1.12±1.8°** **6.1±2.7° > 1.08±1.9°** **5.8±2.8° > 1.08±1.9°**	 **++** **++** **++**
	Prosthetic foot rotation on positive slope		
	Avg rotation angle: **UF>MPA3** **UF>MPA2**	 **9.71±5.2° > 4.78±7.7°** **9.71±5.2° > 3.4±4.8°**	 **++** **++**
	Shank flexion angle of prosthetic side on negative slope		
	Shank flexion **MPA2>MPA3**	 **0.8±3.2° > -5.7±2.3°**	 **++**
	Residual knee moment of prosthetic side on positive slope		
	Knee moment **MPA2<MPA1**	 **-0.02±0.09 < -0.2±0.09** Nm/kg	 **--**
	Residual knee moment of prosthetic side on negative slope		
	Knee moment: **MPA1<UF** **MPA1<MPA3** **MPA2<UF**	 **0.07±0.05 < 0.17±0.11** Nm/kg **0.07±0.05 < 0.20±0.06** Nm/kg **0.06±0.05 < 0.17±0.11** Nm/kg	 **--** **--** **--**

Category	Outcomes	Results	Sig.*
	MPA2<MPA3	**0.06±0.05 < 0.20±0.06** Nm/kg	**--**
	CoP trajectory of prosthetic side on positive slope		
	CoP trajectory	**UF:** 98 cm; **MPA1:** 107 cm **MPA2:** 94 cm; **MPA3:** 93 cm	n.a.
	Cop trajectory increase compared to level ground	**UF:** 15%; **MPA1**: 20% **MPA2:** 3%; **MPA3:** 12%	n.a.
	CoP trajectory of prosthetic side on negative slope		
	CoP trajectory	**UF:** 98 cm; **MPA1:** 100 cm **MPA2:** 94 cm; **MPA3:** 93 cm	n.a.
	Cop trajectory increase compared to level ground	**UF:** 15%; **MPA1:** 12% **MPA2:** 3%; **MPA3:** 12%	n.a.

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author's Conclusion

"The analysis of standing position in standard and constraining conditions (slope) is useful to understand how people with amputation perform static balance in their daily life, especially outdoors. According to this original study, an increased ankle mobility should permit a better posture and balance on slope. The benefits of wearing MPAs on the correct alignment of the lower limb segments and the reduction of residual knee moment were related to their design and mobility capabilities either on positive or negative slope or both. For MPA2, results also reflect the use of the prosthetic ankle in the control of CoP mobility in all situations. Active people with transtibial amputation have naturally high requirements in terms of dynamism and propulsion. The compromise between « mobility and speed » and « comfort and balance » is essential and further gait analysis seems essential to study MPAs relevance." (Thomas-Pohl et al. 2019)