



Capabilities

Communicating the Science of Prosthetics and Orthotics

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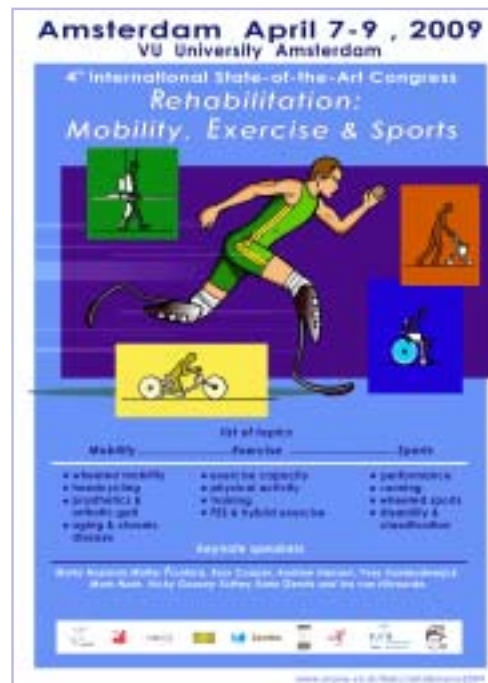
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Hansen Delivers Keynote

R. J. Garrick, Ph.D. and Andrew Hansen, Ph.D.

Andrew Hansen, Ph.D., was an invited keynote speaker at the 4th International State-of-the-Art Congress “Rehabilitation: Mobility, Exercise & Sports” held at the Vrije Universiteit (VU) in Amsterdam, the Netherlands, from April 7-9. This annual 3-day conference attracts worldwide experts in the field of rehabilitation, mobility, exercise and sports whose research focuses on mobility restoration, active lifestyle, exercise training, and sports in the context of contemporary rehabilitation practice. Dr. Hansen’s keynote speech was “Roll-over Shape as a Tool for Design, Alignment, and Evaluation of Ankle-Foot Prostheses and Orthoses.”

Dudley S. Childress, Ph.D., a mentor and collaborator of Dr. Hansen, co-authored the work.



Promotional poster for 4th International State-of-the-Art Congress “Rehabilitation: Mobility, Exercise & Sports.”

invariant roll-over shape when walking at different speeds, carrying different amounts of added weight to the trunk, and when using different footwear. NURERC has used these findings to design prosthetic feet, to evaluate

prosthetic foot features, and to improve understanding of the transtibial alignment process. Lastly, Dr. Hansen described the past and current ankle-foot prosthesis technologies developed to be adaptable to different terrain, and described the adaptable ankle under development at NURERC. Dr. Hansen noted that many participants expressed interest in the NURERC research; and one group reported using roll-over shape to evaluate the use of rocker shoes, specifically the Masai Barefoot Technology (MBT), sometimes advocated for persons with ankle arthrodesis.

The annual conference is organized under the auspices of MOVE, which consists of three VU faculties: the Faculty of Human Movement Sciences, VU Medical Center, and the Academisch Centrum Tandheelkunde Amsterdam (Amsterdam Academic Centre for Dentistry). Both multidisciplinary and collaborative, MOVE research seeks to optimize prevention among healthy persons and recovery among patients. MOVE applies research results to recovery, improvement and prevention of musculoskeletal conditions, such as osteoporosis, arthritis, cerebral palsy and stroke.



Andrew Hansen, Ph.D., presenting keynote address at 4th International Congress on “Rehabilitation: Mobility, Exercise & Sports” in Amsterdam.

Dr. Hansen discussed rocker modeling of walking and direct measurements of effective rockers, or roll-over shapes, of lower limb systems in able-bodied persons. In particular, able-bodied persons maintain an

Continued on page 2

The conference focused on three areas of research: Mobility, Exercise and Sports. Mobility examined wheeled mobility, prosthetic and orthotic gait, and aging and chronic disease. Exercise examined physical activity, capacity, training and hybrid exercise, such as Functional Electrical Stimulation (FES). Sports covered issues of disability classification, performance, running and wheeled sports.

