Reference

Gates DH, Aldridge JM, Wilken JM.

Center for the Intrepid, Department of Orthopaedics and Rehabilitation, Brooke Army Medical Center, Ft. Sam Houston, TX. USA.

Kinematic comparison of walking on uneven ground using powered and unpowered prostheses

Clinical Biomechanics, 2013, vol.28, pp. 467-472.

Products

BiOM (Bionic powered ankle-foot prosthesis)

Major Findings

With BiOM compared to passive, energy storage and return (ESR) prostheses:

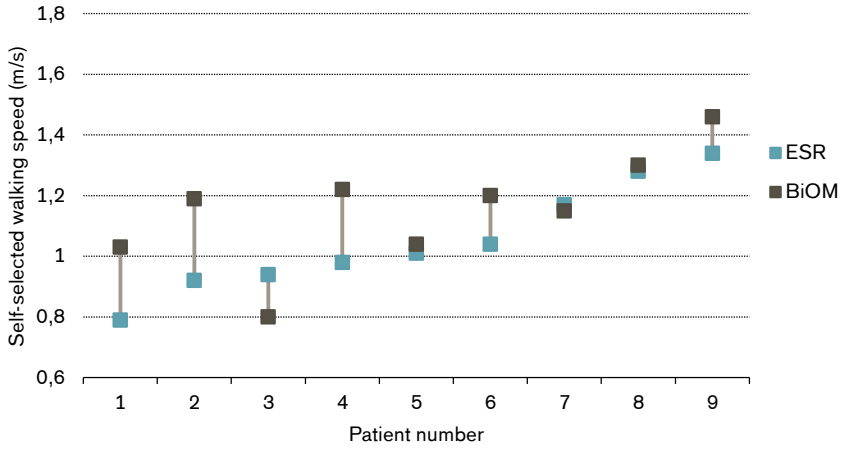
→ 10% faster self-selected walking speed

→ Effects in lower extremity kinematics

Plantarflexion during push-off increased
Knee flexion during early stance decreased
Media-lateral motion of center-of-mass decreased

Walking with self-selected speeds using both prostheses

(Adapted from Fig. 1B, Gates et al. 2017. Data shown here is an approximation; real values may vary slightly)



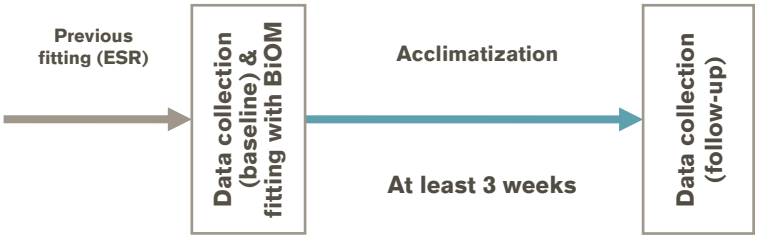
Subjects walked over a loose rock surface, while body kinematics were recorded; subjects walked at their self-selected walking speed (shown above). Subjects had a 10% greater self-selected walking speed when wearing BiOM (p=0.031).

Population

Subjects:	11 (1 F) unilateral transtibial amputees
Previous prosthesis:	Re-Flex VSP (45%), Renegade (27%), Flexfoot (9%), Pathfinder (9%), LP Re-Flex VSP (9%)
Amputation causes:	trauma (100%)
Mean age:	30 ± 5 years
Mean time since amputation:	not provided
MFCL:	not provided

Study Design

Interventional, pre-to-post design :



Data collection consisted on subjects walking over a loose rock surface, while kinematic data was acquired. Subjects walked at self-selected walking speed and afterwards at 3 controlled (ascending) speeds, and a minimum of five strides were collected for each side at each speed.

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 BiOM compared to ESR foot	Sig.*
Uneven Ground, Obstacle Course	Self-selected walking speed	**10% faster** (1.16 ± 0.02 m/s) than ESR (1.05 ± 0.17 m/s)	++
	Step width	No difference	0
	Step length	No difference	0
	Foot contact angle	Decreased	--
	Ankle plantarflexion during loading response and pre-swing	Increased	++
	Ankle dorsiflexion during terminal stance and swing	Decreased	--
	Knee flexion during loading response	Decreased	--
	Loading response on intact limb	Increased	++
	Swing knee flexion on intact limb	Increased	++
	Hip kinematics	No difference	0
	Minimum toe clearance during swing	Increased	++
	Medial-lateral centre of mass (COM) motion while walking	Decreased	--

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

Author's Conclusion

"Kinematic analysis of persons with unilateral transtibial amputation walking on a loose rock surface revealed that the powered BiOM prosthesis increased self-selected speed, ankle plantarflexion at push-off, and toe clearance in comparison to a passive ESR prosthesis. The addition of power did not normalize joint kinematics at the knee or hip. Future devices designed for navigating irregular surfaces should focus on altering the foot orientation at initial contact and actively dorsiflexing the foot during swing to achieve additional increases in toe clearance." (Gates et al., 2013)