Evaluation of a Powered Ankle-Foot Prosthetic System During Walking


With BiOM (PowerFoot BiOM prosthetic device) compared to ESR (Energy-storing and returning foot prosthesis), the contralateral intact limb and matched control subjects:

→ Ankle range of motion (ROM) and peak ankle power increased
→ Peak knee power absorption increased
→ Limb peak hip power generation at preswing increased
→ Walking velocity increased

Ankle ROM

Subject: 11 unilateral transtibial amputees (TAA) and 11 matched control subjects
Previous foot prosthesis: Energy-storing and returning foot prosthesis (ESR)
Amputation causes: Trauma
Mean age: 29.8 ± 5.3 (TAA); 23.4 ± 3.9 (control group)
Mean time since amputation: not reported
MFCL: K2 and K3
Interventional study, pre-post design:

Subjects were tested in a gait analysis laboratory and walked at self-selected velocity and controlled velocity (controlled velocity was calculated on the basis of individual leg length). Temporal-spatial values, walking velocity and kinematics were used for biomechanical analysis. Physical performance was analysed with:

- T-Test (10-meter forward run, 5-meter side-shuffle to right, 10-meter side-shuffle to left, 10-meter backward run)
- Four Square Step Test (moving through 4 quadrants in a clockwise pattern)
- Hill and Stair Assessment test (descending a 16-step staircase and a 10-degree slope)

User satisfaction was evaluated with the Prosthetic Preference Questionnaire (ambulation, frustration, perceived response, sounds, utility, well-being).

### Results

#### Functions and Activities

<table>
<thead>
<tr>
<th>Level walking</th>
<th>Stairs</th>
<th>Ramps, Hills</th>
<th>Uneven ground, Obstacles</th>
<th>Cognitive demand</th>
<th>Metabolic energy consumption</th>
<th>Safety</th>
<th>Activity, Mobility, ADLs</th>
<th>Preference, Satisfaction, QoL</th>
<th>Health Economics</th>
</tr>
</thead>
</table>

#### Level walking

**Temporal-Spatial**

- Step length longer than intact limb ++

**Joint Angle**

- Ankle 30%↑ than ESR ++
- Knee ↓ than intact limb ++
- Hip ↑ than intact limb ++

**Joint Moments**

- Ankle Peak dorsiflexor moment 40%↑ than ESR ++
- Knee Peak knee flexor moment ↓ than intact limb ++
- Hip ↓ than intact limb ++

**Joint Powers**

- Ankle Peak power 125%↑ than ESR ++
- Knee Peak knee power absorption ↑ than ESR +
- Hip Peak hip power ↑ than ESR +
<table>
<thead>
<tr>
<th>Category</th>
<th>Outcomes</th>
<th>Results for BiOM</th>
<th>Sig.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity, Mobility, ADLs</td>
<td>T-Test (s)</td>
<td>1.4 ↓ than ESR</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Four-Square Step Test (s)</td>
<td>0.3 ↓ than ESR</td>
<td>0</td>
</tr>
<tr>
<td>Preference, Satisfaction, QoL</td>
<td>Ambulation</td>
<td>7.3% ↑ than ESR</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Frustration</td>
<td>3.4% ↑ than ESR</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Perceived response</td>
<td>9.6% ↑ than ESR</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Sounds</td>
<td>27.9% ↓ than ESR</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Utility</td>
<td>3.5% ↑ than ESR</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Well-being</td>
<td>9.2% ↑ than ESR</td>
<td>+</td>
</tr>
</tbody>
</table>

**Author’s Conclusion**

“The BiOM demonstrated significantly greater ankle ROM and power generation than the ESR. Proximal joint asymmetries and the introduction of additional asymmetries with BiOM use may result from the uniaxial function of the device. Device-specific training or design modifications may be needed to allow individuals with TTA to utilize the additional functionality of the device and minimize compensatory strategies.” (Ferris et al., 2012)