Dr. Hansen reflected on his experience, noting the scope of the topics and variety of professionals who attended the conference. He particularly enjoyed touring the VU

Institute for Fundamental and Clinical Human Movement Sciences (IFKB) where normal and pathological research is conducted on human movement with respect to Musculoskeletal Biology, Structure and Motion, and Motor Control. He also enjoyed a discussion with **Klaas Postema**, M.D., Ph.D. (University Medical Center, Groningen, the Netherlands), and **Jaap Harlaar**, Ph.D. (VU University Medical Center, Amsterdam, the Netherlands) about research areas of mutual interest and potential future collaboration.

Fatone and Malas Present Workshops

R. J. Garrick, Ph.D.

Stefania Fatone, Ph.D., BPO(Hons), Research Assistant Professor, Department of Physical Medicine and Rehabilitation, Northwestern University, Feinberg School of Medicine, together with **Bryan Malas**, MHPE, CO, CPed, presented two workshops on Lower Limb Orthotics at the **Rehabilitation Institute of Chicago (RIC)** “Annual Interdisciplinary Stroke Course, The Brain and Body Connection After Stroke” held on April 16-17. Bryan Malas, Director, Orthotics/Prosthetics Department, Moira Tobin Wickes Orthotics Program, Children’s Memorial Hospital (Chicago, IL), spoke as Guest Faculty.



Stefania Fatone, Ph.D., BPO(Hons), and **Bryan Malas**, MHPE, CO, CPed, discussed lower limb orthoses at the RIC Annual Interdisciplinary Stroke Course.

The course provided theoretical and clinical advances in the management of stroke rehabilitation. Workshops and lectures addressed new research in neuroscience, cognitive and motor function, as well as the practical management of stroke for professionals and families. Topics featured neuroanatomy of stroke syndromes, disorders of emotional communication, visual neglect, treatment of dysphagia, upper and lower limb motor control, and preparation for discharge to home. The course attracted approximately 80 attendees, consisting of physicians, nurses and allied health professionals such as physical therapists, occupational therapists, speech therapists, social workers, and other professionals interested in stroke rehabilitation.

Dr. Fatone reviewed the available evidence with regard to lower limb orthotic management of stroke, including the AOPA Evidence Note on *The Use of Ankle Foot Orthoses in the Management of Persons with Stroke*¹ (See *Capabilities* 2009(17)2: 3) and the ISPO *Report of a Consensus Conference on the Orthotic Management of Stroke Patients*². Mr. Malas reviewed biomechanical considerations for orthoses, focusing specifically on the development of ideas regarding the alignment and ‘tuning’ of ankle-foot orthoses (AFOs). He presented a case study from the literature that illustrated the effects of a tuned ankle-foot orthoses and footwear in a person with stroke³. Using video-

based observational gait analysis and quantitative gait data, Dr. Fatone and Mr. Malas jointly led the participants through an interactive analysis of the gait and orthotic management of a person with stroke.

References:

1. Fatone, S. and J. Campbell, *The Use of Ankle Foot Orthoses in the Management of Stroke*, in *Evidence Note*, American Orthotic and Prosthetic Association, Editor. 2008, Orthotic and Prosthetic Outcomes Initiative Steering Committee: Alexandria, VA.
2. Condie, E., J. Campbell, and J. Martina, eds. *Report of a consensus conference on the orthotic management of stroke patients*. 2004, International Society for Prosthetics and Orthotics: Copenhagen, Denmark. 55-63.
3. Bowers, R. and B. Meadows, *Use of an ankle-foot orthosis to optimize hip and knee biomechanics following stroke*, in *The Academy Today*. 2007.

Center for the Intrepid and TATRC Reps Visit NURERC

R. J. Garrick, Ph.D.

Troy Turner, M.S., of the **Telemedicine and Advanced Technology Research Center (TATRC)** of the U.S. Army Medical Research and Materiel Command (USMRMC) at Fort Detrick, in Frederick, MD, visited NURERC on April 22 to explain TATRC's goals, research areas and application procedures for funding. Mr. Turner manages the Advanced Prosthetics and Human Performance (AP&HP) research portfolio at TATRC and also serves as Deputy Chief of the Knowledge Engineering Group, including TATRC's Robotic Combat Casualty Extraction and Evacuation program. On April 23, LTC **Rachel Evans**, PT, Ph.D., Research



NURERC Director, **Steven A. Gard**, Ph.D. (right) hosted a didactic tour of laboratory facilities and projects when LTC **Rachel Evans** (left) visited NURERC.

