Capabilities
Communicating the Science of Prosthetics and Orthotics
NORTHWESTERN UNIVERSITY
Volume 15, Number 4, Autumn 2007

Models and Measurements of Spinal Motion during Ambulation

Regina Konz, Ph.D.

This work was supported through funds from Medtronic Sofamor-Danek, Inc., the National Institutes of Health training grant 5T32HD07418-10, and 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.The author acknowledges the use of the VA Chicago Motion Analysis Research Laboratory of the Jesse Brown VA Medical Center, Chicago, IL.

The role that spinal motion plays during ambulation is not clearly understood. Few *in vivo*, regional spinal motion data exist in the literature with regard to walking; and most gait analysis models disregard the upper body altogether, or regard it as a single rigid structure. This study aimed to increase understanding of the contribution of spinal motion during ambulation by improving the way spinal motion is modeled and measured.

The main hypothesis was that regional spinal motion is significant during locomotion, suggesting that the spine plays a more active role during gait than previously thought. To test this hypothesis, a kinematic model was developed and validated that enabled three-dimensional (3D) head, cervical, thoracic, lumbar, and pelvic motion to be collected simultaneously with conventional lower body gait parameters. Regional spinal motions in able-bodied subjects were collected and analyzed across a range of self-selected walking speeds to establish normal patterns of spinal motion across the gait cycle. Comparisons with data available in the literature indicated that 3D lumbar and thoracic spinal range of motion from ten able-bodied subjects were similar to those previously reported in the literature.

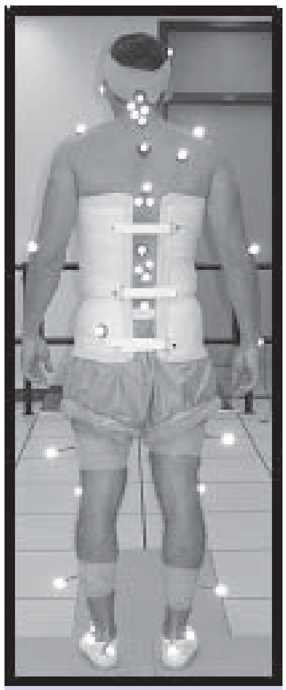


Figure 1: An able-bodied subject wears the fiberglass body jacket and the markers that were designed for this project.

A second hypothesis was that restricting spinal motion produces gait compensations. To address this hypothesis, data were collected as able-bodied subjects walked with and without imposed spinal restriction. Restriction was achieved with a fiberglass body jacket (Figure 1), similar to a Thoraco-Lumbo-Sacral orthosis. Constraints on spinal motion often are present in persons with spine deformity, especially after surgical fusion to correct deformity. To understand the clinical implications of spinal restriction , data from two persons with spine deformity were also assessed pre- and post-operatively.

Some lower body compensations were present in able-bodied persons walking with spinal restriction, indicating that restricted spine motion had a small effect on certain gait parameters. The invariance of their gait characteristics under these conditions may provide evidence of the able-bodied locomotor system's ability to adjust and adapt in order to compensate for reductions in spinal motion and to maintain balance and achieve stability. Changes were evident post-operatively in the two pathological subjects studied, with their post-operative data being more similar to those of unrestricted, able-bodied data. However, it is difficult to discern whether this outcome is the result of compensations for spinal restriction, or represents an improvement based on surgical correction of the spine deformity.

Vertical accelerations were calculated for the head, spine regions, and pelvis during unrestricted and restricted walking. Peak vertical acceleration at the head and cervical

Continued on page 2

Continued from page 1

spine were significantly larger with spinal restriction for able-bodied and fused pathological subjects compared to unrestricted or pre-operative conditions. These results provide some evidence for the spine's role in shock attenuation during gait, suggesting that spinal restriction may lead to accelerated degeneration at higher levels and indicate the need for proper clinical monitoring.

Further sub-hypotheses also were developed and analyzed. Specifically, it was proposed that the spine serves to minimize head motion during unrestricted walking. To evaluate this idea, vertical and medial-lateral (ML) motions were investigated at the head, spine regions, and pelvis. The vertical motion results supported this hypothesis, indicating that during walking the motion in this direction was largest at the pelvis, was reduced at more superior regions, and was smallest at the head. However, able-bodied results in the ML direction did not support the hypothesis, as both pelvis and lumbar motions were actually smaller than head motion, indicating that further research is required to explore these findings.

