Bell EM, Pruziner AL, Wilken JM, Wolf EJ. Department of Rehabilitation, Walter Reed National Military Medical Center, Bethesda, MD, 20889, USA.

Performance of conventional and X2® prosthetic knees during slope descent.


Products

Genium X2®

Major Findings

With Genium X2® (X2) compared to
- Mechanical knee (MECH) (Total Knee & Mauch, Össur) and
- Standard microprocessor controlled knee (MPK) (C-Leg, Otto Bock & Rheo Knee, Össur):

- Walking speed is faster by 9.6% (+0.1 m/s) compared to MPK.
- Step length is longer with X2 by 1.6-16.9% and leads to a more harmonized movement in slope descent.
- Through the stance flexion resistance, walking with the X2 was more comparable to able-bodied individuals.

  Initial knee flexion (0% GC): 326.7% more flexion
  Max knee swing flexion (50-100% GC): 21.2% more flexion

- A heightened use of the intact limb for support in descent could be indicated by the significant increase of the max. support moment flexion with X2 compared to MPK:
  0% GC: 26.3% higher
  35-75% GC: 21.2% higher

- With X2, the prosthetic limb was utilized and loaded more normative. Therefore, the first vertical impact maximum (0-30%) increased up to 13.2%.

Please note: The percentage differences were calculated between the published Median values.
### Population

**Subjects:** 21 unilateral, transfemoral amputees

**Previous prosthetic knee:**
- Mechanical knee (n=8) → Total Knee (Össur)
- Standard MPK (n=13) → C-Leg (Otto Bock)

**Amputation causes:** Trauma

**Mean age:** 32.7 yrs (± 5.3 yrs)

**Time since amputation:** ≥ 2 years

**MFCL:** K4

### Study Design

Interventional, pre- to post-test design:

Use of handrails influenced what data were available for biomechanical analysis. As such, data from participants who self-selected to use handrails for support were not included in temporal-spatial, kinematic, or kinetic analyses.

<table>
<thead>
<tr>
<th>Function</th>
<th>Temporal-spatial</th>
<th>Kinematic</th>
<th>Kinetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH</td>
<td>n=4</td>
<td>n=4</td>
<td>n=3</td>
</tr>
<tr>
<td>MPK</td>
<td>n=12</td>
<td>n=12</td>
<td>n=11</td>
</tr>
</tbody>
</table>

### Results

#### Functions and Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Participation</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level walking</td>
<td>Safety</td>
<td>Preference, Satisfaction, QoL</td>
</tr>
<tr>
<td>Stairs</td>
<td>Activity, Mobility, ADLs</td>
<td>Health, Economics</td>
</tr>
<tr>
<td>Ramps, Hills</td>
<td>Energy</td>
<td>Health, Economics</td>
</tr>
<tr>
<td>Obstacles</td>
<td>Cognitive demand</td>
<td>Economics</td>
</tr>
<tr>
<td>Uneven ground</td>
<td>Energy</td>
<td>Health, Economics</td>
</tr>
</tbody>
</table>

#### Results for Genium X2

**Category**
- Ramps, Hills

**Outcomes**
- Temporal-spatial

**Walking speed is faster:**

\[ X2 \text{ vs. MPK} \quad 9.6\% \text{ faster} \]

++

\[ X2 \text{ vs. MECH} \quad 8.2\% \text{ faster} \]

+

**Step length is longer with X2:**

\[ X2 \text{ vs. MPK} \quad 16.9\% \text{ longer} \]

++

\[ X2 \text{ vs. MECH} \quad 1.6\% \text{ longer} \]

+

No significant differences were found for stance time.

**Kinematic**
- The initial knee flexion (0% GC) increased with X2 compared to MPK (significantly) and MECH:

\[ X2 \text{ vs. MPK} \quad 326.7\% \text{ higher} \]

++

\[ X2 \text{ vs. MECH} \quad 63.3\% \text{ higher} \]

+
### Results for Genium X2

#### Kinetic

**The max. support moment (0-30% GC) increased with X2 compared to the previous knee:**

<table>
<thead>
<tr>
<th></th>
<th>X2 vs. MPK</th>
<th>X2 vs. MECH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26.3% higher</td>
<td>240.6% higher</td>
</tr>
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</table>

**The max. support moment (35-75% GC) increased:**

<table>
<thead>
<tr>
<th></th>
<th>X2 vs. MPK</th>
<th>X2 vs. MECH</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>21.2% higher</td>
<td>147.5% higher</td>
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</table>

**Due to more prosthetic limb utilization and normative loading, the first vertical impact maximum (0-30%) increased:**

<table>
<thead>
<tr>
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<th>X2 vs. MECH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13.2% higher</td>
<td>12.3% higher</td>
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<td>+</td>
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</table>

No significant differences were found for:
- Max. braking force (0-30%)
- Max. propulsive force (35-75%)
- Second vertical impact maximum (35-75%)

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

### Author's Conclusion

“The aim of the current study was to determine if use of the X2® improves overall slope descent mechanics by assessing self-selected technique of decent, and subsequent changes in temporal-spatial outcomes and joint mechanics. Although this analysis finds normalization of some temporal-spatial outcomes and joint mechanics were likely achieved due to the use of stance flexion resistance with the X2® device allowing for improved control lowering the body when both leading and trailing, some values continued to deviate from those of able-bodied individuals. Nevertheless, decreased reliance on handrail use as MECH users descended in the X2® suggest improved function and perhaps greater confidence in the device possibly reducing the risk of falling. Furthermore, overall reductions in intact limb loading and more symmetric loading at impact could indicate more normative loading patterns and a possible reduction of intact limb overuse during downslope walking. Reducing compensatory gait strategies during slope descent, perhaps through use of the X2®, could thus play a role in mitigating longer-term overuse injuries commonly associated with TFA.” (Bell et al., 2016)