INTRODUCTION

Development of advanced prosthetic components requires multiple iterations of testing, design refinement, and retesting. Component testing has traditionally used people with amputation. However, this can be difficult given limited number of potential research subjects available due to the relative rarity of amputation and the confounding factors related to the many comorbidities inherent in this population. Some researchers have accelerated the development process by using individuals with intact limbs wearing prosthesis emulators (Collins, 2010). If these ankle-fixation boots accurately replicate prosthetic gait, they could allow for a larger population of subjects for testing and development of prosthetic foot/ankle systems.

The objective of this study was to provide preliminary validation of ankle-fixation boots as an emulator of prosthetic gait, specifically looking at temporospatial aspects of gait.

METHOD

Subjects: Five males (44.6 ± 12.7 yrs, 92.2± 17.0 kg, 185.5± 16.2 cm) with unilateral trans-tibial amputations (TTA) and five males (86.4 ± 6.8 kg, 178.8 ± 5.36 cm) with intact limbs (EMU) completed this IRB approved study.

Apparatus: Subjects in the intact-limb group utilized an ankle-foot orthosis (Össur, Rebound Air Walker), with a plate attached to allow the addition of a prosthetic foot to the bottom, unilaterally. A boot with a 10 cm lift was worn on the contralateral limb to account additional height provided by the prosthetic foot. An even walkway (7.3 x 0.8m) was used to ambulate on while an eight camera motion captures system (Vicon Motion Systems, Oxford, UK) recorded limb kinematics.

Procedures: A 39-marker set (Vicon PlugInGait) was applied to each subject. The subject walked five times down the walkway to a metronome (108 bpm) with one of three foot conditions (order randomized) An Endolite Multi-flex foot with soft, medium, and firm interchangeable ankle stiffnesses were utilized.

Data Analysis: A mixed ANOVA was used to compare step length, percent time spent in stance, and Froude number across foot stiffnesses and between groups. Statistical significance was declared at p < 0.05.)

RESULTS

There were no significant effects of foot stiffness or group, and no interaction effect. Group effect p-values were as follows: rt. step length (p=0.27), lt. step length (p=0.16), rt. stance % (p=0.34), lt. stance % (p=0.62), and Froude number (p=0.98).

<table>
<thead>
<tr>
<th>Effect of Stiffness (p value)</th>
<th>Soft TTA</th>
<th>Medium TTA</th>
<th>Firm TTA</th>
<th>Soft EMU</th>
<th>Medium EMU</th>
<th>Firm EMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rt Step Length (m)</td>
<td>1.19</td>
<td>1.15</td>
<td>1.14</td>
<td>1.18</td>
<td>1.18</td>
<td>1.13</td>
</tr>
<tr>
<td>Lt Step Length (m)</td>
<td>1.20</td>
<td>1.14</td>
<td>1.21</td>
<td>1.14</td>
<td>1.20</td>
<td>1.15</td>
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<td>Rt Stance %</td>
<td>66.6</td>
<td>63.6</td>
<td>66.9</td>
<td>65.4</td>
<td>65.6</td>
<td>65.7</td>
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<tr>
<td>Lt Stance %</td>
<td>63.9</td>
<td>63.8</td>
<td>63.1</td>
<td>63.8</td>
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<td>Froude Number</td>
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<td>0.13</td>
<td>0.13</td>
<td>0.14</td>
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</tbody>
</table>

Table 1. Mean results for different ankle stiffnesses within each group.

DISCUSSION

There were no significant differences between groups with any temporospatial variable indicating the emulator boots did replicate prosthetic gait. Froude number was used instead of gait speed and cadence as this would be account for the increase in leg length with the prosthetic emulators to show walking dynamics were constant between groups.

CONCLUSION

The emulators were able to replicate the prosthetic gait parameters measured. While these findings suggest that emulators could be valuable tools, further research is needed to test their validity across other biomechanical variables (e.g. joint moments, center of mass work, etc.).

CLINICAL APPLICATIONS

A reasonable and cost-effective method of replicating transfibial amputation gait can help further research, via the use of prosthetic emulator boots. This will create a larger subject pool, thus providing the availability to perform more research that can potentially benefit the amputation population.

REFERENCES