NORTHWESTERN UNIVERSITY

Capabilities

Communicating the Science of Prosthetics and Orthotics

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Striving for Quality: Enlisting Patients to Improve Prosthetic Care

Lauri Connelly, MS, Allen Heinemann, PhD, and Linda Ehrlich-Jones, PhD, RN

The practice of prosthetics and orthotics (P&O) has been described as both an art and a science. P&O clinicians must possess the unique combination of technical and creative skills to fabricate devices that meet their patients' aesthetic and functional goals. Moreover, to implement evidence-based practice, P&O providers must collect data on the outcomes of their work and continuously assess their performance for ways to improve the quality of their care. Measuring quality outcomes can be a challenge and the interplay of these elements can be quite difficult to quantify without a formal structure. The research project, *Enhancing the Quality of Prosthetic and Orthotic Services with Process and Outcomes Information*, conducted by the **Center for Rehabilitation Outcomes Research** (CROR) in collaboration with the **Northwestern University Rehabilitation Engineering Research Center** (NURERC), endeavors to assist prosthetists in measuring these outcomes.

CROR research team (from left), Allen Heinemann, PhD, Lauri Connelly, MS, and Linda Ehrlich-Jones, PhD, RN.

P&O Clinics Use OPUS

Five Midwestern prosthetics and orthotics clinics are participating in the CROR-NURERC research (See *Practice Makes Perfect* in *Capabilities* 18(3)2010). Patients are asked to complete the **Orthotics and Prosthetics Users' Survey** (OPUS) at 3 time points across the continuum of their care: intake, delivery of device, and 2 months after device delivery. The OPUS is a standardized clinical outcome measure that prompts patients to rate their functional status, quality of life and satisfaction with clinical devices and services. Information gleaned from these surveys will allow experts in the field of quality improvement to provide an in-depth quality improvement consultation with each participating clinical site. Clinics will receive information concerning performance at their own site as well as a comparison across sites.

Implementing quality improvement systems can be challenging for clinicians who must meet the time demands of high patient volume while treating cases of prosthetic complexity. To this end, CROR sought creative, efficient and effective ways to gain patients' self-reports on quality of life, perceived level of functioning, and satisfaction with service and device ratings. Through a common interest in developing quality outcome measures for the prosthetic and orthotic community, an exciting opportunity arose to collaborate with **Focus on Therapeutic Outcomes** (FOTO®).

Focus on Therapeutic Outcomes (FOTO®)

FOTO® is a national leader devoted to reporting about the collection, analysis, and comparison of nationwide rehabilitation outcome measures. (For more information visit: www.fotoinc.com.) Since its launch in 1993, the FOTO® database has grown to well over 3.5 million patient records. FOTO® has developed and refined software that efficiently

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collects patient reported data. The software was developed to accommodate the rigorous demands of time and documentation on P&O clinicians. Even in set up, the software avoids burdening the clinician and allows patients to sign on and complete the survey independently.

Providers of outpatient, rehabilitation care partner with FOTO® by submitting patient self-report outcomes to the extensive FOTO® database, thereby improving the quality of the rehabilitation care that they offer. FOTO® analyzes the patient data and provides a detailed risk-adjusted comparison of the provider's quality of services and outcomes to similar providers, as well as feedback about the result of care for individual patients. With these data, providers are able to identify their strengths and areas that need improvement. Moreover, they can develop objective and measurable quality improvement programs.

Currently, FOTO® is in the process of incorporating the OPUS into their system for use in the CROR-NURERC project. The FOTO® software is in the final stage of completion and this spring will be implemented in 2 clinical sites. In exchange for their participation in this study, FOTO® gains valuable data from prosthetic and orthotic practices.

The CROR-NURERC project, *Enhancing the Quality of Prosthetic and Orthotic Services with Process and Outcomes Information*, recognizes that P&O clinicians must deliver high quality, patient-centered services and products while fostering long-term, therapeutic relationships with their clients. The goals of this research project track and evaluate patient perceptions of complex issues of practice quality. These reports help P&O clinicians improve their practice by meeting patients' functional outcomes, quality of life, and overall satisfaction with the care and devices.

