What’s the Buzz? Using Vibratory Haptic Feedback to Improve Grip Strength in Hand Prostheses

According to the Amputee Coalition of America, more than 735,000 Americans have had an upper limb amputation, and up to half of these individuals use a prosthetic hand. A myoelectric prosthesis is a type of prosthetic hand controlled by muscles in the upper arm. The prosthesis is connected to electronic sensors used to detect minute muscle movements and electrical activity from the muscles and nerves. Those movements and electrical activity provide information to the motors that would then use that information to move the wrist, hand, and fingers of the prosthesis. People who use myoelectric prostheses can often achieve good control of their grip, but they may have trouble gauging how tightly they are grasping objects. Vibratory haptic feedback can help prosthetic hand users adjust their grip strength by providing vibrations on their forearm that change as grip strength changes, such as vibrating faster as they strengthen their grip. This feedback may make it easier to perform activities like shaking hands or preparing meals. In a recent NIDILRR-funded study, researchers looked at a new portable vibratory haptic feedback system designed for use at home. They wanted to find out if the system could improve users’ gripping accuracy and hand control, and if the users found the system helpful and comfortable to use at home.

Researchers at a project studying Haptic Feedback Improvements for Prostheses tested the system with six adults whose right hand and wrist had been amputated and who were using a myoelectric prosthetic hand.

The system consisted of a prosthetic hand attachment with a grip sensor built into the thumb. The grip sensor detected whether the user was applying a light grip force (about 2 lb), a medium grip force (about 10 lb), or a strong grip force (around 20 lb). The grip sensor sent a signal over a Bluetooth connection to two vibrating “tactors” placed on the forearm between the prosthetic device and the skin below the elbow. The tactors vibrated faster as the user’s grip force increased, giving a slow pulse with a light grip force, a faster pulse with a medium grip force, and a continuous vibration with a strong grip force. A silicone glove was placed over the sensor on the prosthetic hand since gloves are routine when using a myoelectric prosthesis.

The participants first tested the system in the laboratory. The researchers asked them to hold a gauge and change their grip force from light to medium to strong. The researchers measured how accurately the participants could change their grip force from one level to another with the feedback system and compared it to their accuracy without the system. Then, the participants were asked to prepare a meal, which required them to use the prosthetic hand effectively to grasp, hold, and release objects. An occupational therapist evaluated how well the participants did these tasks with and without the system. Finally, the participants were invited to take the system home and...
use it for up to 3 days or until the batteries died. The participants who took the system home answered questions about the usability of the system and whether they would want to purchase a similar system in the future.

From the laboratory testing, the researchers found that the system improved the participants’ accuracy in adjusting their grip force. In particular, the participants were about 21% more accurate in achieving a medium grip force with the feedback from the system than without it. They also showed a small improvement, on average, in their ability to perform meal preparation tasks with the system.

Five of the participants opted to test the system at home. These participants rated it positively and said that it was easy to use, although one participant felt that the vibration was too strong. They described specific activities that were made easier by using the system. For example, one participant said that he enjoyed shaking hands with his granddaughter and felt confident that he wasn’t applying too strong a grip. Another participant said, when his hand inadvertently made contact with the floor while doing car repairs, the pressure on the tactile sensors provide vibratory feedback which alerted him to change the position of his prosthesis.

The authors noted that the portable vibratory haptic system may have great potential in helping people with disabilities perform everyday activities. In addition to it being useful for people with upper limb amputations, it may also help those who have lost the sense of touch in their hands. The system tested in this study provided effective sensory feedback that helped users improve their hand function. Although the participants generally found the system to be user-friendly, some participants liked the system better than other participants. Possible improvements include making the system more customizable for individual users, and also extending the relatively short battery life. Researchers and developers may want to investigate other ways in which vibratory haptic feedback can help people with disabilities maximize their functioning.

To Learn More
The NIDILRR-funded Rehabilitation Engineering Research Center on Technologies to Evaluate and Advance Manipulation and Mobility (TEAMM) is currently conducting research on improving myoelectric control of prosthesis. See a demonstration of this technology at http://www.ric.org/research/research-centers--programs/teamm-rerc/pattern-recognition-hand-prostheses/

The Limb Loss Resource Center, a center funded by the Administration for Community Living and operated by the Amputee Coalition of America, provides information and referral on limb loss, prostheses, and other assistive technology http://www.amputee-coalition.org/limb-loss-resource-center/

The Amputee Coalition of America sponsors Limb Loss Awareness Month every April. Follow them on Facebook to learn about upcoming events: https://www.facebook.com/AmputeeUSA/
To Learn More About this Article
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