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**Reference**

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## How does ankle power on the prosthetic side influence loading parameters on the sound side during level walking of persons with transfemoral amputation?

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**Products**

**1D10 (SACH), Triton (ESR), Empower (PF)**

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**Major Findings**

With PF with three settings (no power (PF\_np), low power (PF\_lp) and optimal power (PF\_op)) compared to SACH and ESR:

→ **Significantly increased plantar flexion at the end of the stance phase, accompanied by individually optimized active ankle power generation with PF\_op, compared to other power settings and to ESR and SACH (p<0.05)**

The following comparison of the different foot types focuses on PF\_op, SACH, and ESR.

- Reduced knee loading parameters on sound side (1) with PF with individually optimized active ankle power generation (PF\_op) compared to ESR and SACH Significantly reduced external knee adduction moment on the sound side with PF\_op and ESR compared to SACH (p < 0.05)
  - Significantly reduced Knee Flexion moment on the sound side with PF\_op compared to ESR and SACH (p < 0.05)
  - Significantly reduced vertical ground reaction force on the sound side with PF\_op and ESR compared to SACH (p<0.05)
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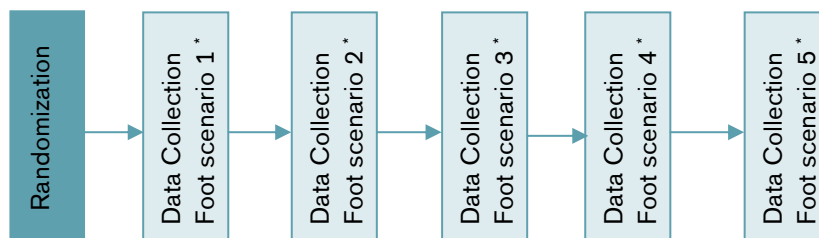
**Population**

Subjects:	6 male amputees
Amputation level:	unilateral transfemoral
Knee joint:	C-Leg 4
Amputation causes:	n.a.
Mean age:	47 years (range from 34 to 58 years)
Mean time since amputation:	n.a.
MFCL:	3 (n=5), 4 (n=1)

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**Study Design**

Interventional, cross-sectional study design:



**Data collection** during level walking first with self-selected comfortable velocity and afterwards with fast walking velocity. With each foot scenario the subjects had at least 1 hour for acclimatisation to get accustomed. The order of foot scenarios was randomised.

**Foot scenarios:**

- 1D10 foot (modified SACH foot)
- Triton (ESR foot)

Empower (PF) with three different power settings:

- no power (PF\_np)
- low power (PF\_lp)
- optimal power (PF\_op)

## 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 foot scenarios	Sig. <sup>a,b</sup>
Level Walking - prosthetic side	Walking velocities (median (min-max)) [m/s]	For both velocities no significant differences between foot scenarios.	
	Plantar flexion (early stance phase) [°]	Average plantar flexion for all subjects and foot scenarios, with: <ul style="list-style-type: none"> <li>- with normal velocity approximately 5°</li> <li>- with fast velocity approximately 6°</li> </ul>	n.a.
	Dorsiflexion (early stance phase) [°]	Average dorsiflexion for all subjects and foot scenarios, with: <ul style="list-style-type: none"> <li>- with normal velocity approximately 14°</li> <li>- with fast velocity approximately 15°</li> </ul>	n.a.
	Plantarflexion (late stance phase) [°]	Significantly higher plantarflexion of the PF for higher power settings for both velocities: <ul style="list-style-type: none"> <li>- PF_np &lt; PF_op</li> <li>- PF_lp &lt; PF_op</li> <li>- PF_np &lt; PF_lp</li> </ul>	++
		No significant differences between SACH, ESR and PF_np.	0
		Significant increased plantarflexion for PF_lp and PF_op compared to SACH, ESR and PF_np.	++
	Ankle power median (min-max) [W/kg]	SACH foot has smallest and PF_op the highest ankle power for both velocities:	

Category	Outcomes	Results for foot scenarios	Sig. <sup>a,b</sup>
		SACH 0.85 (0.33-1.42) 1.02 (0.77-1.88)	
		ESR 1.75 (0.66-2.96) 2.57 (1.28-4.3)	
		PF_np 1.39 (0.73-2.24) 2.08 (1.5-3.14)	
		PF_lp 1.61 (0.70-2.73) 2.53 (1.89-4.33)	
		PF_op 1.99 (0.97 – 4.01) 3.04 (2.28-6.87)	
		For both velocities the ankle power differs significantly between all power settings of the PF (p<0.005) – higher ankle power with higher PF power setting (PF_np<PF_lp<PF_op)	++
		For both velocities significantly higher ankle power with the PF_op compared to SACH and ESR.	++
		For both velocities significantly higher ankle power with the ESR compared to SACH.	++
		For both velocities no differences between ESR and PF_lp nor ESR and PF_np.	0
<b>Level Walking</b> - sound side	First peak vertical GRF (vGRF) [% Body Weight (BW)]	For all subjects and foot scenarios the average first peak GRF is 116% BW at normal velocity. With fast velocity first peak is increased by 21%.  ESR and PF with all three settings did not differ significantly from each other.  SACH foot shows significant increase in the first peak of vGRF compared to ESR and PF in all settings.	n.a.  0  ++
	External knee Adduction Moment (EKAM) [Nm/kg]	For all subjects and foot scenarios the average maximum of EKAM is 0.53 Nm/kg at normal velocity. With fast velocity the average maximum is increased by 17%.  Significantly increased first peak of the EKAM for the SACH foot compared to ESR or PF in all three settings at both speeds.  No differences between ESR and PF_np, PF_lp, PF_op	0  ++  0
	Knee Flexion Moment (KFM) [Nm/kg]	For all subjects and all foot scenarios average maximum of KFM is 0.34 N/kg a normal speed. At increased speed the average maximum is 2.5-times higher.  Significant increased maximum of KFM with SACH compared to all foot scenarios and for both speeds (p<0.05).  At normal speed there were no differences between ESR, PF_np and PF_lp.  Smallest KFM peak with PF_op at normal speed compared to all foot scenarios with significant differences to SACH, ESR and PF_np (p<0.05)  At fast speed there were no differences between the maximum of KFM of the different settings of PF.  Significantly lower maximum of KFM of PF_op compared to ESR and SACH (p<0.05) with fast speed	n.a.  ++  0  ++  0  ++

<sup>a</sup> no difference (0), positive trend (+), negative trend (-), significant (++/--), not applicable (n.a.)

<sup>b</sup> significance set at p<0.05; trends set at 0.1>p>0.05

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**Author's Conclusion**

“Apart from the varied ankle power on the prosthetic side, the construction of the foot section seems to be important for the load on the sound side knee. However, the overall results prove clear advantages using the Empower, which generates positive mechanical work for an active push off over a SACH foot and also an ESR. Especially, a relief of the sound side of amputees using the active foot could be seen, particularly in the reduction of KFM” (Pröbsting et al., 2022)

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