INVESTIGATING THE EFFECTS OF PROSTHETIC HAND DESIGN ON PERFORMANCE

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INTRODUCTION

Persons with arm amputations who use prosthetic hands with articulated fingers are often thought to perform actions more naturally and with reduced compensatory arm and body positioning than persons who use hands without articulated fingers (Metzger, 2012). A study was developed to determine if these perceived differences can be measured quantitatively using standardized performance measures and motion capture.

METHOD

This study was approved by the Northwestern University Institutional Review Board and informed consent was obtained from all participants.

Subjects: A control group of six able-bodied subjects (AB), three male and three female, with mean age 35.8 yrs (range: 22.9 to 48.8). Two amputee subjects: one 65 yr old male (S1) with a middle-third transradial amputation of the right arm (29 yrs prior), who has used an Otto Bock System Electric Hand (Duderstadt, Germany) for 26 yrs; and one 25 yr old male (S2) with a middle-third transradial amputation of the right arm (3 yrs prior), who has used a Touch Bionics Ultra Hand (Livingston, UK) for 11 months. Both subjects had traumatic amputations and were right-hand dominant prior to amputation.

Apparatus: Demographic questionnaire, socket comfort score (Hanspal, 2003), grip force measurement, Orthotics and Prosthetics Users’ Survey - Upper Extremity Functional Status (OPUS-UEFS) (Heinemann, 2003), Southampton Hand Assessment Procedure (SHAP) (Light, 2002), and 12-camera motion analysis system (Motion Analysis Corporation (MAC), Santa Rosa, CA).

Procedures: The OPUS-UEFS was completed by both amputee subjects. The complete SHAP was administered twice to all subjects with the AB group using first their dominant, then their non-dominant hands and amputee subjects using first their intact hands, then their prosthetic hands. All subjects then had reflective markers placed on their arms and torsos using a custom-designed upper-limb model. Data were collected as the subjects completed a subset of five SHAP activities five times each in random order. The AB group used their non-dominant hands and the subjects with amputation used their prosthetic hands. All subjects also completed a semi-structured breakfast activity involving beverages, cereal, and a banana.

Data Analysis: SHAP scores were calculated using the online SHAP Test Centre. Cortex software (MAC) and Matlab (Mathworks, Natick, MA) were used to calculate upper limb and trunk kinematics.

RESULTS

Exemplary range-of-motion (ROM) and kinematics of the SHAP “lifting a heavy object” task from the prosthesis users and a representative AB subject (AB2) are presented in Table 1 and Figure 1, respectively.

<table>
<thead>
<tr>
<th>Average ROM (degrees)</th>
<th>S1</th>
<th>S2</th>
<th>AB2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder Flexion</td>
<td>19</td>
<td>18</td>
<td>31</td>
</tr>
<tr>
<td>Shoulder Ab/Adduction</td>
<td>36</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>Elbow Flexion</td>
<td>48</td>
<td>58</td>
<td>54</td>
</tr>
<tr>
<td>Trunk Transverse Rotation</td>
<td>13</td>
<td>24</td>
<td>9</td>
</tr>
<tr>
<td>Trunk Lateral Flexion</td>
<td>9</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Trunk Forward Flexion</td>
<td>5</td>
<td>15</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1. Average kinematic range-of-motion (ROM).

DISCUSSION

Preliminary results indicated that for most of the SHAP tasks in which kinematics were recorded, kinematic profiles appeared similar between the AB group and prosthesis users. However, prosthesis users of either hand types displayed consistently greater trunk ROM. Metzger et al. (2012) also found greater trunk ROM in users of unspecified myoelectric hands.

CONCLUSION

Preliminary results suggest that SHAP tasks reflecting activities of daily living require similar upper limb kinematics between AB and prosthesis users, but prosthesis users compensate with greater trunk ROM.

CLINICAL APPLICATIONS

Documenting manipulative performance attributable to different prosthetic hand design features may aid the clinician in recommending components.

REFERENCES


American Academy of Orthotists & Prosthetists
40th Academy Annual Meeting &
Scientific Symposium
February 26 - March 1, 2014