Gard Is Invited Panelist for National Health Recruiting

R. J. Garrick, PhD

Steven A. Gard, PhD, was an invited participant in the U.S. Army Medical/Dental Advisory Board meeting at McCormick Place (Chicago) on February 9. **John Michael**, MEd, CPO/L, **Stefania Fatone**, PhD, BPO(Hons), and **R. J. Garrick**, PhD, also participated in the meeting. Lieutenant Colonel **Ronald Walker**, Commander, U.S. Army 3d Medical Recruiting Battalion, presided over the meeting. The meeting was presented by the **U.S. Army** and **Weber Shandwick**, a communications and public relations firm, to encourage peer to peer spokespersons.

Steven A. Gard, PhD (center), discusses strategies for medical/dental recruitment at a U.S. Army Medical/Dental Advisory Board meeting.

To increase awareness about Army medical career opportunities, Medical/Dental Advisory Boards consisting of civilian volunteers have been formed in Chicago, Washington, D.C., Los Angeles, and St. Louis. The meeting featured Wounded Warrior amputee, Sergeant 1st Class **Neal Boyd**, who discussed his injuries and recovery experiences at Brooke Army Medical Center (BAMC) in Fort Sam Houston, Texas; an Army Commissioning ceremony; and small group focus sessions.

Representatives from Chicago area academic centers of influence brainstormed with Army personnel about ways to publicize Army medical/dental careers by accessing untapped organizations and media through personal contacts. The personal approach leverages peer to peer interactions through classrooms, faculty meetings, grand rounds, medical and scientific meetings, professional journals, and other media.

Collaborative discussions identified avenues for a broader scope of outreach that may attract medical school candidates who desire full scholarships, first-class medical education, and cutting-edge research. Desirable candidates also include trained medical professionals who seek to repay their educational loans and mature physicians who want a career change that allows them to serve soldiers and their families.

Learn more about Army medical/dental career opportunities at: www.armymedicine.army.mil/

Developing an Adaptable Prosthetic Ankle Unit

Eric Nickel, MS

Eric Nickel, MS, summarizes his thesis, "Further Development of an Adaptable Prosthetic Ankle Unit", which he completed for a Master's of Science degree in biomedical engineering at Northwestern University. (This work was supported by Grant #H133E080009 of the National Institute on Disability and Rehabilitation Research (NIDRR), a part of the U. S. Department of Education. The opinions expressed are those of the author and do not necessarily reflect those of the Department of Education.)

The human ankle is capable of providing adaptation to sloped surfaces on every step, a function that is unavailable in most lower-limb prostheses. Commercially-available prostheses that claim to adapt to sloped surfaces have limitations such as high cost, delayed response, reduced stability, and energy loss through damping. To address this need, we have been developing a prosthetic ankle-foot system that changes its effective alignment (i.e., its equilibrium point) on every step that is taken on sloped surfaces.

Mr. Nickel's rendering depicts the adaptable ankle as a computerized 3-dimensional graphic.

The purpose of the current phase of the Variable Equilibrium Point Prosthetic Ankle project was to develop a prototype prosthetic ankle that automatically adapts to sloped surfaces with each step and is sufficiently durable for short-term field trials. The prototype that we developed switches between low and high rotational stiffnesses by means of a wrap spring clutch mechanism. During the swing phase of gait when the prosthetic foot is off the ground, the low stiffness springs maintain a neutral alignment of the ankle. When the foot makes contact with the ground, the ankle mechanism rotates to enable the plantar surface of the foot to "find" the floor, after which the high stiffness springs are engaged and the ankle provides appropriate rotational resistance during the remainder of stance.

Preliminary clinical testing was performed with three unilateral transtibial prosthesis users. The prototype demonstrated appropriate adaptation in the effective ankle alignment on surfaces of different slopes. During mechanical testing to 100,000 cycles based on ISO 10328 standards, the rims of the wrap spring clutch arbors demonstrated significant wear, yet the adaptable ankle continued to hold testing loads. No other significant wear was observed.

