Uncommon Surface Electromyography

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Surface electromyography (SEMG) can be used as a tool to help gain the return/discovery of motor function in those with disabilities. This article presents the case of “Joey,” an 18-month-old toddler. An already challenging case due to age is made even more difficult considering his genetically based multiple impairments. SEMG provided a window of opportunity, previously unavailable, to allow Joey to demonstrate the new motor skills that he was capable of learning.

Introduction
Surface electromyography (SEMG) uses sensors attached to the skin to listen to the energy a muscle generates while initiating movement. This energy can then be displayed in a form a human can understand, such as a line on a computer screen or an audio tone. The amplitude of the energy varies with the muscle use. SEMG is often associated with biofeedback training as a tool to help a person relax. A typical demonstration shows a patient sitting in a relaxed position with wire leads attached to his or her arms or head. A simple biofeedback setup can teach relaxation by asking the patient to lower an auditory tone or modify a visual display. The tone or visual display represents the signal from the biofeedback unit, and success equals less muscle tension. A less well-known application is the flip side of relaxation training, that is, muscle activation training, or neuromuscular rehabilitation.

Motor Function and SEMG
This article will describe the use of SEMG to improve motor functioning in a rather difficult case: a young (18-month-old) boy with multiple impairments. In previous articles (Bolek, 1998, 2001, 2006, 2008; Bolek, Mansour, & Sabet, 2001), the author has described a variety of applications using SEMG to promote the return of motor function. In the author’s view, the greatest impediment to promoting more widespread use of SEMG for those with muscle dysfunction is the deceptive simplicity of muscle biofeedback for this population. Neuromuscular rehabilitation is much more complex than simply increasing activity in a single muscle. Without an understanding of muscle dynamics, as well as of SEMG, the likelihood of success is greatly reduced.

Case Background
“Joey” has a genetic disorder, called Lowe syndrome, which causes, among other things, severe vision impairment and floppy tone. Muscle tone is background muscle activity that we all use (without having to think about it) to maintain our standing, sitting, and so forth position. We take it for granted (much like we do gravity). However, there are medical conditions that cause abnormally low muscle tone. This condition creates havoc during the early developmental months.

Joey was diagnosed with Lowe syndrome shortly after birth. This x-linked syndrome is associated with failure to thrive, seizures, hypotonia, hyperactivity, cortical cataracts, and moderate to severe mental deficiency. He was referred by a physical therapist at another local hospital for treatment in the Motor Control Program at the Cleveland Clinic Children’s Hospital for Rehabilitation due to his multiple impairments and failure to make progress in therapy.

Planning the Intervention
During the first visit, Joey demonstrated the ability to commando crawl; transition out of sitting; hold himself on all fours, once placed, for 30 seconds; sit independently, once placed, in sitting position; and tall kneel with moderate assistance. Tall kneeling is just what one would expect, that is, kneeling with a straight back, with the angle of the legs at 90 degrees. By 18 months, one would expect to see, generally speaking, the following gross motor skills: climbing onto low furniture, the ability to walk well, squatting and reerecting.
and walking upstairs with one hand held. His visual impairment limited his social/emotional development. His mother wished to give him every opportunity to develop normally as much as possible, especially motor skills. Given the extent of his deficits, we decided to begin our training with tall kneeling. The protocol used for tall kneeling and standing was developed by the author based on more than 100 children seen with similar deficits. The sites targeted were the bilateral gluteus maximus and the quadriceps. Raising the trunk from a forward-bent position requires the action of the gluteus maximus (Kendall, McCreary, & Provance, 1993). In severe cases, patients must push with their arms to bring themselves upright. The extension of the knee is generated, in part, by the quadriceps. Usually these four sites are all that is needed to teach the movement. Once a firm base of support is established, everything else usually falls into place.

Completing One’s Homework Prior to Treatment

Before any training can be done, thought must be given to the following: cause/effect awareness, motivation, motor planning capability, and sensorium intactness. Sensorium intactness refers to the ability to use the senses (hearing, tactile, vision) to interact with the environment. If tactile awareness is compromised, modification devices will be needed (e.g., changing the cover of the switch from smooth plastic to sandpaper). A certain level of intellect is needed to perceive cause/effect. In those with developmental disabilities, this may or may not be intact. Obstacles to motivation may range from the desire to carry on the sick role with adults to young patients that require frequent changes in the reward to stay motivated. Lastly, the patient may have cause/effect, with an intact sensorium and high motivation, but if the ability to motor plan is compromised, success will be limited. At face value, the above appears obvious, but in a clinical setting, it is very easy to jump to the conclusion that the inability to perform a purposeful act on command is due to a physiological insult such as central nervous system damage or muscle/nerve damage. The author has witnessed many instances of a child with a hemiparesis due to a stroke, who was seemingly unable to generate any purposeful movement, suddenly respond when the reward obtained had value to the child.

