MOTION ANALYSIS TO MEASURE OUTCOMES FOLLOWING TARGETED MUSCLE REINNERVATION SURGERY

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INTRODUCTION

The ‘Box and Blocks’ task (BB) is a component specific task of performance which tests the gross manual dexterity of the upper limb (UL)1 and is a widely used outcome measure for UL function in several populations.2,4 The BB task has also been used to examine UL prosthetic function following amputation, and specifically used to examine myoelectric control after Targeted Muscle Reinnervation surgery (TMR).2,3 The BB task measures speed and quantity with respect to the number of blocks moved in a specific time period,1 regardless of quality of movement or compensatory strategies used by the individual to accomplish the task.

However, restoring “normal” UL function after amputation relies not only on quantitative performance but also on qualitative observation of the smoothness of pattern of motion and the ability to target and control excursion of the grasp.5–8 In addition, it is important for prosthetic users to minimize compensatory motions of the body when adapting to the limitations of a prosthetic device. With advances in UL management, such as TMR surgery, the need to accurately quantify the advantages of such procedures is even more essential, as subjective interpretation by the patient and observations on the quality of movement can be more impressive than timed tasks or traditional outcome measures of upper limb function.10 With a specific repetitive task such as the BB task, the arc and smoothness of motion of the prosthetic limb can be repeatedly observed and recorded; and is amenable to motion capture for the purpose of quantifying this component of performance. Our goal was to establish a method to quantify this improved quality of movement of TMR patients using myoelectric prostheses.

The purpose of this report is to describe a method of quantitative motion analysis, in combination with a modification of the BB task, used to quantify the observed improvements in compensatory movements and control in a subject pre- and post-TMR surgery.

METHODS

Subject

The subject was a 28-year-old male with traumatic left transhumeral amputation on July 4, 2006. The subject was initially fit with conventional body powered prosthesis with mechanical voluntary opening terminal device, and was a successful daily prosthetic user. The subject underwent transhumeral TMR surgery5 20 months post amputation and 8 months post surgery, he was fit with a TMR control myoelectric prosthesis. The motion analysis testing of the subject occurred prior to TMR surgery using the conventional prosthesis, and 3 months after fitting with the myoelectric TMR prosthesis.

Motion Analysis

A total of 6 markers were applied to the subject, including sternum, C7, acromion (bilaterally), lateral elbow hinge, and wrist. There were three markers placed on the box and divider to identify the location of box and blocks in the virtual labspace as well as the subject’s location relative to the box (Figure 1). Motion was captured using eight Motion Analysis Corporation cameras with a sample frequency of 60 hertz (Hz).

Modification to the BB task

Rather than a random assignment of blocks, the placement and order of blocks in the tray to be moved was standardized to 16 blocks placed in 4 rows. The subject was instructed to proceed from lower left corner block, across the row then proceed to the next row. It was felt that this set up would require specific targeting of the terminal device and demand for consistent activation and arc of movement that would require precise control and be amenable to motion analysis. In addition to the kinematics of the prosthetic and trunk motion, the time to complete moving all 16 blocks was recorded or the number of blocks moved within 1 minute, whichever the subject accomplished first.
The subject moved fewer blocks with the myoelectric prosthesis than the conventional prosthesis (Table 1). With the modified task, it took 56 seconds to move 16 blocks with the myoelectric prosthesis, and 29 seconds with the conventional. However, this faster time with the conventional prosthesis was associated with the use of a locked elbow versus normal elbow motion demonstrated with the myoelectric prosthesis. In addition, the locked elbow prosthesis required excessive trunk compensatory motion compared to the trunk motion recorded with the myoelectric prosthesis, which was close to motion of normal subjects.

Table 1: Results of standard and modified tasks for BB

<table>
<thead>
<tr>
<th>Task</th>
<th>Prothesis Used</th>
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</thead>
<tbody>
<tr>
<td>Standard BB Task</td>
<td>Conventional</td>
</tr>
<tr>
<td>(# of Blocks moved in 60 sec)</td>
<td>49</td>
</tr>
<tr>
<td>Modified BB Task (Time (sec) to move 16 Blocks)</td>
<td>20</td>
</tr>
</tbody>
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**DISCUSSION**

In the case study presented, one of the more striking findings is that while the subject clearly had slower performance with the myoelectric, the movement control was better and less compensatory adjustments were required to perform the task. The subject in this case report also had better and less compensatory adjustments were required. The subject in this case report also had faster time with the myoelectric prosthesis, and 29 seconds with the conventional. However, this faster time with the conventional prosthesis was associated with the use of a locked elbow versus normal elbow motion demonstrated with the myoelectric prosthesis. In addition, the locked elbow prosthesis required excessive trunk compensatory motion compared to the trunk motion recorded with the myoelectric prosthesis, which was close to motion of normal subjects.

**REFERENCES**