

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**

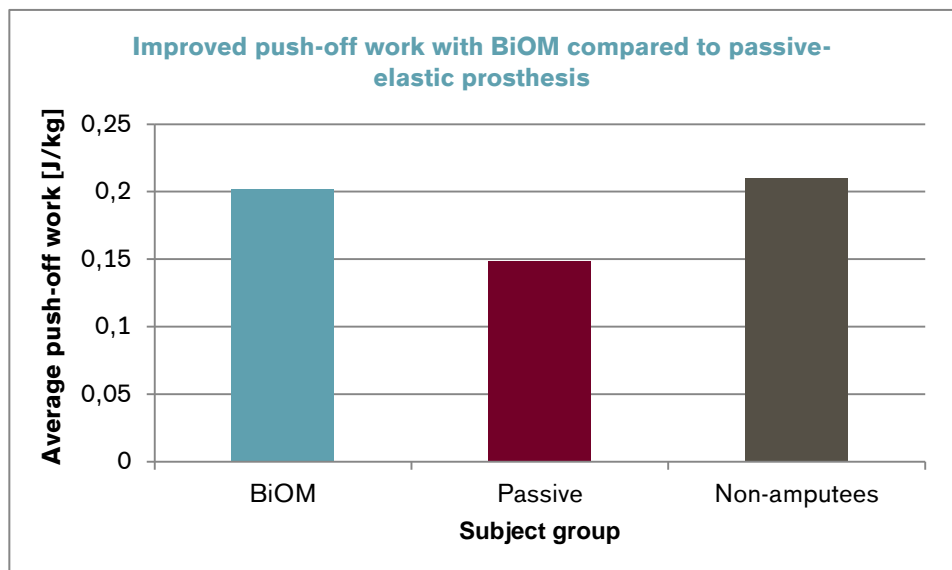
→ **Higher push-off work**

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.**



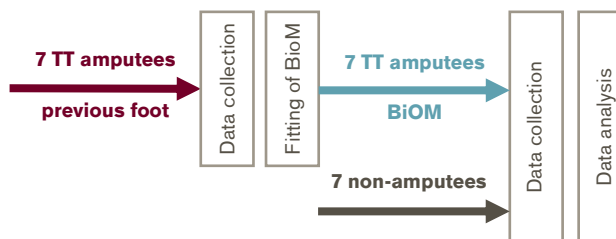
The average push-off work over all walking speeds (0.75 - 1.75 m/s) is shown; BiOM presented an improved push-off work compared to passive-elastic prosthesis.

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 consumption	Safety	Activity, Mobility, ADLs	Preference, Satisfaction, 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			
		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)

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