As expected, able-bodied analyses of regional spinal motions showed that vertical motion of the pelvis decreased with spine restriction, as did the restricted spinal regions (thoracic and lumbar) at normal, fast, and very fast walking speeds. Decreased thoracic axial rotation also was observed with spinal restriction in both able-bodied and pathological subjects. At levels superior to the spinal restriction, cervical lateral bending and flexion/extension increased during walking with spinal restriction for the able-bodied subjects, while results were inconclusive for the two pathological subjects. Global head motion in the transverse and coronal planes increased with spinal restriction for the able-bodied subjects and one of the pathological subjects.

Data from this research provide preliminary evidence that the spine has a more substantial role in gait than has been previously demonstrated. Overall, as measured in this study, post-operative outcomes were positive. Although no data suggested that changes in gait represent a significant problem in people with limited spinal motion, long-term effects remain unclear. If lower limb compensations are not possible or of a sufficient magnitude to achieve adequate shock attenuation, impact forces may increase and be transmitted to the spine and head, potentially generating even larger accelerations than were measured in this study. Increased motion and accelerations at regions superior to the fused levels could potentially lead to accelerated degeneration at these levels, pain, and deviations in normal gait parameters.

This research increases understanding of the potential effects of spinal restriction on gait. Furthermore, it assists clinicians in predicting and avoiding the development of additional problems that could result from restricting spinal motion. Awareness of these issues will enable clinicians to monitor patients for potential long-term problems that may result from walking with restricted spinal motion.

Dr. Konz completed her Ph.D. in biomedical engineering at Northwestern University in 2007 and currently is employed as Senior Research Engineer at Zimmer Spine in Minneapolis, MN.

Learn more about Dr. Konz's research in the following publications:

Konz, R.J., Fatone, S. and Gard, S.A. (2006). The Effect of Restricted Spinal Motion on Gait in Able-bodied Persons. *Journal of Rehabilitation Research and Development*, 43(2), 161-170.

Konz, R., Fatone, S., Stine, R., Ganju, A., Gard, S. and Ondra, S. (2006). A Kinematic Model to Assess Spinal Motion During Walking. *Spine*, 31(24), E898-E906.

Capabilities (ISSN 1055-7156) is published quarterly by Northwestern University's Rehabilitation Engineering Research Center.

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

Subscription is free by post or internet to all individuals interested in prosthetics and orthotics. All issues are available on our website, www.medschool.northwestern.edu/depts/repoc. Send subscription requests and address changes to: *Capabilities*, Northwestern University RERC, 345 E. Superior St., Room 1441, Chicago, IL 60611.

This work is funded by the National Institute on Disability & Rehabilitation Research (NIDRR) of the Department of Education under grant number H133E030030. The opinions expressed in this publication are those of the grantee and do not necessarily reflect those of the Department of Education.

Studies of the Biomechanics of Gait of Persons with Partial Foot Amputation

Stefania Fatone, Ph.D.

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. The author acknowledges the use of the VA Chicago Motion Analysis Research Laboratory of the Jesse Brown VA Medical Center, Chicago, IL.

Figure 1: Partial foot (transmetatarsal).

Partial foot amputation (Figure 1) is a relatively common sequel to advanced diabetes and vascular insufficiency (Dillon *et al*., 2007). In recent years partial foot amputations have become a more viable surgical intervention due to improvements in surgical techniques, especially revascularization (Owings and Kozak, 1998). Many different prosthetic/orthotic designs have been proposed from simple toe fillers and foot orthoses to below-ankle slipper sockets and above-ankle clamshell prostheses (Söderberg *et al*., 2001). However, a recent, systematic review regarding the biomechanics of ambulation after partial foot amputation concluded that our understanding of the biomechanics of ambulation and the influence of prosthetic and orthotic intervention is very much in its infancy (Dillon *et al*., 2007).

Here at NURERC, we are actively exploring some issues regarding gait of persons with partial foot amputations. For example, one of the consistent methodological issues identified in the systematic review by Dillon *et al.* (2007) pertains to how ankle motion is measured. When using marker-based motion analysis systems, the placement of markers is important because it affects the measured movements. Because most marker-based models were designed for able-bodied persons with normal anatomical landmarks, it is important to document where markers are placed when shoes and devices obscure those landmarks (Figure 2). Dillon *et al.* (2007) pointed out that movement between the residual limb and shoe or device (observed clinically as the heel slipping out of the shoe) complicates the measurement of joint motion and should be considered along with marker placement.