Treatment

The treatment scenario with Joey was as follows: A video monitor at a height of 12 inches was placed 3 feet in front of the child, and a bench at 14 inches for support was placed immediately in front of the child. As can be seen in Figure 3, he is wearing supramalleolar orthoses to control severe pronation and supination (pronation is a rotational movement of the foot at the subtalar and talocalcaneonavicular joints; supination is a rotation of the foot and leg with the sole up). Benches were the traditional 32- × 14-inch adjustable padded benches used in pediatric therapy. A soft mat was placed on the floor for kneeling. The equipment used was a Thought Technology Infiniti system with screens/channel sets developed by the author. Electrodes were disposable pre-gelled electrodes (available from Bio-Medical Instruments). The program was set to activate the onset of a video (reward) if all SEMG muscle sites (bilateral gluteus maximus/quadriceps) remained at or above a set threshold. Onset/offset of the video varied depending on the progress attaining the reward. Initially, onset was set at .10 seconds and then gradually lengthened to 1 second over the course of several sessions (i.e., immediate onset to delayed). Likewise, offset was initially set at 1 second and then changed to .10 seconds (delayed to immediate). These parameters are critical, especially in the early stages of treatment. After some trial and error, the thresholds were set (all four sites above threshold) by a therapist-defined approximation of legs to the torso at 90 degrees. In all cases, in the early stages (treatment Sessions 1 through 3), the ratio of success to failure was never allowed to go below 80%. In other words, Joey received the reward at least 80% of the time of the session (usually 50 minutes).

The first two sessions were not especially successful. In addition to his deficits, he was a typical 18-month-old and cried throughout the entire sessions. Consideration was given to ending the treatment. However, by interspersing the work periods with fun activities with his mother, we were able to reach a compromise. By the third session, he had learned to use the targeted muscles, albeit very briefly, allowing him to be well on his way to learning the task. His affect changed from one of trepidation to babbling and
smiling. He would even try to grab the electrodes during application in a seemingly helpful manner! It is important to remember that at specific points in everyone’s life, basic rules of life are learned (or, in psychological terms, operant conditioning). That is, there are times when one must be an active participant in his or her environment to get what is desired. For a child of 18 months, biofeedback can be likened to a large dose of reality, all at one time. In this case, one performs the task and is rewarded, or one fails to perform and is not rewarded. Although the machine settings can be adjusted to soften the blow, there is no escaping the machine-like precision with which the SEMG unit disperses reward/no reward.

**Results**

Figures 1 and 2 summarize the boy’s progress over 13 weeks. These results are all the more impressive considering that he had reached a plateau in traditional physical therapy for 4 weeks prior to coming to the Motor Control Program. Although maturation is always a factor to consider in pediatric research, gains such as these in 13 weeks are not typical for a child with medical issues. Please refer to Table 1, which includes a chronology of motor control notes that provides some interesting corroboration of Joey’s improvements.

There are some notable findings in this report. First, notice that when Joey’s head position improved, his standing deteriorated slightly. This is not an unusual finding. For example, progress in speech therapy some-

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**Table 1. Compendium of chart notes across the treatment span**

<table>
<thead>
<tr>
<th>Date</th>
<th>Distilled Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/27</td>
<td>Initial assessment, demonstrates cause/effect.</td>
</tr>
<tr>
<td>9/24</td>
<td>Able to achieve active hip extension 4 × /2 min period, inconsistent.</td>
</tr>
<tr>
<td>10/8</td>
<td>Able to achieve active hip ext 80% of 2 min. period, was two times able to activate hip ext. 60% of last session versus 30% of previous session.</td>
</tr>
<tr>
<td>10/22</td>
<td>Capable of tall kneeling for a full minute, huge leap from two weeks ago.</td>
</tr>
<tr>
<td>11/12</td>
<td>Due to rapid progress moved on to standing balance.</td>
</tr>
<tr>
<td>12/3</td>
<td>Standing at bench, able to achieve “on” intermittently throughout session, lost control through L knee ext. rotation, head tilt to L.</td>
</tr>
<tr>
<td>12/17</td>
<td>Standing at bench, able to achieve “on” consistently, decreased L knee ext. rotation, improved head control, when head up lost gluteus maximus.</td>
</tr>
<tr>
<td>1/7</td>
<td>Standing at bench, able to achieve “on” throughout session, head upright today.</td>
</tr>
</tbody>
</table>
times is associated with a slight backsliding in gross motor function. If there is one lesson to be learned from SEMG, it is that when it comes to motor function, nothing occurs in isolation. Second, there appears to be a regular feedforward/feedback system in place. Once he was able to stand with a certain level of proficiency, that base of support provided an opportunity for improved head control. With improved head control, he was able to move his head more freely in all four planes, which requires adjustments in his base of support, especially for a child this age for whom the head-to-body ratio is high. As displayed in Table 2, the amount of dispersion of the SEMG signal dropped from 39.6 on November 12, 2009, to 24.19 on January 7, 2010. (The standard deviation provides a suitable index for the amount of dispersion—or scatter—in the EMG signal.) This is a typical finding as a motor skill improves and has been used by others as a representative metric for improvement (Popovic, Williams, Schmitz-Rode, Rau & Disselhorst-Klug, 2009). Last, and perhaps most important, progress was linked to muscle activation patterns as a unit, with the unit consisting of bilateral gluteus maximus and quadriceps. Failure to use the myotatic unit as the metric for change is the reason why, in the author’s view, that motor reeducation via SEMG has such a checkered history. SEMG values (be it raw, rms, etc.) can vary for a number of reasons.

**Conclusion**

Joey represents the “dance” of clinical progress that clinicians have the privilege to observe. As seen in Figure 1, the graph is not linear; the graph is composed of both increases and decreases in percentage of success obtained. Joey presented multiple challenges for treatment, but in the right environment, he was able to make remarkable progress. If SEMG can help a child such as Joey, it also has potential for improving the chances of a more independent lifestyle for others with disabilities.

**References**


**Table 2. The amount of scatter or dispersion of the surface electromyography signal**

<table>
<thead>
<tr>
<th></th>
<th>11/12/09</th>
<th>1/7/10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M</strong></td>
<td>17.56</td>
<td>14.05</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>39.6</td>
<td>24.19</td>
</tr>
</tbody>
</table>

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