Capabilities

Communicating the Science of Prosthetics and Orthotics

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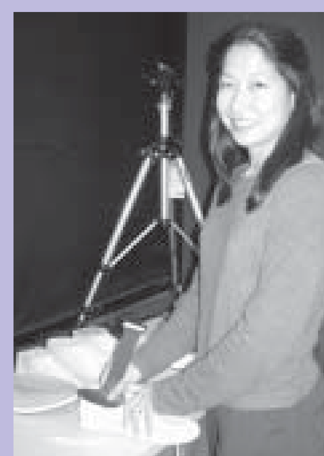
Inside This Issue:

Craig Heckathorne, M.Sc., discusses bionic arms



Pinata Sessoms, M.S., discusses step length

NURERC remembers **Margaret Pfrommer**

Steven A. Gard, Ph.D., Delivers Blatchford Lecture

Steven A. Gard, Ph.D., (left) accepts the Blatchford Award from **John Howitt** (right), Honorary Treasurer and Membership Secretary of the UK ISPO.

Steven A. Gard, Ph.D., was invited to speak as the Blatchford Lecturer for the 2007 Annual Scientific Meeting of the U. K. International Society for Prosthetics and Orthotics (ISPO) and the British Healthcare Trades Association (BHTA) at Stoke-on-Trent, England in November.

Following the lecture, Mr. **John Howitt**, Honorary Treasurer and Membership Secretary of the U.K. ISPO presented the distinguished Blatchford Award to Steven A. Gard, Ph.D.

Dr. Gard presented "Functional Biomechanics of Gait, with Implications for Prosthetics Research" during which he identified the functional requirements of walking during able-bodied ambulation and related these functions to appropriate prostheses for those with a lower limb amputation.

Emphasizing current research projects about gait at Northwestern University Prosthetic Research Laboratory (NUPRL), Dr. Gard addressed issues that included shock absorption, gait initiation and termination, balance and posture, and energy efficient mechanisms for achieving and maintaining forward progression. He related these functional biomechanics of able-bodied walking to future improvements in prosthetic technologies that will enable persons with disability to walk with greater comfort, stability and efficiency.

A New Year in P&O Research

This year *Capabilities* will continue to disseminate quarterly reports about advances in prosthetics and orthotics at the Northwestern University Rehabilitation Engineering Research Center (NURERC). This issue of *Capabilities* offers research articles, a tenth year retrospective in memory of **Margaret Pfrommer**, and updated information about NURERC's research activities.

Bionic Limbs: Promise and Progress

In ***Bionic Arms and Human Performance***, author **Craig Heckathorne**, M.Sc., compares the performance of physiologic and prosthetic hands and elbows.

By definition, *bionics* is the application of biological principles to engineering design; and recently, the word *bionic* touts diverse, non-physiological items from cars to clothes, including DaimlerChrysler's "Bionic Concept Vehicle" patterned after a boxfish; the North Face "Apex Bionic Jacket"; and toys such as Jakks Pacific "EyeClops Handheld Bionic Eye."

A *bionic* device interfaces with the human physiology and imitates the function of the body part it replaces, such as heart, kidney, skeletal joints, cochlear implants, valves, filters or limbs. However, *bionic* limbs may disappoint expectations when based on dramatic projections of superhuman speed, power and agility. Although engineers and consumers alike seek a seamless integration of the prosthesis with the human physiology and its naturalistic, biophysical performance, contemporary prosthetic function is limited by factors such as weight, speed, force, power, and range of motion. Innovations in the converging technologies of nanotechnology, biotechnology, information technology, and cognitive sciences (NBIC) promise tantalizing new *bionic* materials and techniques for the future; yet, the performance of electric-powered prostheses continues to challenge researchers.

A Step Forward: Able-Bodied Step Length

Authors **Pinata Sessoms**, M.S., and **Steven A. Gard**, Ph.D., examine ***Step Length Modulation in Able-Bodied Persons*** and discuss how able-bodied walkers alter their step length and speed. This preliminary study provides data that will allow comparisons of able-bodied walkers and lower limb prosthesis users with respect to the kinematic mechanisms that alter speed and step length.

We hope that you will enjoy this issue. We invite you to visit our website where you can read archived issues of *Capabilities* and learn more about the research conducted at NURERC.

~ R. J. Garrick, Ph.D. ~
Editor, *Capabilities*

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Bionic Arms and Human Performance

Craig W. Heckathorne, M.Sc.

This work was supported through funds from the National Institute on Disability and Rehabilitation Research of the United States Department of Education under grant H133E030030. The opinions in this publication are those of the grantee and do not necessarily reflect those of the Department of Education. This article incorporates material from an invited presentation at the 2005 Myoelectric Control (MEC) Conference and lectures developed by the author for the Prosthetics Certificate Program at the Northwestern University Prosthetics & Orthotics Center (NUPOC).

This article examines speed, grip force, and lifting capacity as three quantifiable characteristics of electric-powered prehension devices and elbow mechanisms. These components have been commercially available for at least one year, demonstrating some degree of acceptance in clinical practice, and generally are considered higher performing devices in their class. To what extent can these components perform in the manner of their living counterparts? In other words, how *bionic* are they?