Director of the Center for the Intrepid (CFI) visited NURERC. On both days, **Steven A. Gard**, Ph.D., Director of NURERC, welcomed the visitors to NURERC and hosted a tour of the laboratory.

NURERC researchers explained this lab's ongoing and prospective research projects. **Andrew Hansen**, Ph.D., discussed the development and testing of the Shape&Roll Prosthetic Foot designed for fabrication in developing economies and introduced an adaptable foot-ankle



Andrew Hansen, Ph.D. (left), and **Troy Turner**, TATRC (right), discuss the advantages of adjustable foot-ankle prostheses for military personnel. NURERC research promotes prosthetic solutions that are, in the words of D. S. Childress, Ph.D., "Not high tech, not low tech, just the right tech."

mechanism that is being developed at NURERC. **Craig Heckathorne**, M.Sc., reviewed up-per limb prosthetics and new research that is being conducted among agriculturists who require prostheses

that can function well in circumstances similar to some military field conditions. **Joshua Rolock**, Ph.D., and **Kerice Tucker**, Research Engineer, reviewed the fabrication of prosthetic sockets using CAD-CAM processes and SquirtShape Technology. **Stefania Fatone**, Ph.D., **Rebecca Stine**, M.S., and **Brian Ruhe**, M.S., discussed motion analysis in the Jesse Brown VA **Chicago Motion Analysis Research Laboratory (VACMARL)**.

TATRC's mission is to shape the use of congressionally allocated funds to Department of Defense (DoD) relevance. Within TATRC, AP&HP funds specific areas of prosthetics

research that enable service personnel and veterans with amputations to attain the highest quality of life. CFI represents state-of-the-science clinical programs that provide comprehensive, outpatient rehabilitation and maximize performance for military with amputations. At CFI, clinical needs drive research. Focusing on amputation and limb salvage, CFI promotes research that promotes optimal outcome, specifically the re-deployment of military patients to active duty.

Mr. Turner and LTC Evans visited NURERC to define and evaluate specific research topics in prosthetic engineering that are consonant with the funding initiatives at TATRC and CFI.



Troy Turner, TATRC (left), examines the fabrication of a prosthetic socket as **Joshua Rolock**, Ph.D. (right) explains CAD-CAM and SquirtShape technology.



VETERANS AFFAIRS

Adaptive Sports and Holistic Rehabilitation

R. J. Garrick, Ph.D.

Summertime, benefits to good health, and Chicago's bid to host the 2016 Olympics and Paralympics are stimulating interest in adaptive sports and physical fitness. Learn more about Chicago's bid for the Olympics and Paralympics at www.chicago2016.org/ and about the Paralympics at www.usparalympics.org/.

Participants and researchers alike recognize the physical and psychological benefits of participating in sports. For persons living with a disability, *adaptive sports* (sports that have been modified to accommodate amputation, paralysis, blindness, and other physical conditions) offer opportunities for self development and physical achievement. The Paralympic Games are the premier adaptive sport event, symbolizing its motto, "*Spirit in motion.*" These games are staged subsequent to the Olympics in the same facilities and feature competition among top ranked athletes with various physical disabilities.

Adaptive sports emphasize ability rather than disability. For veterans and others who live with a disability, adaptive sports provide the chance to participate in sports, build self-confidence, develop new physical skills and compete at the highest level. As part of a holistic, sustainable rehabilitation of veterans, the Department of Defense, the Department of Veterans Affairs (VA), and veterans' service organizations such as Disabled American Veterans (DAV) annually sponsor national and regional adaptive sports workshops and camps.

