Use of an Amputee Gait Score to Assess Rehabilitation Progress

Trevor Kingsbury, Michael Marks, Nancy Thesing, Grant Myers, Mark Isken, Marilynn Wyatt

1Naval Medical Center San Diego, San Diego, CA, USA
2Improvement Path Systems, Inc. Bingham Farms, MI, USA
3Oakland University, MI, USA
email: trevor.kingsbury@med.navy.mil

INTRODUCTION

The use of gait analysis for patients with amputations is a useful tool to evaluate progress made during rehabilitation. While gait data can provide valuable metrics to guide patient care, the ease of acquiring large sets of data for many variables can make interpretation convoluted for a provider without extensive gait training. Originally developed for children with cerebral palsy, the Gillette Gait Index (GGI) utilizes kinematic and temporal spatial data to describe the quality of a subject’s gait. Other measures such as the Gait Deviation Index (GDI) and the Gait Profile Score (GPS) have used only kinematic variables to define gait pathology. These measures have been tested with amputee gait data with some success, finding that the GGI, GDI, and GPS could differentiate patients with different levels of amputation to some degree. However, when focusing on the rehabilitation of a patient with an amputation, loading of both the amputated and the sound limb are important. Previous research has linked degenerative conditions such as osteoarthritis to loading asymmetries in amputees. Thus, kinetic ground reaction force data is an important variable when evaluating the gait of a patient with an amputation. The goal of this study is to develop an amputee gait score that can assess gait quality through rehabilitation. We hypothesize that a patient’s gait score should be at a minimum around 6 months from their baseline study, when they are near the end of physical therapy before discharge.

METHODS

Gait data was collected on 20 normal male subjects and 40 patients with unilateral transtibial amputations. Those forty patients had a total of 173 studies. Baseline studies were collected as soon as the patient could walk without an assistive device and were then followed up over the next year at four time points: 6 weeks, 3 months, 6 months, and 1 year. Due to problems such as socket fit issues, pain, and other activities, not all patients were collected at every time point.

Clinically relevant minimums and maximums were chosen from vectors of gait cycle data. Thirty-six total variables for each study were collected (8 Temporal Spatial, 20 Kinematic, and 8 Kinetic) (Table 1). The data from the 20 normal subjects were normalized to a mean of zero with a unit standard deviation. The 173 studies for patients with unilateral transtibial amputations were normalized to the mean and standard deviation of the 20 normal studies. Absolute step asymmetry, velocity, cadence, and step width were adjusted to account for patients being better than the normal mean. For any patient who had values better than the normal mean value for these variables, the values were set to zero. Additionally, velocity, cadence, step length, and stride length were normalized for patient height. A weighting scheme was then applied to the variables to emphasize key indicators of quality gait in patients with amputations (Table 1). A principal component analysis was run on the normal population and applied to the study population. This was done as a variable reduction technique and to remove the inherent correlation that occurs in gait data. Means were calculated for the normal principal components. A Euclidean distance was taken from the means of the normal principal components to the values of the principal components for each study. This resulted in a single score, for each study, that explained the amount of deviation from normal gait, with a score closer to zero indicating less deviation.

Patient study data was binned by time (in days from baseline) into categories representing baseline, 6 week, 3 month, 6 month, and one year data. An ANOVA model with LSD post hoc tests were used to determine interaction effects if a main overall effect was found.
RESULTS AND DISCUSSION

Amputee gait scores at the five timepoints are summarized in Table 2. A significant main effect was found for the time bins ($F = 19.27, p < .001$). Post hoc analysis revealed significant interaction effects between baseline and all other times as well as between the 6 week and 6 month time point ($p<.05$) (Figure 1). Thus, patients rapidly improve their gait scores throughout the early part of rehabilitation and appear to stabilize around the six month mark.

Table 2: Descriptive Statistics for the Amputee Gait Scores

<table>
<thead>
<tr>
<th>Timepoint</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>95% Confidence Interval</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>39</td>
<td>65.30</td>
<td>13.59</td>
<td>60.90 - 69.70</td>
<td>34.19</td>
<td>87.58</td>
</tr>
<tr>
<td>6 Week</td>
<td>30</td>
<td>49.01</td>
<td>12.38</td>
<td>44.38 - 53.63</td>
<td>26.69</td>
<td>75.21</td>
</tr>
<tr>
<td>3 Month</td>
<td>38</td>
<td>46.59</td>
<td>13.04</td>
<td>42.31 - 50.88</td>
<td>29.31</td>
<td>78.65</td>
</tr>
<tr>
<td>6 Month</td>
<td>45</td>
<td>43.00</td>
<td>10.29</td>
<td>39.91 - 46.09</td>
<td>22.55</td>
<td>68.75</td>
</tr>
<tr>
<td>1 Year</td>
<td>21</td>
<td>45.02</td>
<td>14.92</td>
<td>38.23 - 51.82</td>
<td>25.96</td>
<td>83.22</td>
</tr>
</tbody>
</table>

These results coincide with clinical observations of the patients with amputations undergoing rehabilitation. At our center, as a patient progresses between the three and six month mark in their care, they typically scale back on their physical therapy appointments as they move into higher functional activities and return to their jobs. One of the main obstacles they will face is maintaining quality gait throughout their lives without the assistance of intense physical therapy.

Future aims of this project will be to look at patients with other levels of amputations to create a gait scoring guideline for any patient with amputation starting a rehabilitation program. This will hopefully aid the patients and providers in keeping them on track in therapy to provide the best long term outcomes.

REFERENCES


Disclaimer: Views in the article are those of the authors and not of the DoN, DoD, or the US Government.