Use of the term *bionic* to describe limb prostheses, especially electric-powered prostheses, has surged during these first years of the Twenty-First Century. But what is the meaning of *bionic* and what is its significance for prosthetic limbs? The term *bionic* is derived from the Greek *bios*, meaning life, and the suffix -*onic*, meaning "in the sense or manner of" [1]. The earliest documented appearance of the word dates to 1901 when it was used to define an organism's "quality of continuing" the same morphological features generation after generation [2]. That usage did not prevail and the word was re-coined in 1958 by Jack E. Steele, M.D., a graduate of Northwestern University's Medical School, who was a researcher in the United States Air Force at the time. Dr. Steele used the term to describe the design of improved mechanical and electronic devices through engineering-based analysis of biological systems and organisms.

The word entered popular usage in the 1970s, particularly through Martin Caidin's book *Cyborg* [3] and the four-season ABC television spin off, *The Six Million Dollar Man* (*SMDM*) that aired January 18, 1974 through March 6, 1978. Through this exposure, *bionic* became more specifically associated with the replacement of body parts and functions by artificial devices, including internal and external prostheses and artificial organs. Each *SMDM* episode recapped the central figure's horrific plane crash, physical reconstruction, and demonstration of extraordinary physical abilities that were enhanced through prosthetics. Throughout these scenes, an off-camera voice intoned, "We can rebuild him. We have the technology. We have the capability to make the world's first bionic man....Better than he was before. Better, stronger, faster."

The message was clear: Technology not only could restore a person with replacement parts; it could make a person better than he or she was. The possibility was compelling, and soon the *bionic* man as fiction was transformed by the media into the *bionic* man as fact. In November 1978, the magazine *Omni* [4] featured *The Real Bionic Man*, which described a man who had been fit with one of the early versions of the Utah Elbow [5]. The prosthetic elbow was controlled with minute electrical signals from the same muscles that would have moved his physiological elbow if it were still there. "In effect, all the amputee must do is think and act as if he had a real arm and use his muscles as he did before amputation." [6]. Clearly, this prosthesis was designed in the manner of something living, i.e. *bionic*.

Since then, advancements in upper limb prosthetics often have been characterized as *bionic* firsts. In 1998, the BBC News announced *World's First 'Bionic Arm' for Scot* [7] and described the fitting of the Edinburgh Modular Arm System to a hotel owner in Scotland. Researcher David Gow explained, "It's bionic because it's restoring a biological function in terms of prosthetic upper limb and it's using electronics to control and power it" [8]. In June 2005, the Rehabilitation Institute of Chicago issued press releases introducing *Jesse Sullivan, the World's First 'Bionic Man'*, who had been fit with a prototype total arm prosthesis that was partially controlled with segments of muscle in his chest and activated by nerves that had been transferred from the amputation site at the shoulder [9]. In July 2005, the Agence France-Presse published *Australian Amputee Becomes World's First Bionic Arm Receiver*, after the gentleman had been fit with Otto Bock's newly developed Dynamic Arm elbow [10].

All limb prostheses are designed to replicate some aspect of the physiological limb that they are intended to

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replace and combine considerations of appearance, biomechanical function, physiological control, and physical coupling to the human body. Therefore, it can be said that all limb prostheses are designed along *bionic* principles. Current excitement about *bionics* focuses on prostheses that incorporate electric-powered components.

Experiments in our laboratory have shown that physiological fingers can move at a maximum speed of about 2300°/sec. At this speed, the tip of the finger can move through a distance of 10 cm in 25 msec. No commercial electric-powered prehension device comes close to achieving this speed. However, in handling objects, as when picking them up or setting them down, the average "pick-and-place" physiological finger speed is about 170°/sec, considerably less than the maximum possible speed. Three electric-powered prehension devices are able to achieve this "pick-and-place" speed: the Otto Bock SensorHand Speed with a 7.2 volt battery; the Hosmer Synergetic Prehensor with a 9.0 volt battery [11] and the Motion Control Electric Terminal Device (ETD) with a 10.8 volt battery. The Motion Control ETD is, in fact, able to exceed the average "pick-and-place" finger speed when operated at greater voltages, up to the maximum of 18 volts. *Figure 1* shows the four higher-performing prehension devices. *Figure 2* compares diagrammatically how far the fingers of these devices can move in 330 msec, the time it takes the tip of the physiological finger to move 10 cm at the average "pick-and-place" speed of about 170°/sec.

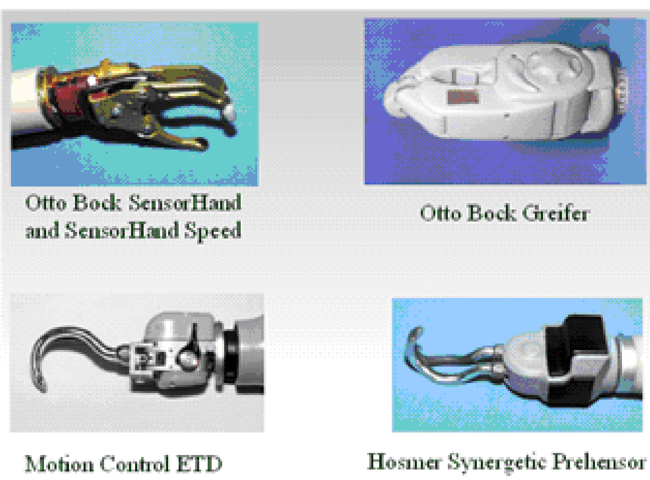

Figure 1: Electric-powered prehension devices examined for speed and force characteristics.

