Control system shows potential for improving function of powered prosthetic leg

June 9 2015

A control system that incorporated electrical signals generated during muscle contractions and gait information resulted in improved real-time control of a powered prosthetic leg for different modes of walking (such as on level ground or descending stairs), according to a study in the June 9 issue of *JAMA*, a theme issue on the Americans with Disabilities Act.

Most prosthetic lower limbs are mechanically passive (cannot provide power) and so do not restore full function. Leg prostheses that provide power are becoming available; however, different ambulation modes require very different control sequences for operating powered prosthetic limbs. Transitioning currently available powered limbs between different ambulation modes requires patients to slow down, stop, press buttons on an electronic key fob, or perform unrelated body movements. To maximize benefit from these devices and ensure patient safety, control systems must automatically identify which ambulation mode the patient is using and provide the correct prosthesis response, according to background information in the article.

Electromyographic (EMG) signals—electrical signals generated during muscle contractions—are routinely used to control powered arm prostheses. Advanced pattern recognition algorithms can decode the unique EMG signal patterns generated by multiple muscles during specific movements, thus determining user intent and providing intuitive prosthesis control.

Levi J. Hargrove, Ph.D., of the Rehabilitation Institute of Chicago, and

colleagues assessed the effect of including EMG data from residual muscles with mechanical sensor data in a real-time control system on ambulation performance using a powered prosthetic leg. The trial included 7 patients with single-sided above-knee (n = 6) or knee-disarticulation (n = 1; separation at the knee joint) amputations. All patients were capable of ambulation within their home and community using a passive prosthesis (i.e., one that does not provide external power).

The researchers used pattern recognition algorithms to predict ambulation mode for the next stride. Electrodes were placed over 9 residual limb muscles and EMG signals were recorded as patients ambulated and completed 20 trials involving levelground walking and stair and ramp ascent and descent. Data were acquired simultaneously from 13 mechanical sensors embedded on the prosthesis. Two real-time pattern recognition algorithms, using either (1) mechanical sensor data alone or (2) mechanical sensor data in combination with EMG data and historical information from earlier in the gait cycle were evaluated.

The order in which patients used each configuration was randomly assigned. The primary measured outcome for the trial was classification error for each real-time control system (defined as the percentage of steps incorrectly predicted by the control system).

The authors found that including EMG signals and historical information in the real-time control system resulted in significantly lower classification error (average, 7.9 percent) across an average of 683 steps compared with using mechanical sensor data only (average, 14.1 percent) across an average of 692 steps.

"This preliminary study is, to our knowledge, the first clinical evaluation of the ability of individuals with above-knee amputations to control a powered knee-ankle prosthesis across different ambulation modes and

the first time EMG signals have been incorporated into a real-time control system for a powered lower limb prosthesis," the researchers write. "This control system allowed for automatic, natural transitions between ambulation modes, in contrast to current control systems that require the patient to use an electronic key fob or perform a set of exaggerated movements to transition between modes."

The authors note that the study had limitations that should be considered, including a small sample size, and experiments were only performed by patients who could already ambulate freely in a variety of environments. "Additional work needs to be completed to determine if patients with more limited ambulation capabilities could benefit from the proposed system."

"These preliminary findings, if confirmed, have the potential to improve the control of powered leg prostheses."

More information: *JAMA*, DOI: 10.1001/jama.2015.4527