The size of the prototype precluded the use of an unmodified commercial cosmetic foot cover and the weight remained substantively greater than that of the anatomical ankle (4.6 [lbs], as opposed to approximately 3 [lbs] for the human ankle). Further efforts to reduce the weight and size of the prototype are essential, and continued refinement of the clutch engagement mechanism is recommended. Significant size and weight reductions could be achieved by the use of a custom foot plate designed to withstand greater deflections under load, thus reducing the number and complexity of parts needed. We recommend further efforts to reduce the weight and size of the prototype, and to refine the clutch engagement mechanism.

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Editor: **R. J. Garrick, PhD**

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Subscription is free to all individuals and institutions interested in prosthetics and orthotics. Issues are archived on the NUPOC website, **www.nupoc.northwestern.edu**. Send subscription requests and address changes to: *Capabilities*, Northwestern University RERC, 680 North Lake Shore Drive, Suite 1100, Chicago, IL 60611.

Reflections from a Biomedical Engineer and Aspiring Prosthetist

Charles Wang, MS

"Why don't you sit in on classes at NUPOC?" "Take the NUPOC Prosthetics Certificate Program!" "Prosthetics training will be a benefit to your career!" These well-meaning suggestions summed up precisely what I did *not* wish to consider while I was scrambling to complete my Master's of Science in Biomedical Engineering at NUPRL (*Capabilities* 17(3)6, 2009). In the spring of 2009, committing to additional years as a student and more student loans were certainly not my top priorities! But that summer, I was fortunate enough to travel to Cambodia and Laos, where I saw firsthand the desperate need for prosthetic and orthotic services.

Learning: Charles Wang (left) focuses on details of alignment and fitting, explained by Prosthetics Director, Tom Karolewski (right).

My eyes were opened to the reality of the meager P&O resources throughout the world and I sensed a calling. Those trips reaffirmed and refined my perceptions about P&O in the developing world: a strong demand for P&O service providers and educators, but a complicated and opaque process before American practitioners can get involved.

I realized that my training as a biomedical engineer and researcher was insufficient to meet pressing P&O needs in the developing world. My interactions with patients had been limited to the laboratory and my knowledge was rudimentary about prosthetic devices, equipment, impression and modification techniques, gait training, and rehabilitation. I do not speak for my peers in engineering research, but often I saw that my research work merely sought appropriate solutions for generalized engineering problems. It seemed impersonal and detached. Perhaps I could not clearly see the far-reaching implications of the research that I helped conduct. Perhaps I was naively and unreasonably impatient that data and results did not speedily improve the quality of life of prosthetic users.

Creating: Charles Wang adjusts a prosthetic component.

Ultimately, I recognized that working to find solutions for the average patient or representative subject was not sufficiently satisfying for me. Initially, I had chosen Biomedical Engineering to interact with people whom I could help, to generate creative solutions for life's real problems. My trips to Laos and Cambodia crystallized the realization that I must better equip myself to achieve what I had originally envisioned. Those well-meaning suggestions to attend prosthetics school that I had casually brushed aside began to ring true and soon I was back in school.

Now that I have completed the **NUPOC Certificate Program in Prosthetics**, I have a broader perspective of the P&O field and how I can contribute to it. I have a new appreciation for the work that goes into forming a prosthetic device. Each is a unique creation—part art, part science—that might never be duplicated again. A prosthesis becomes an intimate part of the human body, a device that an individual relies on daily to achieve a quality of life that s/he cannot achieve otherwise. Gone are the days when I see a prosthesis and think only about its general designs, features, and capabilities. Now I see the artistic intricacies of a socket interface, while also perceiving the moments and force couples that transfer to a person's limb, and the joys and sorrows behind each person's life story. Now I see individuals who are directly affected by the work that I do, and their firsthand responses to a "golden prosthesis" or a dud. As a prosthetist, I see the unique human and personal side of P&O. At the same time, I have experienced the challenges, frustrations, and joys of the relatively non-standardized process of building a prosthesis.

As a researcher, I perceive the many benefits to finding generalized solutions for standard prosthetic problems, solutions with a standardized process and goal that can be appropriately applied to many individuals. Research is important, even if the outcome may not be realized until years later. There is a place and time for everything; personalized attention and rigorous research are both crucial to the development of P&O in the U.S. and abroad—undoubtedly a conclusion drawn by many who have preceded me.