Grip force is important in holding objects. The most common grasp pattern for both the dominant and non-dominant hands is palmar prehension, meaning that the palmar surface of the last segment of the thumb opposes the palmar surfaces of the last segments of the index and middle fingers. Using this grip, a person can produce a maximum force of about 9.8 kg-force (96 N, or 21.5 lbs_f).

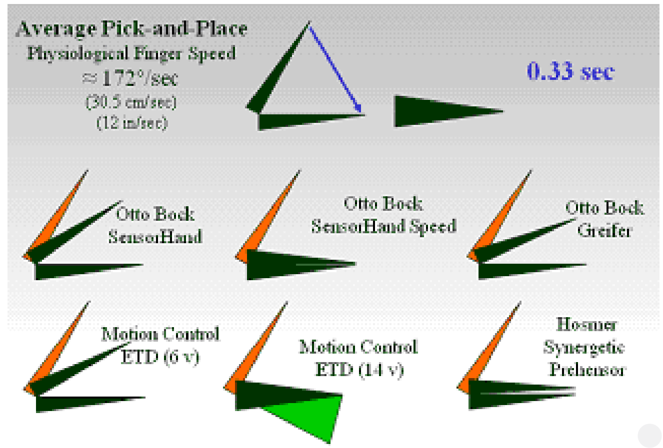

Figure 2: Comparison of distance traveled by human fingers and prosthetic fingers in 330 msec at the average "pick-and-place" physiological speed of 172°/sec. The topmost diagram represents human fingers. The diagrams for the prosthetic prehensors show the starting position as a reference.

All of the higher-performing electric-powered prehension devices can meet or exceed this grip force, including Otto Bock's SensorHand Speed and Greifer; Motion Control's Hand and ETD; and Hosmer's Synergetic Prehensor.

Turning to elbow performance, one can consider the speed of the elbow's movement as well as its lifting capacity. The average maximal speed for human elbow movement is 600°/sec over a range of 120°. When operating at their highest speeds, the higher-performing electric elbows move at one-fifth to one-quarter of this speed. These devices include the Motion Control Utah Arm 3, the Liberating Technologies Boston Digital Arm System, and the Otto Bock Dynamic Arm. However, as with finger movement during targeted motions that have a specified starting and stopping point, the human elbow moves at slower speeds. For these types of activities, the peak speed of elbow movement is a function of how far the elbow is required to move, and is 2.9°/sec per degree. For example, if the distance between the starting and stopping points is 20°, the peak speed of elbow movement will be about 58°/sec. If the distance is 40°, the peak speed is about 116°/sec. All of the higher-performing electric elbows can achieve physiological speeds for small distances, i.e. less than 40° for the Utah Arm 3 and the Boston Digital Arm, and less than 50° for the Dynamic Arm. For movements over greater distances, the electric elbow will lag the human elbow.

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When lifting heavy objects, people can generate more elbow torque at lower speeds of elbow flexion than at higher speeds. At low flexion speeds, the physiological elbow exerts an average maximum torque of 74 N-m (55

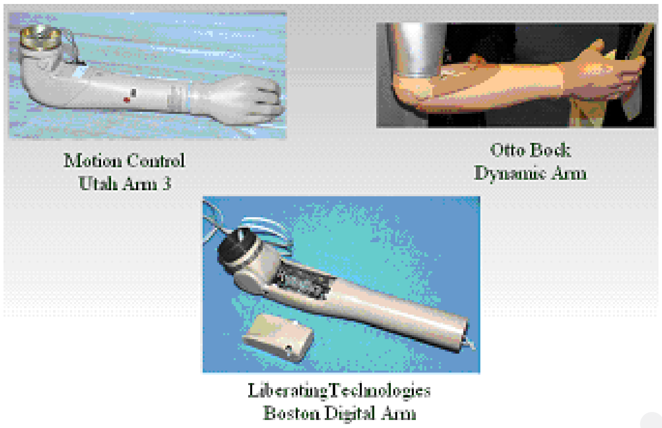

Figure 3: Electric-powered elbows examined for speed and torque characteristics.

ft-lbs$_f$). *Figure 3* shows the three elbows under consideration. *Figure 4* compares their lifting capacity to the lifting capacity of the human elbow. Although both the Dynamic Arm and the Boston Digital Arm can actively lift less than a quarter of the weight that the human elbow can lift, both electric elbows produce sufficient torque to

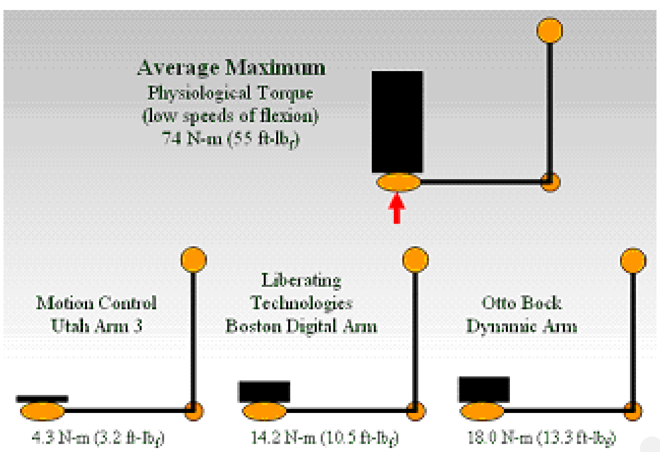

Figure 4: Comparison of active lift torques for the physiological elbow and three electric-powered elbows. The topmost diagram represents the capacity of the physiological elbow.

lift a four liter container of water. Therefore, these two elbows can lift many everyday objects.

