

SUMMARY OF SCIENTIFIC/TECHNICAL PAPERS IN THIS ISSUE

Cineplasty as a control input for externally powered prosthetic components

Richard F. *ff.* Weir, PhD; Craig W. Heckathorne, MS; Dudley S. Childress, PhD (p. 357)

Purpose of the Work. We believe it is necessary to develop better control interfaces with inherent sensory feedback if significant improvement in the function of electric-powered upper-limb prostheses is to be achieved. Small cineplasties, or other surgical procedures, which externalize the force and excursion of a muscle, could potentially provide this superior control. Connecting a muscle to a prosthetic component via a controller that embodies the concept of extended physiological proprioception (EPP) would enable the physiological sensory feedback inherent in the skin, muscle, and other tissues of the cineplasty to inform the user of the state of the prosthesis. **Subjects/Procedures.** The control capabilities of individuals with preexisting biceps muscle tunnel cineplasties were quantified using pursuit tracking experiments and a “proof-of-concept” EPP electric hand prosthesis was developed for a subject with agonist-antagonist forearm tendon exteriorization cineplasties. **Results.** Our tracking results show that control with the use of the contralateral intact elbow is superior to control with the use of either a tunnel cineplasty or a conventional figure-of-nine harness. However, the differences between tracking performance with a cineplasty and a figure-of-nine harness are not statistically significant. The variability of control with the use of the figure-of-nine harness was far greater than that with the tunnel cineplasty, indicating that control with the cineplasty is more consistent. These results indicate that control by tunnel cineplasty is comparable to current body-powered positioning methods, and thus superior to velocity-control techniques (the techniques currently favored for commercially available myoelectrically controlled prostheses). **Relevance to the Veteran Population.** This work demonstrates the efficacy of using direct-muscle attachments as a method of upper-limb prosthesis control. As a result, better upper-limb prostheses could be developed because direct muscle attachment used in conjunction with EPP controllers

could provide force and excursion amplification, additional control sources, freedom from proximal harnessing, and natural feedback to the central nervous system, and make possible meaningful multidigit control of hand prostheses.

Richard F. ff. Weir, PhD

Mechanical performance of inflatable inserts used in limb prosthetics

Joan E. Sanders, PhD, and
Damon V. Cassisi, BSME (p. 365)

Purpose of the Work. The purpose of this research was to gain insight into the mechanical function of inflatable inserts, devices inserted between the residual limb and socket to overcome residual limb shrinkage. **Procedures.** Inflatable insert products from four different manufacturers were tested under compressive loading conditions. **Results.** Results demonstrated that insert thickness increased dramatically to above 12 mm as the inserts were inflated up to ~2 kPa, but then at higher pressures (up to ~48 kPa), further thickness increases were minimal. This result suggests that in a socket if an insert is to be inflated to a thickness of less than 12 mm, stress to resist insert expansion is taken by the residual limb and socket more than by the insert itself. **Relevance to the Veteran Population.** These results help to explain why some users claim that inserts do not provide equal and consistent support unless pumped up to a very high insert pressure.

Joan E. Sanders, PhD

The effect of body weight and age on frequency of repairs in lower-limb prostheses

Naseer H. J. Haboubi, MBChB, MRCP;
Michael Heelis, BSc; Ruth Woodruff, DIPT, MCSP;
Imad Al-Khawaja, PhD, MRCP (p. 375)

Purpose of the Work. The purpose of this paper is to study the effects of age and body weight on the frequency of lower limb prosthetics repairs. **Subjects/Procedures.** 116 lower-limb amputees were studied over period of six months. Retrospective data about their age, sex, weight, causes of amputation, level of

amputation and number and types of prosthetic repairs were analyzed. **Results.** A total of 101 repairs were documented. The number of repairs was found to be correlated positively to the body weight and negatively to the age. No significant effects of sex, causes of amputation and the level of amputation, were found on the number of prosthetic repairs. **Relevance to the Veteran Population.** Body weight and age are significant factors in determining frequency of repairs of lower-limb prosthetics. Those amputees who are young and overweight should be provided with high-endurance prosthetic components.