Figure 2: Partial foot with markers attached for gait analysis.

Recent investigations of partial foot amputees have reported relatively normal or reduced ankle motion in barefoot studies (Boyd *et al*., 1999; Garbalosa *et al*., 1996; Tang *et al*., 2004) but increased dorsiflexion range in studies involving footwear and below-ankle prosthetic/orthotic interventions (Tang *et al*., 2004; Dillon *et al*., 2001). We are exploring these issues using a mechanical model of the leg, ankle and foot, and are comparing marker-based measurements to those obtained using a potentiometer mounted within the mechanical model (Figure 3).

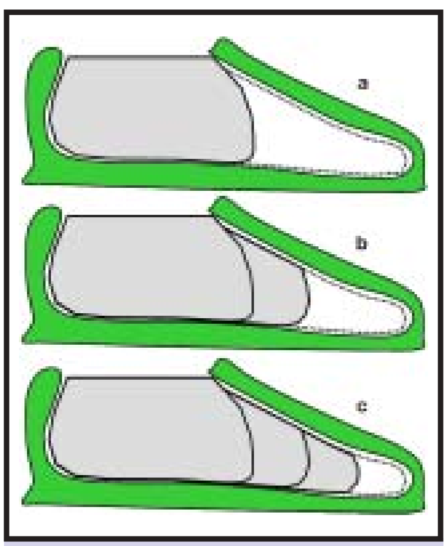


Figure 3: Schematic of the different partial foot amputation levels to be tested using a mechanical model: (a) Lisfranc, (b) transmetatarsal and (c) meta-tarsalphalangeal.

Many different prosthetic/orthotic designs have been proposed for use by partial foot amputees, including both below- and above-ankle devices (Söderberg *et al*., 2001). Although the literature on the biomechanics of partial foot amputation is characterized strongly by observational studies, few have described the effects on gait of different prosthetic/orthotic interventions (Dillon *et al*., 2007). It is difficult to distinguish between the relative merits of different interventions since investigations often compare the gait of independent groups with

Continued on page 4

Continued from page 3

different devices (Green and Cary, 1982), making it difficult to observe systematically any subtle adaptations specific to a particular device. In order to address this issue, we are collaborating with clinicians at **Scheck and Siress Prosthetics, Orthotics, & Pedorthics**, Chicago IL, to conduct a repeated measures observational study of the gait of persons with partial foot amputations ambulating with a range of different prosthetic/orthotic devices.

A partial foot amputation, in theory, should be better than a transtibial or Symes amputation because the physiologic ankle joint is preserved. However, studies of partial foot amputee gait suggest that partial foot amputees are unable to generate ankle power and that center of pressure progression beyond the distal end of the residuum during single limb stance is only restored by devices that extend above the ankle, have a stiff enough forefoot to support body weight, and substantially reduce or eliminate ankle motion (Dillon *et al*., 2007). The relationship between forefoot design, ankle motion and center of pressure progression has yet to be explored. This issue forms the basis of a study we are conducting in collaboration with **Michael Dillon**, Ph.D., from the National Centre for Prosthetics and Orthotics, La Trobe University, Australia, during his sabbatical with NURERC as a Visiting Professor.

References

Boyd LA, Rao SS, Burnfield JM, Mulroy SJ, Perry J. (1999) Forefoot rocker mechanisms in individuals with partial foot amputation. Paper presented at the Gait and Clinical Movement Analysis, Dallas, Texas, March 10–13, 1999. *Gait Posture, 9:144.*

Dillon MP. *Biomechanical models for the analysis of partial foot amputee gait* [dissertation] (2001) Mechanical, Manufacturing and Medical Engineering, Queensland University of Technology, Brisbane, Australia.

Dillon M., Fatone S. and Hodge MC. (2007) Biomechanics of Ambulation after Partial Foot Amputation. Proceedings of the American Academy of Orthotists and Prosthetists State of the Science Conference 8: Biomechanics of Partial Foot Amputation, March 1-4, 2007, Chicago, Illinois. *J Prosthet Orthot, 19:(8 Proceedings):P2-P61.*

Garbalosa JC, Cavanagh PR, Wu G, Ulbrech JS, Becker MB, Alexander IJ, Campbell JH. (1996) Foot function in diabetic patients after partial amputation. *Foot Ankle Int, 17:43–48.*

Greene WB, Cary JM. Partial foot amputations in children. A comparison of several types with the Syme amputation. (1982) *J Bone Joint Surg Am, 64:438–443.*

Owings, M.F., Kozak, L.J. (1998) *Ambulatory and Inpatient Procedures in the United States, 1996.* National Center for Health Statistics, Vital and Health Statistics, National Health Care Survey, Series 13, No. 139.