This examination of speed, grip force, and lifting capacity of electric-powered prehensors and elbows shows that these devices generally are not capable of reaching peak human performance, with the exception of maximum palmar prehension grip force. However, these devices can achieve human-like performance in significant daily activities. Several electric-powered prehension devices can achieve speeds comparable to human finger speeds for picking up and releasing objects. All three of the electric elbows can achieve physiological speeds for targeted movements over short distances. Two of the electric elbows achieve physiological torques capable of lifting objects that many persons would consider heavy objects.

One might not consider these *bionic* devices to be “better, stronger, faster,” but they have characteristics within the range of human performance in many activities of daily living. However, that is not enough. Most persons with amputations want their prostheses to achieve physiological performance as a minimum standard in all activities. This demand for complete equivalency in *bionic* replacement continues to drive the development of new prosthetic components.

References

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5. Teresi, D. 1978. *The Real Bionic Man*. *Omni* 1(2):138-140.

6. *Ibid*., p. 47.

7. *World's First 'Bionic Arm' for Scot.* BBC, Tuesday, August 25, 1998.

8. *Ibid.*

9. *Jesse Sullivan, The World's First 'Bionic Man'*. RIC Press Release, June 2005.

10. *Australian Amputee Becomes World's First Bionic Arm Receiver*. Agence France-Presse, July 2005.

11. The Synergetic Prehensor was discontinued in 2007; however, many of these devices remain in use.

AAOP Matters

AAOP Provides Online Glossary

The American Academy of Orthotists and Prosthetists announced access to a *Glossary of Research Terminology* (http://www.oandp.org/glossary) for researchers. Terms may be searched in alphabetical order. Definitions are gleaned from diverse sources such as The Canterbury District Health Board, Mayo Clinic Clinical Trials Glossary, the U.S. Food and Drug Administration, as well as Wikipedia and others. The glossary provides links to original, contextual resources.

2008 AAOP Conference Slated for Florida

The American Academy of Orthotists and Prosthetists will hold its 34th Annual Meeting and Scientific Symposium from February 27 through March 1, 2008 in Orlando, Florida.

Step Length Modulation in Able-Bodied Persons: Preliminary Findings

Pinata H. Sessoms, M.S., and Steven A. Gard, Ph.D.

Funds from the National Institute of Disability and Rehabilitation Research (NIDRR) of the Department of Education under Grant H133E030030 supported this work. The opinions in this publication are those of the grantee and do not necessarily reflect those of the Department of Education. The authors acknowledge the use of the VA Chicago Motion Analysis Research Laboratory of the Jesse Brown VA Medical Center, Chicago, IL.

Introduction

Lower-limb prosthesis users generally walk at slower speeds than able-bodied persons. The reason(s) for this is not yet fully understood. Persons with unilateral amputation tend to walk with step length asymmetry, adopting a shorter step length with their sound leg compared to their prosthesis [*1-4*], which may partially account for their slower walking speed. It is possible that the lower limb prosthesis cannot adequately replicate the function of the leg that it replaces, or that the differences in the prosthesis mass and leg trajectory during swing create a different motion that does not mimic that of the intact leg. In either case, persons with lower limb amputation make changes to their gait mechanics that compensate for their limb loss. In order to determine what types of compensations they make to increase their speed and step length while walking, it is important first to understand how able-bodied persons perform these tasks and then compare their method of step length/speed modulation to persons with lower limb amputations.

Methods

Ten healthy adult volunteers with no known lower limb pathologies were recruited for this study. Quantitative gait analyses were performed on them in the VA Chicago Motion Analysis Research Laboratory while walking at a range of different step lengths (SL). After walking at their freely selected speed (and step length), subjects were asked to walk at a SL of 0.65 m (a shorter than normal SL); and longer than normal SLs of 0.87 m, 1.09 m, and with a SL equal to 1.4 times their leg length, ensuring that those of all heights were challenged to take a long step length. Lasers projected lines on the floor to demarcate the distance for these fixed SL. Subjects then were asked to walk with their longest possible step length across the laboratory walkway. We also collected insole pressure measurements and energy expenditure data, but do not discuss those data in this article.

