Reference

Herr HM, Grabowski AM.

Biomechatronics Group, Media Laboratory, Massachusetts Institute of Technology, 75 Amherst Street E14-348U, Cambridge, MA 02139, USA.

Bionic ankle-foot prosthesis normalizes walking gait for persons with leg amputation

Proc Biol Sci. 2012 Feb 7;279(1728):457-64.

Products

BiOM (Bionic powered ankle-foot prosthesis)

Major Findings

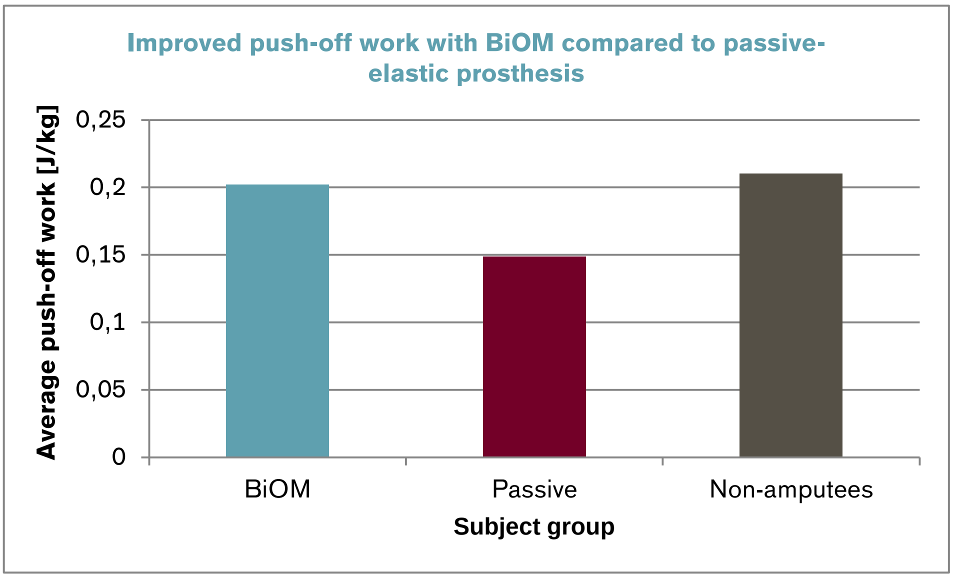
With BiOM compared to conventional passive-elastic prosthetic foot (Passive) and non-amputees:

→ **Preferred walking velocity higher (22.4%) compared to passive prosthesis**

→ **Higher push-off work**
by 26.7%-45.3% (across all walking speeds tested) compared to Passive

→ **Improved metabolic cost of transport**
by 8.9-12.1% (walking speed from 1-1.75 m/s) compared to Passive

→ **Similar results for amputees with BiOM and non-amputees in walking velocity, biomechanical pattern and metabolic energy costs.**



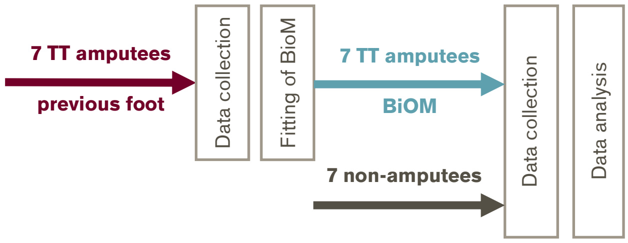
The average push-off work over all walking speeds (0.75 - 1.75 m/s) is shown; BiOM presented an improved push-off work compared to passive-elastic prosthesis.

Population

Subjects:	Seven unilateral, transtibial amputees (Seven male) Seven non-amputees
Previous prosthetic feet:	Flex-Foot, Ossur (3); Axtion, Otto Bock (1); Venture, College Park (1); Renegade, Freedom Innovations (1); Silhouette, Freedom Innovations (1)
Amputation causes:	Trauma
Mean age:	Amputees: 46 ± 8 yrs Control: 49 ± 9 yrs
Mean time since amputation:	21.9 ± 10.3 yrs
MFCL:	K3

Study Design

Interventional, pre- to post design:



Subjects with an amputation completed two experimental walking sessions; one using their own passive-elastic prosthesis and one using the powered ankle-foot prosthesis (acclimation session of at least 2 hours). Non-amputee subjects completed one experimental session.

Each subject walked at 0.75, 1.00, 1.25, 1.50, and 1.75 m/s and with preferred walking velocity, while the stiffness and power delivery of the powered prosthesis was adjusted so that prosthetic ankle angle at toe-off and net positive mechanical work matched average biological ankle data.

Results

Functions and Activities						Participation			Environment
Level walking	Stairs	Ramps, Hills	Uneven ground, Obstacles	Cognitive demand	**Metabolic energy consump-tion**	Safety	Activity, Mobility, ADLs	Preference, Satisfac-tion, QoL	Health Economics

Category	**Outcomes**	**Results for BiOM vs Passive vs non-amputees**	**Sig.***
Level Walking	Preferred walking velocity [m/s]	**With BiOM the preferred walking speed was significantly higher by 22.4% than with Passive.**	++
		There were no significant differences between BiOM and non-amputees in preferred walking velocity.	0
	Step-to-step transition work of the trailing leg (Push-off work) [J/kg]	**Push-off work was significantly higher with BiOM by 26.7-45.3% (across walking speeds tested), when compared to Passive.**	++
		The push-off work was similar for amputees with BiOM and non-amputees.	0
	Step-to-step transition work of the leading leg (Collision work) [J/kg]	**Using the BiOM, collision work was greater by 22.6-41.1% for 1-1.5 m/s, when compared to Passive.** (No significant differences for 0.75 and 1.75 m/s)	++
		There were no significant differences between BiOM and non-amputees in Step-to-step transition work of the leading leg.	0
Metabolic Energy Consumption	Metabolic cost of transport [JN/m]	**BiOM decreased the metabolic cost of transport significantly by 8.9-12.1% when walking with 1-1.75 m/s, when compared to Passive.**	++
		The metabolic energy cost was similar for amputees with BiOM and non-amputees.	0

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

Author's Conclusion

"…We found that with adequate power provided by a bionic prosthetic ankle, high-functioning PWA (Note: people with a leg amputation) achieved normative metabolic energy costs, preferred walking velocities and mechanical work compared with non-amputees. Never before has a lower limb prosthetic device been able to emulate biological function in this manner." (Herr and Grabowski, 2011)