Improving lives: Charles Wang shows a transfemoral prosthetic leg that he fabricated.

As I develop my career as a prosthetist and engineer, I am simultaneously excited and apprehensive. I have always dreamt big and I hope that it will not be too daunting to establish a career that is personally fulfilling and meaningful and that also positively improves the lives of others. I am extremely grateful for all the wonderful people who have shaped my path and the ways I perceive my life and this world. Thank you and I hope I will do you all proud!

NUPOC Welcomes Postdoctoral Fellow: Oluseeni Komolafe, PhD

R. J. Garrick, PhD

Oluseeni Komolafe, PhD, a postdoctoral fellow supported by the Department of Defense grant (Development of Sub-Ischial Prosthetic Sockets with Assisted-Vacuum Suspension for Highly Active Persons with Transfemoral Amputations) headed by Principal Investigator **Stefania Fatone**, PhD, BPO(Hons), has joined NUPOC, where he will apply his computational and design skills to prosthetic socket development. Dr. Komolafe completed his dissertation (*Fascicle-scale Experiments and Computational Analyses of the Achilles Tendon*, 2010) in the Department of Biomedical Engineering in the Computational Imaging and Biomechanics Laboratory at Drexel University (Philadelphia, PA). He completed a BSc degree (2005) in Mechanical Engineering at the University of Maryland-Baltimore County. He considered entering medical school, but ultimately preferred the analytic focus of engineering.

Oluseeni Komolafe, PhD

At Drexel, Dr. Komolafe began his clinical and translational research working on powered orthoses for a population of Duchene Muscular Dystrophy pediatric clients at a nearby hospital. For his dissertation, he conducted basic science research to investigate the micro-structure, material properties, and failure behavior of the human Achilles tendon. By applying concepts of solid mechanics to a sub-macroscopic analysis of the Achilles tendon, Dr. Komolafe's thesis work sought to understand the clinical problems of connective tissue rupture. He integrated novel imaging systems and micro-mechanical testing systems, both of which were developed in-house with constitutive and finite element modeling.

Dr. Komolafe's research interests include micro-structural experiments and computational modeling of collagenous connective tissues; lower limb knee and ankle mechanics; and prosthesis design and development. In addition to research, he has experience teaching and brings skills in troubleshooting, machining, electronics, and hardware/software programming skills.

Dr. Komolafe's father and mother are engineers who raised him in a stimulating environment that emphasized intellectual exchange about both abstract and applied ideas. Consequently, he feels comfortable in the analytic environment of engineering. He is eager to continue his work in clinical and translation research *"I believe that prosthetics and orthotics is a powerful application of engineering. When I visited Nigeria in 2010, I observed the need for low cost, high functioning prosthetic products. Disability in Nigeria is compounded by the problems of malnutrition, poverty, and even the continuing presence of polio."* When asked about his future beyond postdoctoral work, Dr. Komolafe reflected, *"I can't predict my future, but my goals are to use research and engineering principles to solve these problems."* He is a member of the Open Prosthetic Project and is interested in international applications of P&O engineering that can improve the quality of life of persons who live with a disability.

Not a proponent of all work and no play, Dr. Komolafe admitted with a smile, *"I am serious about my hobbies."* At Drexel he was a member of the Biomedical Graduate Association, a Big Brothers mentor, the African Students Association, and Habitat for Humanity. An active sportsman, Dr. Komolafe enjoys basketball and rugby. *"Rugby is the most fun I've ever had. It's such a fun sport!"* A long distance cycler, he rode a 200 kilometer self-sufficiency trip from Pennsylvania to New Jersey. He is an avid photographer and contributed his photos to Drexel's paper, *The Triangle*. His friends call him Seeni (pronounced Shay-nee). Welcome to NUPOC, Seeni!