Results

A preliminary investigation of the gait data was performed. Subjects' mean freely selected step length was 0.73 ± 0.04 m. When asked to take 0.65, 0.87, and 1.09 meter step lengths, the mean actual step lengths were 0.66 ± 0.005, 0.85 ± 0.007, and 1.07 ± 0.014 m, respectively. Interestingly, subjects took their longest step length when asked to take a step length equal to 1.4 times their leg length (mean SL=1.38 ± 0.90 m), as opposed to when they were asked to take their longest step length

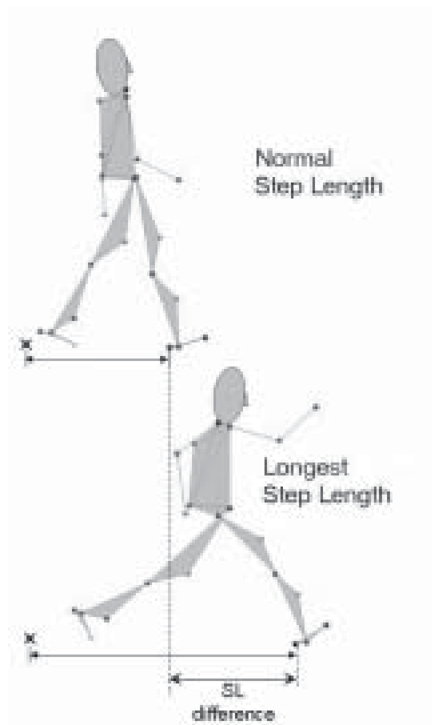

Figure 1: Depiction of one subject walking at his normal, freely selected step length (top) and longest step length (bottom). The increase in distance traversed in one step is depicted by the arrow labeled "SL difference." X denotes where the trailing heel contacted the ground at the beginning of the step.

(mean actual step length was 1.34 ± 0.20 m). Speed was proportional to the SL, ranging from 1.14 ± 0.12 up to 2.22 ± 0.38 m/s for the shortest and the longest possible step length conditions, respectively. Cadence ranged from 89 to 110 steps/min, with the highest cadence occurring

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at the freely selected step length. Step length, cadence, and speed were all significantly different for the different step length conditions ($p<0.05$). *Figure 1* depicts the differences in step length between a typical subject walking at his normal, freely selected step length and his longest step length.

Sagittal-plane hip, knee, and ankle rotations, and pelvic rotation, obliquity, and tilt were analyzed to determine what changes in joint motion accounted for these step length changes. Hip flexion range of motion (ROM) increased the most for increasing step length, followed in decreasing order by pelvic rotation, ankle flexion, pelvic obliquity, pelvic tilt, and, to a minimal extent, knee flexion. Joint ranges of motion were found to be significantly different ($p<0.05$) for the different step length conditions for all the joint motions listed above except for knee flexion ROM ($p=0.179$). *(See Figure 2)*.

The greater hip ROM that was observed with longer step lengths apparently resulted from a greater increase in peak hip flexion, rather than peak hip extension. Ankle flexion ROM increases were due to both increasing peak ankle flexion and extension. Pelvic tilt ROM increases were due mainly to increases in anterior pelvic tilt as opposed to posterior pelvic tilt.

Discussion

Able-bodied persons are able to modulate their gait through a wide range of step lengths, up to as much as 1.9 times their normal step length. This modulation is done through various kinematic joint manipulations, but is attributable primarily to changes in the rotations of the hip, ankle, and pelvis. These changes will be compared to those of persons with lower limb amputation to determine if they also modulate their speed and step length in a similar manner. It is hypothesized, however, that because their prostheses do not function in the same manner as a sound leg, the same methods of step length modulation will not be possible. Thus, we hypothesize that persons with amputation use different kinematic mechanisms to change their speed and step length. However, through gait training and design modifications in prosthetic devices, we may be able to improve the gait characteristics and walking performance of persons with lower limb amputations.