Naseer H. J. Haboubi, MBChB, MRCP

Predictive factors for successful early prosthetic ambulation among lower-limb amputees

Michael C. Munin, MD; Maria Carolina Espejo-De Guzman, MD; Michael L. Boninger, MD; Shirley G. Fitzgerald, PhD; Louis E. Penrod, MD; Jaspaal Singh, MD (*p. 379*)

Purpose of the Work. The purpose of this study was to determine the success rate for using a prosthesis when a patient is immediately transferred to a rehabilitation facility after amputation surgery. In prior studies, some experts have advocated delaying prosthetic fitting for weeks to months after surgery, while others have allowed more rapid prosthetic ambulation to occur. **Subjects/Procedures.** Seventy-five individuals with lower limb amputations were studied at a major university medical center. Successful prosthetic ambulation, defined as the ability to walk with a prosthesis at least 45 m, was measured at the time of discharge from rehabilitation. **Results.** 68% of the patients were successful prosthetic ambulators at rehabilitation discharge. The absence of residual limb contracture (limited range of motion) and a longer length of stay during rehabilitation were related to successful prosthetic outcome. In terms of success of an early ambulation program, there were no significant differences between patients who had above-knee amputations versus below-knee, or between patients who had traumatic amputations versus amputations because of poor blood flow, such as from diabetes. The successful prosthetic user's average daily time was 5.7 h with an average distance walked of 67 m. Of those who failed this early ambulation approach, 70% of failures related to wound-healing problems. **Relevance to the Veteran Population.** This study revealed that over two-thirds of

the subjects who were selected for a trial of early prosthetic ambulation could attain independent use of the prosthesis by discharge. This approach appears to be more effective for relatively younger patients without contractures of the residual limb.

Michael C. Munin, MD

A neuromuscular platform to extract electrophysiological signals from lesioned nerves: A technical note

Michael R. Wells, PhD; Urmi Vaidya, PhD;
John L. Ricci, PhD;
Carl Christie, BS (*p. 385*)

Purpose of the Work. The control of prosthetic devices could be greatly improved if the information formerly supplied by peripheral nerves to the amputated limb could be used to guide a prosthesis. A method was devised to form a stable interface to obtain physiological information from lesioned nerves. **Subjects/Procedures.** In rats, a branch of a lesioned nerve was used to innervate an isolated strip of a host muscle. A silicone cuff electrode was placed around the muscle slip and nerve. **Results.** After 4 weeks, reliable signals were obtained from the electrode upon stimulation of the lesioned nerve fascicle. Histological examination showed that the muscle strip remained intact and axons could be identified growing in and over the surfaces of the isolated muscle. **Relevance to the Veteran Population.** These interface techniques with lesioned nerves may supply a source of signals for a more natural and detailed control of prosthetic devices.

Michael R. Wells, PhD

Physiological response to the ambulatory performance of hand-rim and arm-crank propulsion systems

Goutam Mukherjee, MSc, DPT, and
Amalendu Samanta, MSc, PhD (*p. 391*)

Purpose of the Work. Two types of propulsion systems, hand-rim and arm crank, are in common use in India. The purpose of the study was to compare the physiological performances of the two propulsion systems under environmental conditions commonly encountered in India that may be helpful in recommendation of the suitable propulsion system according to the requirement of the user. **Subjects.** Seventeen regular users of each propulsion systems participated. **Procedures.** The

physiological parameters were measured at freely chosen propulsion speed of the two propulsion systems, simulating actual locomotive conditions. **Results.** The propulsion speed was reported to be higher and the physiological demand was lower in arm-crank system than the hand-rim. The magnitude of the differences in experimental parameters was highly significant. **Relevance to the Veteran Population.** Considering the Indian environment, the arm-crank system is more efficient in terms of speed and physiological demands than hand-rim and that enables the user for a sustain locomotion at a higher speed. Hand-rim propelled chair is suitable only for indoor use where low-speed and short-duration locomotive task is desired.

Goutam Mukherjee, MSc, DPt

Shoulder imaging abnormalities in individuals with paraplegia

Michael L. Boninger, MD; Jeffrey D. Towers, MD;
Rory A. Cooper, PhD;
Brad E. Dicianno; Michael C. Munin, MD (*p. 401*)

Purpose of the Work. Shoulder pain and rotator cuff tears are common in individuals with spinal cord injury and paraplegia (IWP). This study used magnetic resonance imaging, x-rays, questionnaires, and physical examination to help determine how common shoulder problems are in IWP. **Subjects/Procedures.** Twenty-eight IWP participated; their average age was 35 years and average years since spinal cord injury was 11.5. Each subject completed a questionnaire designed to identify arm pain, had a physical examination of the shoulder, and had shoulder x-rays and MRIs. **Results.** Thirty-six percent of the subjects experienced shoulder pain in the month prior to testing. Only one rotator cuff tear was documented in all the subjects. Thirteen percent of the x-rays showed loss of bone at the end of the clavicle (commonly referred to as the collar bone). More x-rays and MRI abnormalities were seen in individuals with higher body mass index (weight divided by height squared). **Relevance to the Veteran Population.** It is critical for clinicians and IWP to understand common injuries occurring in the shoulder. It is important for IWP not to ignore shoulder pain because this can lead to long-term problems. One means of preventing shoulder pain may be to maintain an ideal weight.