Söderberg, B., Wykman, A., Schaarschuch, R., Persson, B.M. (2001) *Partial Foot Amputations: Guidelines to Prosthetic and Surgical Techniques.* Second Edition. Swedish Orthopaedic Association's Publication Series No. 13. Helsingborg, Sweden.

Tang SFT, Chen CPC, Chen MJL, Chen WP, Leong CP, Chu, NK (2004) Transmetatarsal amputation prosthesis with carbon-fiber plate: enhanced gait function. *Am J Phys Med Rehabil,* 83:124–130.

Michael Dillon, Ph.D., Spends Sabbatical at NURERC

Michael Dillon, Ph.D., BPO(Hons), from La Trobe University in Australia, spent a sabbatical month at NURERC.

Michael Dillon, Ph.D., BPO(Hons), was in residence as Visiting Professor at NURERC during the month of August. While at NURERC, Dr. Dillon, **Stefania Fatone**, Ph.D., BPO(Hons), and **Andrew Hansen**, Ph.D., worked together investigating the gait of persons with partial foot amputation.

Dr. Dillon is Senior Lecturer in the National Centre for Prosthetics and Orthotics in the Division of Allied Health at La Trobe University, Melbourne, Australia. Among his duties, he instructs students in transfemoral prosthetics and supervises research students. He serves as Chair of the Scientific and Education Committee of the Australian National Member Society of the International Society for Prosthetics and Orthotics (ISPO). Also, he has taught prosthetics programs at the Hong Kong Polytechnic University and more recently at Kobe College of Medical Welfare in Japan.

Dr. Dillon began his career as a prosthetist working in both hospital and private settings where he developed expertise in transfemoral prosthetics. After completing his Ph.D. at Queensland University of Technology, he returned to clinical practice and later became an instructor at La Trobe University.

Dr. Dillon has a broad background in clinical P&O for both adult and pediatric populations. His research experience is equally extensive with foci in the biomechanics of ambulation, gait analysis, and transfemoral prosthetic suspension and alignment. His research interests include understanding the influence of different transfemoral socket designs and alignment practices on the mechanics of gait. An area of particular focus is partial foot amputation.

Aside from his work at NURERC, Dr. Dillon enjoyed attending outdoor jazz concerts, a White Sox baseball game, riding his bike, and touring Chicago's architecture. Also, he hiked a portion of the Ice Age Trail at Kettle Moraine State Park in southern Wisconsin.

NEWS FROM THE DEPARTMENT OF VETERANS AFFAIRS

Preventing Limb Loss Is Key Goal for Seattle VA Group

Mitchell Mirken
VA Research and Development Communications
103 S. Gay St., Rm. 517
Baltimore, MD 21202

Innovations in Limb Loss Prevention

Engineers at several VA sites are known for their expertise in designing and testing high-performance prosthetics. But equally important is research focused on the *prevention* of limb loss, namely in cases where the lower extremities are at risk due to diabetes or peripheral vascular disease.

In VA, much of this work takes place at the **Center of Excellence for Limb Loss Prevention and Prosthetic Engineering**, based at the VA Puget Sound Healthcare System. While this center also hosts important research involving prosthetics engineering and testing, it is perhaps equally known nowadays for its innovative studies on the factors leading to foot ulcers. These open sores, usually on the bottom of the foot, often become infected and do not heal well. They are usually the first step in a downward spiral leading to amputation. This issue is especially critical for the Veterans Health Administration, as more than a quarter of VA patients are diabetic. In the U.S. in general, some 15 percent of diabetic patients will develop foot ulcers during their lifetime, and people with diabetes account for about two-thirds of all lower-limb amputations.

Under the leadership of Director **Bruce Sangeorzan**, M.D., and Associate Director **Joseph Czerniecki**, M.D., investigators at this VA center in Seattle explore a variety of approaches to understanding and preventing the ulceration process. Among the topics they study are foot anatomy and biodynamics; footwear and orthotics; and the effects of diabetes on lower-extremity function and tissue health. A few examples of their recent and ongoing research include the following areas.