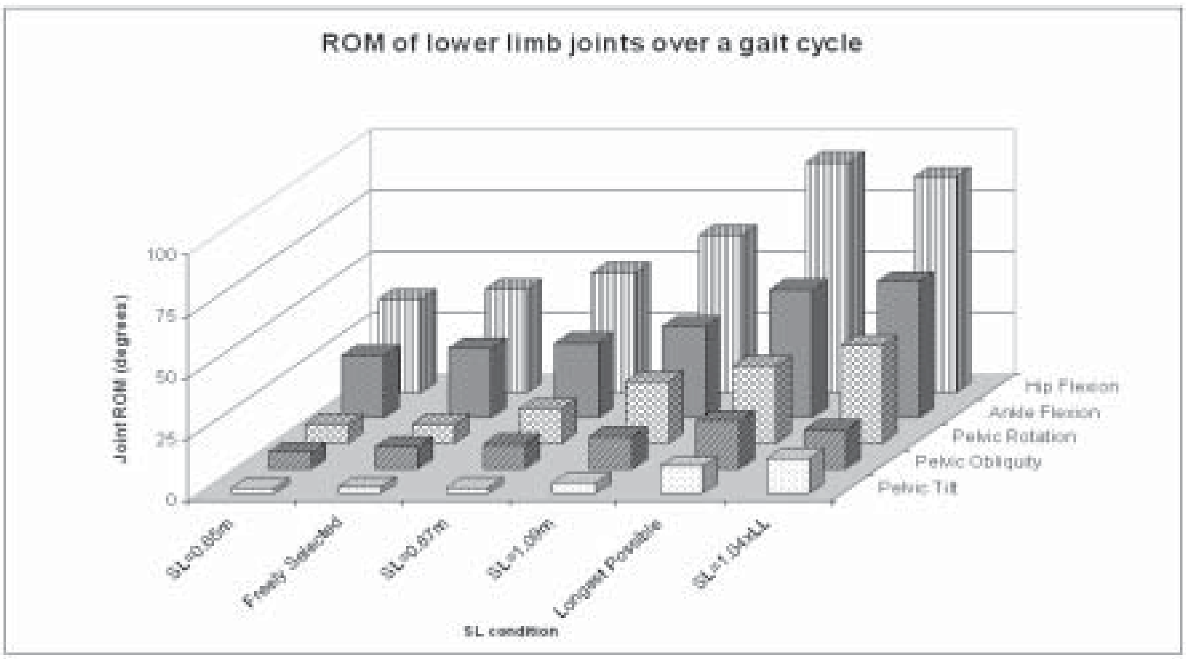

Figure 2: Joint range of motion (ROM) of joint motions found to be significantly different between step length conditions. Step length conditions are plotted from shortest to longest step length achieved. Data are mean values from 10 subjects.

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Margaret C. Pfrommer (1937-1998): Extraordinary and Inspiring

R. J. Garrick, Ph.D.

On this tenth year since **Margaret C. Pfrommer** died, NURERC remembers her with respect, admiration and affection. She was a vibrant, creative person who lived independently for 40 years with quadriplegia due to poliomyelitis. After surviving bulbar polio in 1956 at the age of 19, Ms. Pfrommer's parents assisted her in their home. Following their deaths, she lived two unhappy years (1971-1973) in a nursing home where she was dependent on institutional care.

Ms. **Margaret C. Pfrommer** was a respected disability rights activist and a member of NURERC/NUPRL.

After she contacted the Northwestern University Prosthetics Research Laboratory, Professor **Dudley S. Childress**, Ph.D., and his team of biomedical engineers devised mobility and communications systems that enabled Ms. Pfrommer to live and work independently. Using sip-and-puff technology, she worked in the Northwestern University Prosthetics Research Laboratory (NUPRL) for 25 years where she consulted on assistive devices, answered phones, wrote reports, typed correspondence, chaired committees, organized conferences, and more. Perhaps most importantly, she educated and inspired all who were fortunate to meet her.

A tireless activist and advocate for disability rights, Ms. Pfrommer urged legislation, health policy and technological innovations that would empower individuals by enhancing their mobility and independence. She worked diplomatically to broker understanding between persons living with a disability and society, institutions and government. Ms. Pfrommer highlighted the importance of individually customized care plans, improved community support, transportation, insurance reimbursements, personal care assistants and home health care professionals. Ms. Pfrommer was invited to testify before the Joint Committees of Congress, the House Ways and Means Subcommittee on Social Security reform where she called for changes in national law that would benefit the disabled in their daily lives.

Ms. Pfrommer devoted much of her life to enhance mobility and access for those living with a disability. Fiercely independent, Ms. Pfrommer championed devices that could enable her and others to live independently. She challenged researchers and engineers to design useful assistive devices that would improve the quality of life for persons living with disability. Showing the value of the end user's subjective experience, she evaluated and suggested modifications to the design of devices such as reclining wheel chairs, inspiratory muscle trainers, ventilation systems, and speech recognition programs.

Ms. Pfrommer worked for 25 years as an integral member of NUPRL. Also, she completed a certificate program as a paralegal (1983) and was commissioned a Stephen Minister (1996), allowing her to act as a crisis intervention counselor. She wrote fiction, produced computer art, and was recognized for her selfless advocacy on behalf of people living with a disability. She appeared on radio and television to achieve social change. Her awards include the James F. Victorin Award for Fiction (1974); Illinois Governor's Voluntary Action Award presented by Governor James Thompson; the Everest and Jennings Lectureship Award presented by the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA); Victory Award presented by the National Rehabilitation Hospital, Washington, D. C.; and many others.

(The author appreciates Ms. ***Rosemary L. Collard****, NUPRL Departmental Assistant, who shared information that contributed to this article.)*

Learning from Margaret Pfrommer

R. J. Garrick, Ph.D.

Margaret Pfrommer was unforgettable. A person who lived with quadriplegia due to polio, she inspired many people with her quiet strength and determination. Everyone who met her learned something from the template of her life.

NURERC researchers remember developing mobility aids, such as sip-and-puff reclining wheelchairs, and computer access and control systems. **Craig Heckathorne**, M.Sc., NURERC Research Engineer, observed, *"Margaret's wheelchair enabled her to move through space, but it also enabled her to control her environment and to manipulate information. Margaret was a pioneer in the use of environmental control systems and personal computers….With her chair and her computer access, Margaret continually demonstrated the possibilities of navigating both space and information by persons who could neither walk nor move their arms and hands. Part of her legacy is that many people now do what Margaret did and, to a great extent, it is no longer remarkable."*

She resisted invasive technology while struggling with progressive neuromuscular hypoventilation. She used non-invasive intermittent positive-pressure ventilation first by mouth then by nose. Finally, forced by respiratory insufficiency, she agreed to a tracheostomy. She mastered glossalpharyngeal or "frog" breathing. Using the muscles of the tongue, soft palate, pharynx and larynx, she forced air from her mouth into her trachea and lungs. Like many others with chronic bulbar post polio syndrome, she used this skill as a voluntary but temporary method of breathing that allowed freedom from the respirator. Eventually, due to post polio neuromuscular deterioration, Ms. Pfrommer used a positive pressure ventilator, but required improved ventilation while sleeping.