Michael L. Boninger, MD

Analysis of vibrations induced during wheelchair propulsion

David P. VanSickle, PhD; Rory A. Cooper, PhD;
Michael L. Boninger, MD;
Carmen P. DiGiovine, MS (*p. 409*)

Purpose of the Work. This study measured how much vibration an individual is exposed to while using a manual wheelchair. The results were described in mathematical terms so that new, better wheelchairs may be designed. **Procedures.** Custom-made computer and acceleration measuring equipment was used to collect information during both simulated and real-world conditions. During the simulated test, the subjects used a manual wheelchair on a laboratory obstacle course. During the real-world tests, the subjects used the wheelchair, with its on-board computer, as if it were their personal wheelchair. **Subjects.** Only individuals with disabilities participated in this study so that the results would be as realistic as possible. **Results.** This data showed instances where individuals experienced infrequent, but sudden and severe, shocks such as when driving off a curb. **Relevance to the Veteran Population.** Due to suddenness of these shocks, relatively lightweight dampeners should be effective at improving ride quality rather than requiring much heavier full-size shock absorbers.

David P. VanSickle, PhD

Reliability of cardiorespiratory measurements during wheelchair ergometry

Randall E. Keyser, PhD; Mary M. Rodgers, PhD;
Elizabeth R. Rasch, MSPT (*p. 000*)

Purpose of the Work. Constant work-rate endurance tests are frequently used to study the physiological and biomechanical responses to sustained wheelchair propulsion. This study evaluated the reliability of cardiorespiratory measurements made during constant work-rate endurance tests on a wheelchair ergometer. **Subjects/Procedures.** Subjects were 10 nondisabled people who were inexperienced with using a manual wheelchair. Intraclass correlation coefficients were calculated to determine the reliability of cardiorespiratory measurements made over three constant work-rate wheelchair ergometer tests. **Results.** Intraclass correlation coefficients were high for cardiorespiratory measurements across the three tests. **Relevance to the Veteran Population.** Many veterans use manual wheelchairs for

ambulation. The results of this study indicate that reliable information about the cardiorespiratory system can be obtained from constant work-rate exercise tests with the use of the wheelchair ergometer.

Randall E. Keyser, PhD

The virtual retinal display as a low-vision computer interface: A pilot study

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Erik S. Viirre, MD, PhD; John P. Kelly, PhD;
Thomas A. Furness III, PhD (*p. 431*)

Purpose of the Work. The purpose of this study is to evaluate the merits of the Virtual Retinal Display (VRD) as an alternative display for low-vision computer users. **Subjects/Procedures.** Visual acuity and reading speed test results of thirteen low-vision individuals (ages 28 to 59 years old) were collected and used to compare the performance between the VRD and the standard cathode ray tube (CRT) screen. **Results.** Six subjects had higher visual acuity when viewing the VRD compared with four subjects who demonstrated higher visual acuity while viewing the CRT. Individuals with predominantly optical causes of vision impairment recorded increases in reading speed when viewing the VRD compared to the CRT; whereas, those with predominantly retinal damage showed a slight disadvantage using the VRD. Averaged across all subjects, the two displays were equivalent; however, four subjects demonstrated clinically significant increases in reading speed when viewing the VRD versus CRT. **Relevance to the Veteran Population.** Whether for work or for personal use, the computer is an essential tool. The

VRD has the potential to make the computer more accessible to certain visually impaired individuals who find the traditional CRT interface problematic. This study reviews the rationale for continued development of the VRD for low-vision use.

Eric J. Seibel, PhD

A comparison of the recognition distance of several types of pedestrian signals with low-vision pedestrians

Ron Van Houten, PhD; Bruce Blasch, PhD;
J.E. Louis Malenfant, PhD (*p. 443*)

Purpose of the Work. The purpose of this research was to compare the relative conspicuity of several types of WALK signals. **Subjects.** Subjects were 18 legally blind participants who had some vision. Participants varied in age and cause of visual impairment. **Procedure.** The research compared the recognition distance of white and blue WALK signals illuminated by incandescent bulbs and light-emitting diodes. We also examined a new WALK signal with animated eyes to prompt sighted pedestrians to look for cars while crossing. **Results.** There was no difference between incandescent and LED signals without the animated eyes. The addition of an animated "eyes" display to the WALK sign significantly improved recognition distance and accuracy. **Relevance to the Veteran Population.** Many aging pedestrians have reduced vision. These results show that enhancing the WALK signal can allow persons who are legally blind but have some remaining vision have greater independence crossing the street.

Ron Van Houten, PhD