NUPOC Represented at the 40th Annual Career Day for Girls

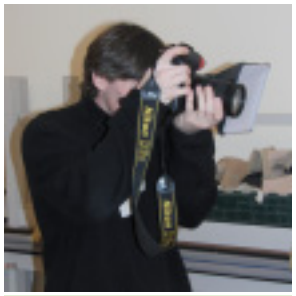
R. J. Garrick, PhD

Craig Heckathorne, MSc (left), and Erin Boutwell, MS (right), represented NUPOC research at the 40th Annual Career Day for Girls. (Photo courtesy Ellen Worsdall)

Craig Heckathorne, MSc, and **Erin Boutwell**, MS, represented NUPOC in three consecutive panel sessions at the 40th Annual Career Day for Girls (Impacting the World through Engineering). Presented by the Society of Women Engineers Northwestern University Chapter and McCormick School of Engineering and Applied Science (Evanston) on February 26, high school girls attended the day-long workshop that introduced them to potential careers in science. Showing examples of various prostheses, Mr. Heckathorne discussed upper extremity prosthetic components and Ms. Boutwell discussed lower extremity prosthetic components. They also explained research projects that are conducted at NUPOC and responded to questions about careers in P&O and rehabilitation engineering.

Photographer Focuses on Prosthetists

R. J. Garrick, PhD



As part of his Northwestern Portrait Series, Scot Wittman photographed NUPOC prosthetists.

Scot Wittman, MFA, President of the Independent School Art Instructors Association and Chair of the Art Department at Rutgers Preparatory School, was artist-in-residence at **The Three Walls** program (Chicago). Mr. Wittman is a professional photographer who visited NUPOC on March 11 as part of his work creating the **Northwestern Portrait Series**.

Mr. Wittman's project spotlights specialists at Northwestern University who are involved in the advancement of science. At NUPOC Mr. Wittman focused his camera on prosthetists and instructors **Thomas Karolewski**, MA, CP, FAAOP, and **Jared Howell**, CPO.

Echoing the combination of science and art in prosthetics, Mr. Wittman's creative work also fuses art and science. In his studio, Mr. Wittman provides context by digitally placing an overlay of a Chicago map over each full length portrait. The map is set to 50% opacity, so viewers may identify the portraits. His forthcoming photographic installation may expand public awareness about P&O research and education conducted at NUPOC. **R. J. Garrick**, PhD, facilitated this event.

Bateman Students Learn about Prosthetics

R. J. Garrick, PhD

Bateman School students, Principal Carl Dasko and Science Teacher Ms. Valkanas visited NUPOC. (Front, from right) Sara Koehler, MS, Kiki Zissimopoulos, MS, and R. J. Garrick, PhD.

NUPOC hosted an educational tour for 22 science students from the **Newton Bateman School** on March 15. Mr. **Jared Howell**, CPO, discussed the goals and applications of P&O, as well as education, training, and career opportunities in P&O. Mr. **Craig Heckathorne**, MSc, discussed upper extremity prostheses with respect to function and design. Doctoral candidates **Sara Koehler**, MS, and **Kiki Zissimopoulos**, MS, who have contributed to the Bateman science curriculum as volunteer teachers (*Capabilities* 16(2), 2008), introduced NUPOC facilities and explained current projects in rehabilitation engineering research. This educational tour expands public knowledge about NUPOC's rehabilitation engineering research projects; supports the **Get-a-Grip!** prosthetics curriculum; and promotes Northwestern University's efforts to provide science resources to the broader community. **R.J. Garrick**, PhD, facilitated this tour.

NUPOC NEWS

Visitors to NUPOC

Yasmine Othman, a professional orthotist working in Dublin, Ireland, visited NUPOC on February 3-8.

Daniel Blocka

Daniel P. Blocka (Professor, George Brown College, Toronto, Ontario, Canada, and Immediate Past President of the International Society for Prosthetics and Orthotics), visited NUPOC on February 4-5.

Brian Hafner, PhD, and **Daniel Abrahamson**, CPO, both of the Department of Rehabilitation Medicine, University of Washington (Seattle, WA), visited NUPOC on February 7. Dr. Hafner, assistant professor, Department of Rehabilitation Medicine, University of Washington, Seattle, and **Orthotic and Prosthetic Education and Research Foundation** (OPERF) board member and research committee chair, is a strong proponent of integrating research into clinical practice, educational programs, and patient care.

Daniel Abrahamson, CPO (left), and Brian Hafner, PhD (center), discuss prosthetics and engineering research with Steven A. Gard, PhD (right).