At night, she used a rocking bed to shift her body weight to prevent decubitus ulcers and to activate her diaphragm. NURERC engineers **Dudley S. Childress and Edward Grahn** worked as a team with pediatric pulmonologist, **Allen I. Goldberg**, M.D., and others, to improve her respiratory issues.

Ms. **Margaret Pfrommer** (left) at her job in the main office of the Northwestern University Prosthetics Research Laboratory, in conference with Dr. **Allen I. Goldberg**, M.D. (right). Photograph is circa 1991.

Edward Grahn, Engineer, reflected, *"When passive ventilation was no longer sufficient to aid her breathing, she needed positive ventilation. To solve this problem while she slept in her rocking bed, we used a modified, portable positive ventilator. We removed the electric belt drive mechanism and attached a sprocket to the drive shaft. We attached a similar sprocket to the rocking mechanism and then linked the two with a drive chain. We adjusted the chain so that the rocking motion, ventilator and Margaret's breathing were in sync. The chain drive ensured that this synchronizing never changed. This served her well for many years."* The NURERC team of rehabilitation engineers improved her oxygen saturation by using the stronger motor of the rocking bed to operate both the bed and the respirator. By synchronizing the inspiration-expiration ratio of the respirator with the angle and direction of the rocking bed, they helped Ms. Pfrommer achieve adequate oxygen saturation while sleeping.

Most impressive to all who met her were her personal characteristics. **Joshua Rolock,** Ph.D., reflected, *"Anyone who took the time to know Margaret Pfrommer was certain to become a better person because of it. Margaret faced a lifetime of challenges: physical, societal, and medical…she met them head on with the courage, stamina and resolve to conquer them….To know Margaret was to understand the difference between right and wrong; to understand that there was no justification for prejudice or bias or silence or inaction. Margaret was honest and forthright. She spoke her mind without concern of offending, yet with respect, that demanded attention and consideration."*

High School Seniors Visit NURERC

R. J. Garrick, Ph.D.

Andrew Hansen, Ph.D. (left), holds a cosmetic cover for a prosthetic foot. **Rich Marrano** (right), a teacher at Crystal Lake South High School, holds a Shape&Roll Prosthetic Foot core made of copolymer. In the foreground is a lever press that can be used in economically challenged countries. It is easy to assemble and uses economical and accessible materials to create the Shape&Roll Prosthetic Foot.

Outreach and education about innovations in prostheses and orthoses are vital roles for the Northwestern University Rehabilitation Engineering Research Center (NURERC). To that end, NURERC provided an educational tour designed to introduce students to the field of prosthetics and orthotics. Mr. **Rich Marrano**, a teacher at **Crystal Lake South High School**, and seniors in the new elective class, *Science and Society*, toured the Northwestern University Prosthetics Research Laboratory (NUPRL) and NURERC in November.

Mr. Marrano and three other teachers in his district designed the course to help students understand science issues as reported in the news and interpret how scientific issues relate to society. Their interests include replacement body parts, stem cell technology, vision aids, and medical/surgical advances.

Craig Heckathorne, M.Sc., a research engineer at NURERC, explains the principles of myoelectric control in upper limb prostheses.

Twenty students toured the laboratory and learned from NURERC staff how each individual researcher had selected his or her specialization. Groups of students rotated among five stations in the laboratory: 1) **Mark Edwards, CPO**, discussed careers in prosthetics and orthotics; 2) **Craig Heckathorne, M.Sc.,** presented upper limb prostheses; 3) **Andrew Hansen, Ph.D.,** presented lower limb prostheses and fabrication systems; 4) **Kerice Tucker,** research engineer, presented SquirtShape and CAD/CAM fabrication of prosthetic sockets; and 5) **Stefania Fatone, Ph.D., Rebecca Stine, M.S., and Brian Ruhe, M.S.,** demonstrated motion and gait analysis.

Stefania Fatone, Ph.D., explains how the PEDAR system measures the distribution of pressure through the soles of the feet.

The students reported that they learned interesting, new concepts. Mr. Marrano, who had observed first-hand the results of war-inflicted amputations in Sierra Leone, responded enthusiastically to the economical and accessible field fabrication system for the Shape&Roll Prosthetic Foot that was designed here at NURERC.

Brian Ruhe, M.S., a graduate student at NURERC and a prostheses user, demonstrates gait analysis by walking on a force plate and wearing reflective markers that cameras transmit to a computer, which constructs a 3-dimensional model of his movements.

NURERC NEWS

Publications

Andrew H. Hansen, Steven A. Gard, and Dudley S. Childress, "Quasi-stiffness of the Ankle during Able-Bodied Walking at Different Speeds: Implications for Design of Prostheses." *Foot and Ankle Motion Analysis: Clinical Treatment and Technology*, eds. Gerald F. Harris, Peter A. Smith and Richard M. Marks, CRC Press, 2008.

