A New Kinetic Profile of Foot Function in People with Diabetes and Peripheral Neuropathy: A Pilot Study

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A New Kinetic Profile of Foot Function in People with Diabetes and Peripheral Neuropathy: A Pilot Study

Frank E. DiLiberto

My disclosure is in the Final AOFAS Mobile App. I have no potential conflicts with this presentation.
Background

• Single segment foot modeling may mask informative characteristics of foot function

• People with Diabetes Mellitus and peripheral neuropathy (DMPN) exhibit elevated forefoot plantar pressure but reduced ankle power generation\(^1\)

• Multi-segment foot modeling and multi-joint kinetic analysis may offer a more informative profile of diabetic foot function
Purpose

To apply a novel multi-segment model and incorporate multi-joint power analyses (midfoot and rearfoot) to extend current knowledge regarding DMPN foot function in relation to forefoot plantar pressure
Methods

• Pilot Case Control Study
• Sample: N = 6
  – 3 people with DMPN (age: 55.6 yrs; M/F 3:0)
    • Loss of protective sensation (monofilament testing)
  – 3 Healthy Controls (age: 55.8 yrs; M:F 1:2)
• Participants walked at 0.79 m/s² over a force plate (kinematic and kinetic data) and then over a pressure mat
Kinematic and Kinetic Model

**Kinematic Model (electromagnetic sensors)**
- 5 segments: Tibia, Calcaneus, Metatarsals 1, 3 and 5
- *Primary outcome measure*: Sagittal plane excursion (60-100% of stance)

**Kinetic Model**
- Tibia, Rearfoot (calcaneus), Forefoot (created from 1\textsuperscript{st}/3\textsuperscript{rd}/5\textsuperscript{th} metatarsals)
- Centers of rotation: Ankle (rearfoot) and Middle Cuneiform (midfoot)
- *Primary outcome measures*: Midfoot and Rearfoot positive (+) and negative (-) peak power and work (after heel off)
Pressure Model and Results

• **Outcome measure**: Forefoot pressure time integral (PTI)
  – Peak pressure over time

• People with DMPN demonstrated higher forefoot PTI than the control group (DMPN: 390 vs. Control: 227 kPa/Kg*s)
Results - Kinematics

Sagittal plane angular excursion (dorsiflexion/plantarflexion) during gait was reduced across all examined segments in people with DMPN

<table>
<thead>
<tr>
<th>Segment</th>
<th>DMPN Mean° (SD)</th>
<th>Control Mean° (SD)</th>
<th>Effect Size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcaneus to Tibia</td>
<td>12.5 (3.8)</td>
<td>20.4 (4.5)</td>
<td>1.8</td>
</tr>
<tr>
<td>Forefoot to Rearfoot</td>
<td>5.7 (2.7)</td>
<td>12.2 (3.6)</td>
<td>2.0</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Metatarsal to Calcaneus</td>
<td>5.7 (2.)</td>
<td>10.3 (2.5)</td>
<td>1.8</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Metatarsal to Calcaneus</td>
<td>6.2 (2.1)</td>
<td>15.0 (1.1)</td>
<td>5.3</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Metatarsal to Calcaneus</td>
<td>6.8 (1.5)</td>
<td>11.9 (1.2)</td>
<td>3.6</td>
</tr>
</tbody>
</table>
Positive peak power was reduced at the rearfoot (Cohen’s d = 0.2) and midfoot (Cohen’s d = 0.6) in people with DMPN (above).

<table>
<thead>
<tr>
<th></th>
<th>DMPN Mean (SD)</th>
<th>Control Mean (SD)</th>
<th>Effect Size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rearfoot</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Work</td>
<td>14.3 (9.9)</td>
<td>20.5 (3.8)</td>
<td>0.8</td>
</tr>
<tr>
<td>- Work</td>
<td>14.9 (4.3)</td>
<td>6.7 (2.4)</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Midfoot</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Work</td>
<td>2.5 (2.1)</td>
<td>4.1 (0.7)</td>
<td>1.0</td>
</tr>
<tr>
<td>- Work</td>
<td>1.9 (1.7)</td>
<td>2.1 (0.7)</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The analysis of multi-joint work during walking revealed a new finding of increased rearfoot negative work in people with DMPN (Table).
Discussion

- People with DMPN demonstrated increased forefoot PTI and reduced ankle power generation.

- The multi-segment rigidity, as demonstrated by this model, may partially account for the elevated PTI despite reduced ankle power.

- The finding of increased rearfoot negative work in people with DMPN, newly detected by this model, may also be related to elevated forefoot PTI.
Conclusions

• People with DMPN demonstrated less sagittal plane motion at multiple locations during terminal stance.

• The kinetic profile of people with DMPN was one of reduced power generation at both the rearfoot and midfoot and excessive power absorption / negative work at the rearfoot.

• Further study is recommended to determine if this kinetic profile is reproducible and related to elevated forefoot plantar pressure and the potential for tissue breakdown in people with DMPN.
References