| 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 | | | | | |
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| | 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 o 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 U 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 durin 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% of positive and negative slopes. The Cop trajectory increased 20% on positive slopes and 12% on negative slopes for Elan (see Figure 1 below). | | | | | |

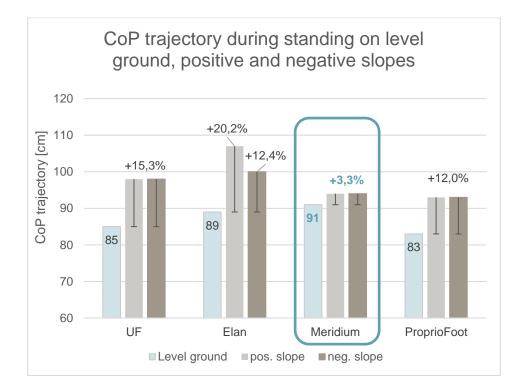
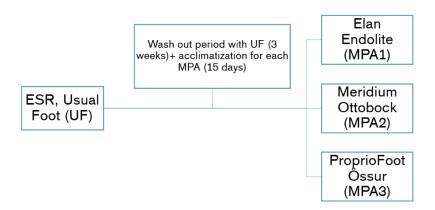


Figure 1: Average CoP trajectory [cm] and increase [%] during standing on level ground, positive and negative slopes with UF, Elan, Meridium and ProprioFoot

| 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. |
| | Mean age: Mean time since amputation: |

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.

| Functions a | and Activities | | | | | Participatio | on | | Environment |
|------------------|----------------|-----------------|--------------------------------|---------------------|---|--------------|--------------------------------|---------------------------------------|-----------------------|
| Level walking | Stairs | Ramps, Hills | Uneven ground, Obstacles | Cognitive demand | Metabolic Energy Consump- tion | Safety | Activity, Mobility, ADLs | Preference, Satisfac- tion, QoL | Health Eco- nomics |

<u>All results regarding angles depict the difference between an anatomical reference</u> 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 |
|-------------|-------|-----------|-------------------|
|-------------|-------|-----------|-------------------|

| Outcomes | Results | Sig.* | | | | |
|---|--|---|---|--|--|--|
| 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. | | | | |
| 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 | -6.2±0.2°>-2.36±1.3° | | ++ | | | |
| MPA2>UF | -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: | | | | | | |
| | | | ++ ++ | | | |
| MPA1>MPA3 | 5.8±2.8° > 1.08±1.9° | | ++ | | | |
| Prosthetic foot rotation on positive slope | | | | | | |
| Avg rotation angle: | | | | | | |
| UF>MPA3 | 9.71±5.2° > 4.78±7.7° | | ++ | | | |
| | | | ++ | | | |
| | | | | | | |
| 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< td=""><td>-0.02±0.09 < -0.2±0.09 Nm/kg</td><td></td><td></td></mpa1<> | -0.02±0.09 < -0.2±0.09 Nm/kg | | | | | |
| Residual knee moment of prosthetic side on negative slope | | | | | | |
| Knee moment: | | | | | | |
| MPA1 <uf< td=""><td>0.07±0.05 < 0.17±0.11 Nm/kg</td><td></td><td></td></uf<> | 0.07±0.05 < 0.17±0.11 Nm/kg | | | | | |
| MPA1 <mpa3< td=""><td>0.07±0.05 < 0.20±0.06 Nm/kg</td><td></td><td></td></mpa3<> | 0.07±0.05 < 0.20±0.06 Nm/kg | | | | | |
| | Flexion angle for ankle, knee, hip, pelvis and trunk CoP trajectory Ankle dorsiflexion (DF) Max angle UF & MPA1 Max angle UF & MPA1 Max angle MPA2 & MPA3 Avg DF angle: MPA2>MPA1 MPA2>UF Ankle Plantarflexion (PF Max angle UF & MPA3 Max angle MPA1 Max angle MPA2 Avg PF angle: MPA2>UF MPA2>UF MPA1>MPA3 Prosthetic foot rotation of Avg rotation angle: UF>MPA3 UF>MPA3 MPA1>MPA3 Prosthetic foot rotation of Avg rotation angle of p Shank flexion MPA2>MPA3 Residual knee moment Knee moment MPA2< | Flexion angle for ankle, knee, hip, pelvis and all tested angles and prosthetic feet <2° trunkCoP trajectoryUF: 85±12cm; MPA1: 89±20cm MPA2: 91±13cm; MPA3: 83±11cmAnkle dorsiflexion (DF) of prosthetic side on positive slopeMax angle UF & MPA13.9°Max angle MPA2 & MPA36.6°Avg DF angle: MPA2>MPA1-6.2±0.2°>-2.36±1.3° MPA2>UFMPA2>JUF-6.2±0.2°>-2.36±1.3° MPA2>UFMax angle UF & MPA34°Max angle UF & MPA34°Max angle UF & MPA34°Max angle MPA19.7°Max angle MPA28.6°Avg PF angle: MPA2>UF6.1±2.7° > 1.12±1.8° MPA2>UFMPA2>UF6.1±2.7° > 1.08±1.9°Prosthetic foot rotation on positive slopeAvg rotation angle: UF>MPA39.71±5.2° > 4.78±7.7° 9.71±5.2° > 3.4±4.8°Shank flexion MPA2>MPA30.8±3.2° > -5.7±2.3°Residual knee moment of prosthetic side on positive slopeKnee moment MPA2 <mpa1< th="">-0.02±0.09 < -0.2±0.09 Nm/kgResidual knee moment of prosthetic side on negative slopeKnee moment:Knee moment</mpa1<> | Flexion angle for ankle, Difference to the reference position for knee, hip, pelvis and all tested angles and prosthetic feet <2° | | | |

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| Category | Outcomes | Results | Sig.* |
|----------|--|---|-------|
| | MPA2 <mpa3< td=""><td>0.06±0.05 < 0.20±0.06 Nm/kg</td><td></td></mpa3<> | 0.06±0.05 < 0.20±0.06 Nm/kg | |
| | CoP trajectory of prosth | etic 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 prosth | etic 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)

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