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


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.**

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### 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

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![Graph showing improved push-off work with BiOM compared to passive-elastic prosthesis.](image)

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.
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

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<th>Functions and Activities</th>
<th>Participation</th>
<th>Environment</th>
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<tr>
<td>Level walking</td>
<td>Stairs, Hills</td>
<td>Safety, Activity, Mobility, ADLs, Preference, Satisfaction, QoL, Health Economics</td>
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<tr>
<td>Step-to-step transition work of the trailing leg (Push-off work) [J/kg]</td>
<td>Push-off work was significantly higher with BiOM by 26.7-45.3% (across walking speeds tested), when compared to Passive.</td>
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<tr>
<td>Step-to-step transition work of the leading leg (Collision work) [J/kg]</td>
<td>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)</td>
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<tr>
<td>Metabolic Energy Consumption</td>
<td>Metabolic cost of transport [JN/m]</td>
<td>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.</td>
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</tbody>
</table>

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

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**Study Design**

Interventional, pre- to post design:
"...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)