INTRODUCTION
Orthotic and Prosthetic (O&P) devices are commonly used to improve ambulation, especially gait. The clinical analysis of gait is an essential part of O&P care. In addition, third party payers are placing additional demands on clinicians to provide evidence-based justification for O&P interventions. These changes in the clinical landscape increase the need to incorporate outcome measures into clinical practice to quantify improvements in gait due to an O&P intervention (Brinkmann et al., 2013).

The introduction of “smart” devices with integrated cameras (e.g. iPad and iPhone) and the development of application software specific to motion capture (Dartfish Express) have enabled these devices to be used as a potential method to measure improvements in gait due to O&P intervention. However, the accuracy and precision of this application is unknown.

The purpose of this research was to examine the validity and accuracy of joint angles calculated with the Dartfish Express (DE) iPad application compared to the same angles calculated with a laboratory based 3-D motion capture system (Vicon). This information will enable clinicians to use this technology appropriately to provide objective data supporting the O&P interventions being provided to their patients.

METHOD
Subjects: A group consisting of thirteen rehabilitation professionals (O&P, OT, & PT) and eighteen rehabilitation students (O&P & OT) completed the study. The study was approved by the IRB and subjects gave written informed consent.

Procedures: A non-pathological ambulator walked at a self-selected speed. Two iPad 2s loaded with DE held ~3 m orthogonal to the center of the walkway recorded sagittal plane motion (30 Hz) simultaneously with an eight-camera Vicon motion capture system (100 Hz, 39 markers, PlugInGait full-body model).

Apparatus: Seven angles were calculated over two steps on the right leg. These angles included: between limbs at double-limb support (3 events), peak knee flexion during stance (2 events), peak hip extension, and peak knee flexion during swing.

The subjects used DE to quantify the seven angles on each iPad (14 angles per subject). The order of iPad videos was randomized. Each subject received brief instruction on how to use DE.

RESULTS
Vicon Bodybuilder 3.6.1 was used to process joint angles collected with Vicon. A random Monte Carlo analysis was performed to estimate variability inherent in Vicon calculations based on system calibration.

Data Analysis: RM ANOVA assessed significant differences between Vicon and DE (2 iPads).

<table>
<thead>
<tr>
<th></th>
<th>DOUBLE LIMB SUPPORT</th>
<th>KNEE STANCE FLEX.</th>
<th>PEAK HIP EXT.</th>
<th>KNEE SWING FLEX.</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPad1</td>
<td>-2.9±3.3</td>
<td>5.0±5.7</td>
<td>3.6±5.2</td>
<td>2.2±5.0</td>
</tr>
<tr>
<td>iPad2</td>
<td>-1.9±3.1</td>
<td>3.6±5.0</td>
<td>2.2±6.3</td>
<td>-2.2±5.1</td>
</tr>
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Table 1. Mean difference ± one standard deviation between DE & Vicon measurements in degrees.

DISCUSSION
The statistical differences between Vicon and DE could be attributed to variability in each subject’s judgment of the joint center location and difficulty using the iPad to identify this location. Parallax error, low frame rate, and lens distortion also contribute to the increased variability. Despite the statistical differences and limitations of the iPad, DE can quantify most joint angles to within ~10 degrees (95% CI) and the purchase price is much lower ($4.99) than laboratory based motion capture systems (>$100k).

CONCLUSION
The large variability in angle measurements with the Dartfish Express iPad application limits but does not preclude clinical use. The system can be used to show angular differences greater than 10 degrees. For example, gait analysis with DE of patient with a transfemoral prosthesis may reveal a stance flexion measurement of 10+ degrees. This measurement would demonstrate the patient is utilizing this design feature and would provide justification for the L5845 code. The Dartfish Express iPad application is a cost-effective technology that will (with limitation) allow clinicians to support their O&P intervention.

REFERENCES