'Boning Up' on the Foot

A team at the center analyzed CT scans of 65 feet from 40 research volunteers with different foot types—for example, high or low arches—to learn how bone position varies across the types. This is important in understanding how risk factors for foot problems may differ from one patient to another. Other technologies used at the center to study foot structure and function include MRI of volunteers' feet as they move through a range of motion; and computerized motion analysis in which video cameras record the movement of feet marked with special reflective material.

Deepening Understanding of the Diabetic Foot

Recent studies at the center involving CT scans of the feet of diabetic patients showed that certain foot types—for example, high arches—are strongly associated with foot deformities such as hammer and claw toes, which in turn are strongly linked to ulceration. Another finding from this work challenges the common assumption that increased pressure on the sole of the foot leads to ulcers. The data show that this belief is well-founded for the ball of the foot, but may not be accurate with regard to the heel or toes. The researchers are now analyzing CT scans of more than 400 diabetic feet to compare foot structure between patients who develop ulcers and those who do not.

Along similar lines, investigators at the center have funding from the National Institute of Diabetes and Digestive and Kidney Diseases to conduct lab studies, in conjunction with the University of Washington, comparing fatty tissue from beneath the feet of diabetic subjects with similar tissue removed from healthy feet. The researchers are looking mainly at tissue mechanical properties and protein expression, with the goal of identifying potential targets for new drug therapies.

Improving Orthotics

Orthotic prescriptions are often intended to help relieve plantar pressure (pressure on the sole of the foot). However, pressure is not typically measured during fabrication. Researchers at the Seattle center have developed a new manufacturing process that provides orthotists with real-time feedback on plantar pressure, so they can gauge the effects of their modifications to the devices they are crafting.

Building a Better Model

A team at the center is developing a second version of their Finite Element Foot Model (Figure 1), which allows for computer simulation of how the foot moves and reacts to various stresses. The 3D model includes dynamic visual representations of bones, ligaments, cartilage, tendons,

Continued on page 6

Continued from page 5

adipose (fat) tissue, muscle and skin. The model offers many advantages to researchers and clinicians. It can simulate the effects of surgery on foot function, aid the development of foot orthoses, and provide data on internal stresses and strains of structures within the foot. Also, this model can limit the need for cadaveric experiments that are often technically difficult, time-intensive and costly.

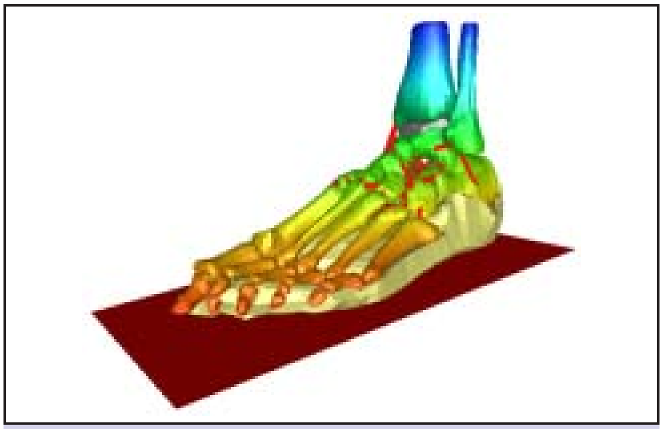


Figure 1: A view of the Finite Element Foot Model developed by researchers at VA's Center of Excellence for Limb Loss Prevention and Prosthetic Engineering (VA Puget Sound Healthcare System).

Like most scientific research, much of the work that goes on at the Seattle center may not seem particularly exciting or glamorous, and it may not be featured on magazine covers or the evening news. But, this research contributes to the understanding and prevention of the ulceration process and makes an important difference in the work of clinicians and scientists. Moreover, it helps to improve the lives of veterans and other Americans at risk for foot problems and amputation.

(For more information about the Center of Excellence for Limb Loss Prevention and Prosthetic Engineering, visit their website at http://www.va.gov/psortholimb.)

Capabilities appreciates **Robert M. Baum** for facilitating this article. Mr. Baum is Program Manager of Prosthetics and Clinical Logistics at the VA Central Office (10FP) in Washington, D. C. 20420. Contact Mr. Baum at the above address (Telephone: 202-254-0440 or Fax: 202-254-0470) to ask questions about this article or to suggest articles.