A new book, *The Future of Disability in America*, (Committee on Disability in America, Board on Health Sciences Policy; M. J. Field and A. M. Jette, eds., the National Academies Press, 2007) has been added to the NURERC library. **Dudley S. Childress**, Ph.D., served as a member of the Committee on Disability in America and contributed to the book's inception and compilation.

Presentations

Stefania Fatone, Ph.D., BPO(Hons), was invited to discuss AFOs at the University of Illinois, Champaign-Urbana on October 15. On November 9, 2007 Dr. Fatone presented "Effect of an Ankle Foot Orthosis on Roll-Over Shape in Adults with Hemiplegia Following Stroke" at Children's Memorial Hospital 16th Annual Visiting Professor Program in Chicago.

Meetings

Andrew H. Hansen, Ph.D., participated in the VA Research and Development Center of Excellence workshop on *Lower Limb Amputee Needs Assessment*, held in Seattle, WA, in October.

Stefania Fatone, Ph.D., BPO(Hons), a member of the Orthotics and Prosthetics Outcomes Initiative Steering Committee, participated in a panel discussion at the AOPA National Assembly, held in Las Vegas, September 17-20, 2007. She presented an overview about the meaning of outcomes research and its relationship to evidence-based practice.

Visitors

Ms. Jessie Duff-McLaurin toured the Prosthetics Orthotics laboratory and NUPOC on October 4, 2007. She remarked on many improvements since she worked here during the late 1950s and early 1960s. Dr. **Colin McLaurin** had been appointed by Dr. **Clinton L. Compere** to serve as NUPRL's first engineering director, a post which he held until 1964.

Northwestern University Rehabilitation Engineering Research Center (NURERC) participated in the **Rehabilitation Institute of Chicago** (RIC) Open House on October 10 when approximately 200 individuals toured RIC and NURERC laboratories. Visitors learned from NURERC staff about our past and present research projects and observed demonstrations of prosthetic and orthotic products that have been designed and developed here.

CHEST Award to Dudley S. Childress, Ph.D.

R. J. Garrick, Ph.D.

Dudley S. Childress, Ph.D., addressed the 73rd Annual International Scientific Assembly of the American College of Chest Surgeons on October 24 as the **2007 Margaret Pfrommer Memorial Lecture in Long Term Mechanical Ventilation**. In honor of Ms. Pfrommer's life and work, **Eveline Fauré,** M.D., and **Allen I. Goldberg,** M.D., established the **Margaret Pfrommer Memorial Lecture in Long Term Mechanical Ventilation**. Dr. Goldberg reflected, "*Margaret taught me. We all learned from her. She helped us learn from the patient's perspective what kinds of assistive technology were important, useful and desirable.*"

Dr. Childress' address, "Let Their Air Prevail and Their Hearts Endure," discussed assistive technology that was available to Ms. Pfrommer in the 1970s and identified her assistance in modifying many of the devices that he and his rehabilitation engineers developed. Ms. Pfrommer and NUPRL engineers worked cooperatively to design new assistive technology that improved the mobility, activities of daily living and overall quality of life for persons living with disability. Dr. Childress noted that Ms. Pfrommer was an important member of Northwestern University Prosthetics Research Laboratory (NUPRL) for 25 years until her death in 1998.

Responding to Dr. Childress' talk, Dr. Goldberg reviewed the U.S. polio epidemics with respect to social, medical and technological issues. He emphasized solutions that had emerged through cooperative interaction among physicians, engineers, families and patients, all of whom sought to care for and improve the lives of those living with disabilities caused by polio. Remarking that many people who survived the acute stage of polio now battle post-polio respiratory insufficiency, Dr. Goldberg called for fresh, cooperative efforts in the partnership among the multidisciplinary care team and individuals living with a disability. (To learn more about innovations that result when professionals and patients work in partnership, see A. I. Goldberg, *CHEST* 121:321-324, 2002.)

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NURERC Welcomes Kathryn E. Waldera, M.S.

Kathryn Waldera, M.S.

Kathy Waldera, M.S., conducted bioengineering graduate work in this laboratory during the 1980s and has returned to NURERC on a part-time basis to work with **Andrew Hansen**, Ph.D., on the development and fabrication of prosthetic feet and other devices.

After completing a B.S. in Biomedical Engineering from Marquette University in Milwaukee, she was awarded a 3 year National Science Foundation Graduate Fellowship. She graduated in 1989 with an M.S. degree in Biomedical Engineering from Northwestern University under the mentorship of Professor **Dudley S. Childress**. Her early research includes building a barograph to convert light intensity to pressure values in order to measure pressure distribution on artificial tissue.

Since 1989 Ms. Waldera was employed by the **Rehabilitation Institute of Chicago** as a Clinical Rehabilitation Engineer who provided design and fabrication services to inpatients and outpatients. She specialized in wheelchair seating and positioning, wheeled mobility, adaptive equipment for ADL, and some worksite modifications. She is a 20 year member of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA). From 1998, she was a guest lecturer in Rehabilitation Engineering at Marquette University (Milwaukee, WI) and at Dominican University (River Forest, IL). She lives in Chicago with her husband and two children.

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Director: Steven A. Gard, Ph.D.
Director Emeritus: Dudley S. Childress, Ph.D.
Editor: R. J. Garrick, Ph.D.

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