Honors

Stefania Fatone, PhD, BPO(Hons), accepted an invitation to join the International Editorial Board for *Prosthetics and Orthotics International*.

Mark Edwards, CP, was promoted to director of professional and clinical services for Otto Bock HealthCare in February. A clinical educator and practitioner, Mr. Edwards will continue to focus on education and training, while promoting strong ties with Otto Bock customers.

Presentations

Desmond Masterton, CO, CPed, presented a poster, *What are the Predictors of Student Success at the Northwestern University Prosthetics-Orthotics Center?*, for the Master of Science in Education, Higher Education Administration and Policy Meeting held at Northwestern University on March 10.

Publications

Dillon, M, Fatone, S, and Hansen, A. The Effect of Prosthetic Design on the Centre of Pressure Excursion in Partial Foot Prostheses. *Journal of Rehabilitation Research and Development*, 2011:48(2)161-178.

Presentations

Craig W. Heckathorne, MSc, presented a guest lecture, *Myoelectric Control and Electric-powered Upper-limb Prostheses*, for the course Rehabilitation Engineering (Biomedical Engineering Department) Marquette University, Milwaukee, WI, on November 11, 2010.

Gait Society Reviews NURERC Article

In February, the on-line Journal Club of the American Academy of O&P Gait Society considered why prosthetists and clients prefer certain prosthetic feet. To address these questions, the Gait Society reviewed "Effects of Prosthetic Forefoot Flexibility on Oxygen Cost and Subjective Preference Rankings of Unilateral Transtibial Prosthesis Users", a NURERC publication by **E. Klodd, A. Hansen, S. Fatone,** and **M. Edwards** (*Journal of Rehabilitation Research and Development*, 2010:47(6)542-552).

Gait Society reviewer **Shane Wurdeman**, CP, wrote, *"This is an excellent study that ... future studies [can] build upon. They used sound methodology...double blind-randomized crossover. This study [shows] that the forefoot flexibility of a prosthetic foot affects patient preference but does not affect oxygen cost."*

Kudos to Dilip Thaker

Dilip Thaker

Dilip Thaker, Instrument Maker at NUPOC, has completed twenty years of continuous service with Northwestern University. He will receive a certificate at the 34th Annual Staff Service Recognition Luncheon on May 10. Upon hearing the announcement, Mr. Thaker thanked **Ed Grahn, Steven A. Gard**, PhD, and **Dudley S. Childress**, PhD (Emeritus), remarking, *"Time has passed quickly because my work is interesting and I enjoy working with my colleagues at NUPOC."* Mr. Thaker has been an integral part of the NUPOC research team for 20 years.

Congratulations, Dilip!

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Margaret Parker Adds Up

R. J. Garrick, PhD

Margaret Parker, Master's of Science degree candidate in Epidemiology and Biostatistics (expected June 2011), is applying her knowledge to the NIDRR-funded research project, *Assessing and Responding to the Prosthetic Needs of Farmers and Ranchers*. Since October 2010, she has been working with **Kathy Waldera**, MS (Research Engineer, NUPOC), to code and categorize transcripts of interviews with farmers who use a prosthesis. Researchers will develop these data into a comprehensive survey for distribution by prosthetists and clinics to meet the prosthetic needs of farmers and ranchers.

Maggie Parker

The Rehabilitation Engineering Research Center (RERC) for Prosthetics and Orthotics funded by the National Institute for Disability and Rehabilitation Research (NIDRR) of the United States Department of Education is committed to providing opportunities that engage students in rehabilitation engineering research. While contributing her biostatistical skills to the RERC project, Ms. Parker has the opportunity to develop new perspectives that she can utilize in future research efforts.

Ms. Parker graduated from the University of Minnesota with a Bachelor of Science degree in genetics, cell biology, and development; and a minor in anthropology. She plans to begin coursework toward a doctorate in biostatistics. She has worked with autistic children and hopes to pursue research in the genetics of autism.

She is a 3rd degree black belt in Taekwondo and a Certified Emergency Medical Technician (EMT-B). In her leisure time, she enjoys music and skiing.