NURERC Featured in *O&P Business*

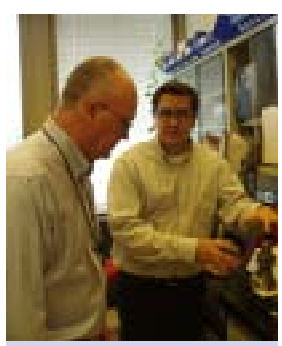
The September 2007 issue of *OandP Business News* featured an article about NURERC's State of the Science meeting that identified important areas of prosthetics/orthotics research. Read more about NURERC's efforts to define and promote evidence-based practice, as well as efficacy and outcomes research in "Where Science and Art Converge" (*O&P Business News*, Volume 16, Number 18, pp. 44-49).

O&P members may access it online at www.oandpbiznews.com.

NSF's Robert J. Jaeger, Ph.D., Visits NURERC

Robert J. Jaeger, Ph.D. (Director, Research to Aid Persons with Disabilities Program; Chemical, Bioengineering, Environmental and Transport Systems Division; **National Science Foundation** in Arlington, VA), visited NURERC on June 12. From 1997 through 2006, Dr. Jaeger was on staff at the **National Institute on Disability and Rehabilitation Research** (NIDRR), Office of Special Education and Rehabilitative Services, United States Department of Education, Washington, D.C.

(*From left to right*) Robert Jaeger, Ph.D., Andrew Hansen, Ph.D., and Dudley S. Childress, Ph.D., discuss lever compression molding of the Shape&Roll Prosthetic Foot for low income countries.



During his recent visit to NURERC, Dr. Jaeger (*left*) discussed foot and ankle biomechanics with Andrew Hansen, Ph.D. (*right*).

Robert Jaeger (*left*) shares an observation with Dudley Childress, Ph.D., (*center*) and NURERC Instrument Maker, Dilip Thaker (*right*).

After reviewing new research being conducted at NURERC, Dr. Jaeger presented a talk, "Evaluating Interventions to Improve Gait in Cerebral Palsy: A Meta-analysis of Spatiotemporal Measures." (Dr. Jaeger's paper is co-authored with Scott Paul, Karen Siegel and James Malley and may be read in its entirety in *Developmental Medicine & Child Neurology 2007*, *49*:542-549.)

NURERC NEWS

Meetings

Steven A. Gard, Ph.D., **Angelika Zissimopoulos**, M.S., and **Ryan Williams**, B.S., attended the Annual Meeting of RESNA in Phoenix, AZ, on June 16-17, 2007.

Steven A. Gard, Ph.D., was invited to speak at the Midwest Chapter Meeting of the American Academy of Orthotists and Prosthetists held in Lisle, IL, on Friday, June 1, 2007. Dr. Gard presented an overview of the research activities conducted at NUPRL and RERP. Following Dr. Gard's presentation, **John Michael**, MEd, CPO/L, FAAOP, FISPO, presented information about how prosthetists and orthotists can contribute to research by assisting NUPRL and RERP with recruitment of research subjects.

NURERC faculty and researchers **Dudley Childress,** Ph.D.**, Steven Gard,** Ph.D.**, Edward Grahn, Stefania Fatone,** Ph.D.**, Andrew Hansen,** Ph.D.**, Craig Heckathorne,** M.S.**, Kerice Tucker, Sara Koehler,** M.S.**, and Pinata Sessoms,** M.S.**,** attended the 12th World Congress of the International Society of Prosthetics and Orthotics (ISPO) from July 29 through August 3 in Vancouver, Canada.

Awards

Dudley S. Childress, Ph.D., attended the annual conference of the Amputee Coalition of America (ACA) on June 16-17, 2007 in Atlanta, GA, where he was awarded the **2007 Ernest Burgess Lifetime Achievement Award**. While at the meeting, Dr. Childress presented an original poem in honor of Ernest Burgess, M.D., Ph.D. *The Dawn Has Come*, Dr. Childress' original poem, describes Dr. Burgess as a multi-talented physician: "*We don't have many Renaissance Men anymore…but Burgess clearly belonged as surgeon, scholar, scientist, sculptor, swimmer, poet, politician…and more*." You may read this poem in its entirety at: www.rehab.research.va.gov/jour/00/37/6/memor376.htm

Ryan Williams, B.S., won a Student Design Award at the RESNA 2007 Annual Conference, held in Phoenix, AZ, June 15-19, 2007, for his project entitled "Adaptable Prosthetic Foot & Ankle Mechanism for Sloped Walking."

