Reference	Schmalz T, Bellmann M, Sottong J, Altenburg B.

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Advantages and Limitations of New Sports Prosthetic Components Developed for Running in Lower Limb Amputees

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Products

1E95 "Challenger" Foot, Otto Bock (Transtibial "TT" amputees)

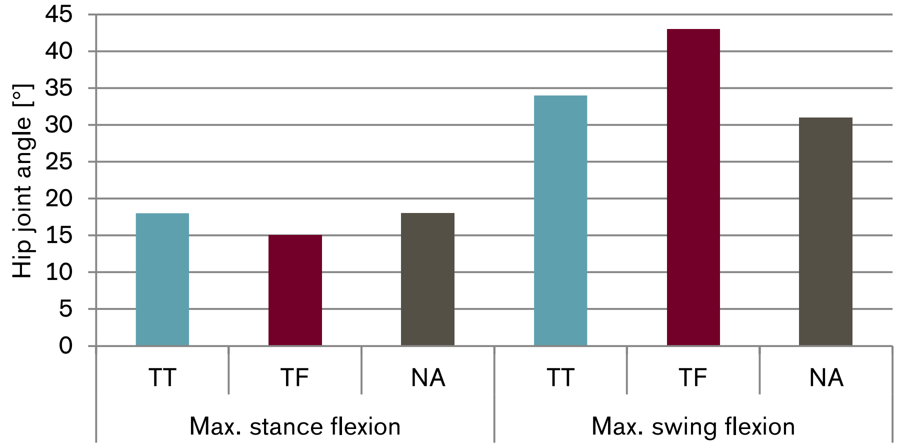
3S80 (Knee joint) and 1E90 (Foot), Otto Bock (Transfemoral "TF" amputees)

Major Findings

With Sports prosthesis compared to non-amputees (NA):

→ **The motion pattern of TT amputees with sports prosthesis components is similar to that of non-amputees while running.**

→ **TF amputee running requires a specific motion pattern, because of the absence of knee stabilising muscles. Furthermore, an extension moment has to act at the prosthetic knee joint during the support phase. Therefore, a compensatory hip motion pattern is necessary for TF runners. In addition, specific alignment instructions must be fulfilled.**



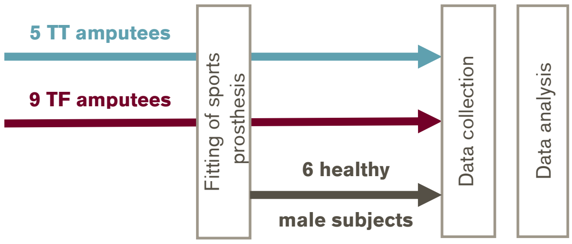
The results represent the values of the prosthetic limb of TT amputees with 1E95 "Challenger", the prosthetic limb of TF amputees with 3S80 and 1E90 and NA.

Population

Subjects:	5 male unilateral TT amputees 9 unilateral TF amputees (8 male, 1 female) 6 neurologically & orthopaedically healthy male subjects (NA)
Previous knee joint (TF):	C-Leg, Genium / Genium X3
Mean age:	TT: 44 ± 12 yrs TF: 30 ± 10 yrs NA: 24 ± 3 yrs
Mean time since amputation:	TT: 16 ± 12 yrs TF: 12 ± 9 yrs
MFCL:	K3 and K4

Study Design

Interventional, non-randomized study:



The athletes in all three groups were instructed to run several times (6-10 test runs) in the laboratory at a self-selected speed that should subjectively correspond to running in a natural environment.

- TT amputees were fitted with the sports prosthesis and tested it 30 to 60 minutes intensively before data collection.
- TF amputees had been fitted with the sport prosthesis system between 4 and 8 weeks before the laboratory tests and used it during this period for recreational sports, including running.

Results

Activities		Participation				Body function			Other
Sprinting, running, jumping	Other sports	Leisure / recreational sports	Competitive sports	Paralympic sports	Preference, satisfaction, QoL	**Biomechanics (kinematics / kinetics)**	Clinical (metabolic / performance)	Medical (pain, injuries)	Technical aspects / alignment

Category	Outcomes	Results for Sports prosthesis (TT/TF) vs NA	Sig.*
Sprinting, running, jumpling **(Running)**	Running speed	**The running speed for TT, TF and NA was similar.**	**0**
Biomechanics (kinematics / kinetics)	Stride length	**The mean stride lengths of TT and TF between 1.08 m and 1.14 m were within the known range for NA.**	**0**
	Support times	**The mean support times of TT and TF between 0.24 s and 0.28 s were within the known range for NA.**	**0**
	Vertical component (F_z)of the ground reaction force (GRF)	**No significant differences were found between TT, TF and NA.**	**0**
	Horizontal compo-nent (F_x)of the ground reaction force (GRF)	1st peak –Braking force: The maximum braking force in the first half of the support phase was reduced significantly for both TT (-10% of body weight (BW)) and TF (-8% BW) compared to NA.	––
		2nd peak –Acceleration force: The maximum acceleration force was significantly reduced in TT (-13% BW) when compared to NA.	––
		For TF and NA the corresponding value was similar.	**0**
	Knee flexion moment	The knee flexion moment for the knee joint of the prosthetic limb of TT was significantly decreased by 39%.	––
		For TF this value was not measured, according to limitation of the prosthetic alignment of TF sports prostheses.	n.a.
	Max. Dorsal exten-sion (ankle joint)	The maximum dorsal extension increased significantly by 41% in TT when compared to NA.	––
		The maximum dorsal extension was slightly higher for TF	–

Category	Outcomes	Results for Sports prosthesis (TT/TF) vs NA	Sig.*
		when compared to NA.	
	Max. knee flexion	Stance flexion: The maximum stance flexion angle of the knee was higher for TT when compared to NA. *For TF, natural knee flexion during stance is not possible.*	– n.a.
		Swing flexion: **For TT and NA the swing flexion angle of the knee was similar.** The maximum swing flexion angle of the knee was slightly increased for TF when compared to NA.	**0** –
	Max. hip flexion	Stance flexion: **Hip stance flexion angle was similar for TT and NA.** The maximum stance flexion angle of the hip was slightly decreased for TF when compared to NA.	**0** –
		Swing flexion: **For TF and NA the swing flexion angle of the hip was similar.** Significantly increased swing flexion angle of the hip of TF by 39% when compared to NA.	**0** ––

* no difference to NA (0), slight difference to NA (–), significant difference to NA (––), not applicable (n.a.)

Authors' Conclusion

"Newly developed sports prosthetic components enable a great number of lower limb amputees to participate in running as an endurance sport. The results of biomechanical analyses clearly show that the motion pattern of TT amputees is similar to that of nonamputees. Currently, in TF amputee running there is the inevitable requirement that an extension moment must act on the rotational axis of the prosthetic knee joint during the support phase. This is realised by a specific prosthetic alignment and a compensatory motion pattern. The most important characteristics of this motion pattern are both a high hip extension velocity during the support phase and an abnormal hip flexion during the flight and swing phases. Therefore, the primary hypothesis can be confirmed partly, as only TF amputee running requires a specific motion pattern compared with nonamputees. The secondary hypothesis is completely confirmed, since the biomechanical parameters reflect both reduced compensatory movements and reduced loading of the locomotor system for lower limb amputee running with specific sports components." (Schmalz et al, 2017)