Reference

Russell Esposito E, Aldridge Whitehead JM, Wilken JM.

Center for the Intrepid, Brooke Army Medical Center, Fort Sam Houston, TX, USA.

Step-to-step transition work during level and inclined walking using passive and powered ankle-foot prostheses

Prosthet Orthot Int. 2016, 40(3), pp.311-319.

Products

BiOM (Bionic powered ankle-foot prosthesis)

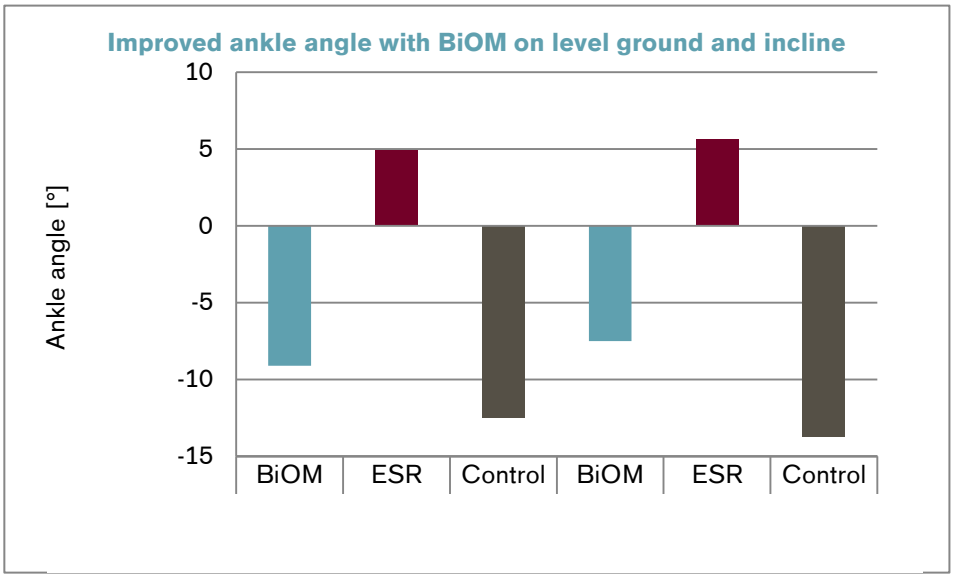
Major Findings

With BiOM compared to energy return and storage foot (ESR) and to able-bodied control subjects (Control):

→ **Greater trailing limb step-to-step transition work on level with BiOM**
by 63% when compared to ESR

→ **Lower metabolic rate with BiOM on level ground with BiOM**
by 16% when compared to ESR

→ **Improved ankle angle and ankle power**
with BiOM compared to ESR.
Ankle angle improved by 14° (Level ground) and 13.1% (5° incline)
Ankle power improved by 110% (Level ground) and 63% (5° incline)

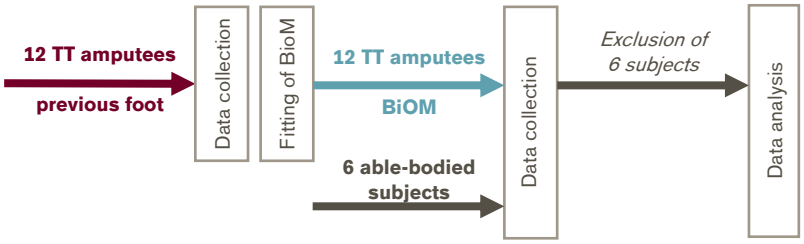


Population

Subjects:	6 unilateral, transtibial amputees (5 male, 1 female) 6 able-bodied control subjects (Control)
Previous prosthetic foot:	Flex-Foot, Ossur (3); Renegade, Freedom Innovations (2); Pathfinder, Ohio Willow Wood (1)
Mean age:	Amputees: 29 ± 6 yrs Control: 23 ± 5 yrs
Mean height:	Amputees: 1.81 ± 0.1 m Control: 1.79 ± 0.1 m
Mean body mass:	Amputees: 92.7 ± 6.3 kg Control: 91.4 ± 12.1 kg

Study Design

Interventional, pre-to post design:



Subjects walked at a standardized velocity (±5%) over level ground and up the inclined walkway (5°). Three successful trials in which the prosthetic limb and then the intact limb contacted consecutive force platforms were recorded. Metabolic demand was assessed as the steady state rate of oxygen consumption (VO_2). As subjects breathed into a plastic mask that sealed around the nose and mouth, a portable metabolic unit recorded VO_2 using indirect calorimetry and 30-s averaging. Six subjects were excluded, because they had step lengths that were either too long or too short to fully contact each of the force platforms on the inclined walkway without adjustments.

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 ESR vs Control**		
Level Walking	Step –to-step trailing leg transition work [J/kg]	**BiOM vs ESR** **++ (+63%)**	BiOM vs Control + (+28%)	ESR vs Control – (–22%)
	Peak plantarflexion Angle [°]	**BiOM vs ESR** **++ (-286%)**	BiOM vs Control 0	**ESR vs Control** **–– (+139%)**
	Ankle Moment [Nm/kg]	BiOM vs ESR – (–12%)	BiOM vs Control – (–8%)	ESR vs Control 0
	Ankle Power [W/kg]	**BiOM vs ESR** **++ (+110%)**	**BiOM vs Control** **++ (+38%)**	**ESR vs Control** **–– (-34%)**
Ramps, Hills	Step –to-step trailing leg transition work [J/kg]	BiOM vs ESR + (+53%)	BiOM vs Control 0	ESR vs Control 0
	Peak plantarflexion Angle [°]	**BiOM vs ESR** **++ (-234%)**	BiOM vs Control + (-45%)	**ESR vs Control** **–– (+141%)**
	Ankle Moment [Nm/kg]	BiOM vs ESR 0	BiOM vs Control – (–11%)	ESR vs Control – (–13%)

Category	Outcomes	Results for BiOM vs ESR vs Control		
	Ankle Power [W/kg]	**BiOM vs ESR** **++ (+63%)**	BiOM vs Control + (+19%)	**ESR vs Control** **–– (-27%)**
Metabolic Energy Consumption	Metabolic rate (Level walking) [Steady state VO_2]	**BiOM vs ESR** **++ (-16%)**	BiOM vs Control 0	ESR vs Control – (+9%)
	Metabolic rate (5° Incline) [Steady state VO_2]	BiOM vs ESR 0	BiOM vs Control 0	ESR vs Control – (+11%)

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

Author's Conclusion

"In conclusion, the powered BiOM prosthesis increased ankle power and trailing limb push-off work during step to- step transitions on both level ground and inclines. The improvement in trailing limb push-off may partly account for the reduction in metabolic rate over level ground, but it had little effect on reducing the energy lost during step-to step transitions. On inclines, the ESR trailing limb did not display deficiencies in push-off work relative to able-bodied individuals; the slightly lower values still resulted in leading limb compensations and net energy dissipation. Although leading and trailing limb mechanical work during step-to-step transitions do not account for total metabolic demand, they do contribute substantially to a portion of it. The powered BiOM ankle–foot prosthesis reduced metabolic rate on level ground but not on inclines, but resulting values were equivalent to able-bodied individuals. Overall, there were limited negative biomechanical or metabolic consequences to wearing a powered ankle–foot prosthesis. The results of this study may be used to guide the development and use of actively powered prosthetic devices in high-functioning individuals. Future work may examine how different inclines and velocities affect VO_2 and individual limb work in individuals with amputations who are using new prosthetic technology." (Russell Esposito et al., 2016)