Regina J. Konz, Ph.D., received the Sarah Baskin Award for Excellence in Research for her paper, "Development of a Kinematic Model to Assess Spinal Motion During Walking." It can be read in its entirety in *Spine*, 2006, Volume 31, Number 24 pp. E898-E906, authored by Konz R., Fatone S., Stine R., Ganju A., Gard S., and Ondra S.

Visitors

Saeed Zahedi, Ph.D., from Charles A. Blatchford & Sons, Ltd, UK, visited NURERC in August to learn more about the Shape&Roll Prosthetic Foot that was developed in our lab. Dr. Zahedi specializes in trans-tibial foot-ankle alignment.

Sophie (Lambla) Dussud, M.S., who worked as a Research Engineer at NUPRL (1992-1993) on the Shape&Roll Prosthetic Foot returned from France to NURERC for a visit in August 2007.

New Faces at NURERC

Elizabeth Klodd, B.S., joins NURERC and NUPRL as a graduate student.

Elizabeth Klodd, B.S., has joined NURERC as a graduate student. She graduated from Syracuse University (2006) where she focused on bioengineering with an emphasis in biomechanics. She works under the supervision of **Andrew Hansen**, Ph.D., investigating the principles of roll-over shape and the effects of the prosthetic foot rocker radius on gait. She is a member of Northwestern University's **Society of Women Engineers (SWE)**.

Lisa D'Amico Joins NURERC Staff

We extend a warm greeting to **Lisa D'Amico** who joined NURERC's support staff as Financial Coordinator. Prior to her position at Northwestern University, Lisa worked at Purdue University and the University of Chicago. Ms. D'Amico lives in Indiana where she pampers a venerable Akita dog named Kato. She plans to complete her M.B.A. at DeVry University in February 2008.

Welcome to NURERC!

Lisa D'Amico

Capabilities
ISSN 1055-7156
Northwestern University
Prosthetics Research Laboratory and
Rehabilitation Engineering Research Program
345 E. Superior Street, Room 1441
Chicago, IL 60611-4496

Phone Help Line: (312) 238-6524
FAX: (312) 238-6510
TTD: (312) 238-6530
E-mail: reiu@northwestern.edu
Web Site: http://www.medschool.northwestern.edu/depts/repoc

RETURN SERVICE REQUESTED

Non-Profit
U.S. Postage
PAID
Northwestern University

Eric Nickel: New Graduate Student and CLIMB Participant

Graduate student Eric Nickel, B.S., has joined NURERC and NUPRL.

Eric Nickel, B.S., joined NURERC during the summer. He is a participant in Northwestern University's **Collaborative Learning and Integrated Mentoring in the Biosciences (CLIMB) Program**. CLIMB is a professional development program that aims to improve students' learning experience and increase their success rate through better mentorship. **Steven A. Gard**, Ph.D. (Director of NURERC), is Eric's mentor and advisor. Prior to beginning Northwestern University's combined M.S./Ph.D. program in biomedical engineering, Eric graduated from the Milwaukee School of Engineering (MSOE) with a major in Biomedical Engineering (2004). Also, he served for 7 years in the Wisconsin ARMY National Guard, including a deployment in support of Operation Iraqi Freedom with D Company, 2nd Battalion, 128th Infantry.

Eric's research interest is in human functional kinematics, specifically during intense physical activity such as athletic competition and military operations. He plans to investigate methods of assessing the functional capacity of amputees to determine their ability to return to active military service. His personal interests include backpacking, short story writing, and playing Irish music. He performs vocals and plays the *bodhran* (Irish drum) at local Irish pubs. Also, he plays a good game of euchre.

Read *Capabilities* On-line!

You can read *Capabilities* on our website, http://www.medschool.northwestern.edu/depts/repoc.

***Capabilities* is free to those who request it and you may receive this publication by post or read all current and archived issues on-line.**

If you read *Capabilities* on-line, or if you no longer wish to receive it by mail, please contact us to remove your name from the list of postal recipients.

E-mail: reiu@northwestern.edu
Phone: (312) 238-6524
FAX: (312) 238-6510

Northwestern University PRL & RERP
345 E. Superior St., Room 1441
Chicago, IL 60611
USA