**Reference**
Grabowski AM, D’Andrea S.
Integrative Physiology Department, University of Colorado Boulder, Boulder, CO.

**Effects of a powered ankle-foot prosthesis on kinetic loading of the unaffected leg during level-ground walking**

J Neuroeng Rehabil. 2013 Jun 7;10:49.

**Products**

**BiOM (Bionic powered ankle-foot prosthesis)**

**Major Findings**

With BiOM compared to conventional passive-elastic feet (Passive) and non-amputees (Control):

- **Reduction of the resultant ground reaction forces (GRF) acting on the unaffected**
  
  Decrease by 2.1% to 10.7% (for walking speeds from 0.75 to 1.5 m/s) with BiOM compared to Passive

- **BiOM decreased the external adduction moment (EAM) on the unaffected knee**
  
  Reduction by 20.6% and 12.2% (for walking speeds of 1.5 and 1.75 m/s, respectively) with BiOM compared to Passive

![Graph showing reduced resultant GRF on the unaffected leg with BiOM](image)

The average resultant first peak GRF on the unaffected leg for all walking speeds (0.75 – 1.5) was calculated; BiOM presented a reduced resultant GRF compared to passive feet.

**Population**

- **Subjects:** Seven unilateral, transtibial amputees (Seven male) Seven non-amputees (Control)
- **Previous prosthetic feet:** Flex-Foot, Ossur (3); Axtion, Otto Bock (1); Venture, College Park (1); Renegade, Freedom Innovations (1); Limb Logic, Ohio Willow Wood (1)
- **Amputation causes:** Trauma
- **Mean age:** Amputees: 45 ± 6 yrs Control: 48 ± 7 yrs
- **Mean time since amputation:** 21.6 ± 11.6 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 foot 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, 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**        |               |             |
| Category                 | Outcomes      | Results for BiOM vs Passive vs Control | Sig.* |
| Level Walking            | Unaffected leg: 1st peak ground reaction force (GRF) [N/kg] | For all walking speeds from 0.75 to 1.5 m/s, amputees with BiOM showed a significant decrease of the 1st peak of GRF by 2.1% to 10.7% when compared to Passive. | ++ |
|                          |               | There were no significant differences between BiOM and Control for the 1st peak GRF while walking with different walking speeds. | 0 |
|                          | Unaffected leg: GRF rate [N/kg/s] | There were no significant differences between BiOM, Passive and Control while walking, except for one specific walking speed: For 1.25 m/s, Control showed significant lower GRF rates than amputees with BiOM (+30.3%) or Passive (+49.1%). | 0 |
|                          | Unaffected leg: 1st peak external knee adduction moment (EAM) [Nm/kg] | For the two fastest walking speeds (1.5 and 1.75 m/s), the BiOM reduced the 1st peak of the EAM significantly by 20.6% and 12.2%, respectively, when compared to Passive. | ++ |
|                          |               | Apart of that, there were no significant differences between BiOM, Passive and Control while walking with different walking speeds. | 0 |
|                          | Unaffected leg: knee EAM rate [Nm/kg/s] | There were no significant differences between BiOM, Passive and Control in knee EAM rate for all walking speeds. | 0 |

* no difference (0), positive trend (+), negative trend (−), significant (++/−−), not applicable (n.a.)
“A passive-elastic prosthesis cannot emulate normative biological function during the stance phase of walking; thus people with a lower-extremity amputation employ compensatory mechanics and have a higher incidence of musculoskeletal injury, specifically knee osteoarthritis in their unaffected leg. A biomimetic prosthesis could mitigate the risk of knee osteoarthritis by decreasing unaffected leg forces and knee moments. In this investigation, we found that when people with a unilateral transtibial amputation due to trauma and K3 level of ambulation used a powered ankle-foot prosthesis during level-ground walking over a range of speeds, they reduced the peak resultant force and knee adduction moment on their unaffected leg compared to when they used their own passive-elastic prosthesis. At the walking speed closest to preferred, subjects with an amputation using a powered ankle-foot prosthesis reduced their unaffected peak knee EAM by over 20%. A significant reduction in peak knee EAM has the potential to decrease the risk of knee osteoarthritis. Based on these results, we conclude that a biomimetic powered ankle-foot prosthesis could potentially limit musculoskeletal stress to the contralateral leg during walking, thus decreasing the risk of secondary injury in people with a lower-extremity amputation.” (Grabowski and D’Andrea, 2013)