In May 2009, Fort Lewis (WA), in partnership with the U.S. Paralympics (a division of the U.S. Olympic Committee) and other community groups, hosted the first Paralympics Military Regional Sports Camp. Coaches from the U.S. Paralympics conducted the camp and helped veterans engage in sports such as adaptive rowing, sitting

volleyball, swimming, and track and field. This camp and other similar events encourage a lifetime of fitness for veterans, regardless of physical disability. Additionally, the U.S. Paralympics help veterans develop sports programming in their local communities so they can continue to be active.

Today, participation in adaptive sports is popular and internationally available; however, the movement is relatively recent. **Ludwig Guttman**, M.D., a spinal cord injury (SCI) specialist, recognized the physical and psychological rehabilitative importance of sports participation. In 1948 he established the **Stoke Mandeville Games** for paralyzed WW II veterans. These Games are considered to be the precursor of today's Paralympics. The 2012 Paralympics will be hosted in London, only 50 miles away from the site of the original Games at Stoke Mandeville Hospital. No longer limited to paralyzed veterans, current Paralympics feature top-ranked athletes with many kinds of disability. Consequently, the meaning attributed to *Paralympic* has evolved to mean "alongside," rather than "paralyzed." If Chicago succeeds in its bid to host the 2016 Olympic and Paralympic Games, the Olympics will be held from July 22 to August 7 and the Paralympics will be held between August 12 and August 28.

DID YOU KNOW?

Two Paralympians have been associated with NURERC:

Brian Ruhe, M.S.: Winner of gold medal as defenseman on the U.S.A. Sledge Hockey Team at the 2002 Winter Paralympics in Salt Lake City.

Jan Little, M.S. (deceased 2003): Winner of 6 gold medals in swimming; silver medals in archery; and represented the U.S.A. on five U.S. Wheelchair Teams to the Paralympics, competing in England, France, Spain, Japan and South Africa.

MORE ABOUT ADAPTIVE SPORTS PROGRAMS:

- ♦ www.usparalympics.org/
- ♦ www.nationalresourcedirectory.org/nrd/public/DisplayPage.do?parentFolderId=6078
- ♦ www.dsusa.org/
- ♦ www.specialevents.va.gov/
- ♦ www.woundedwarriorproject.org/content/view/425/942/
- ♦ www.defenselink.mil/news/newsarticle.aspx?id=51346
- ♦ www.defenselink.mil/news/newsarticle.aspx?id=54181
- ♦ www.summersportsclinic.va.gov/
- ♦ www.rectech.org/
- ♦ www.ncpad.org/



VETERANS AFFAIRS

Hansen Speaks at The Center for the Intrepid

R. J. Garrick, Ph.D.

Andrew Hansen, Ph.D., was invited to visit **Brooke Army Medical Center** (San Antonio, TX) and **The Center for the Intrepid** (CFI) on April 16-17, where he presented a talk entitled “Simple Models for the Biologic Ankle-Foot Complex: Applications for Ankle-Foot Prostheses.” Members of the CFI research team who attended Dr. Hansen’s talk, included **Jason Wilken**, Ph.D., MPT, Director of the Military Performance Laboratory, and LTC **Rachel Evans**, PT, Ph.D., Research Director (See page 3).

Dr. Wilken hosted Dr. Hansen’s visit to CFI, conducted a tour of the facility,



Jason Wilken, Ph.D., MPT, Director of the Military Performance Laboratory at CFI, hosted **Andrew Hansen**, Ph.D., during his visit.

and presented information about several ongoing projects at CFI. While discussing research that is conducted at CFI and NURERC, Drs. Wilken and Hansen identified many similar interests, including the fact that both had studied ankle-foot systems for their doctoral work. They discussed potential collaboration on future studies.

The CFI opened in February 2007 to provide state-of-the-art care for veterans with amputation, burns or undergoing limb salvage¹.

Reference

1. Sadowski, J. Wounded Warrior Care at The Center for the Intrepid, *Capabilities* 2007:15(3):6-7.

VACMARL Adds Software Enhancements

R. J. Garrick, Ph.D.

The **VA Chicago Motion Analysis Research Laboratory (VACMARL)** recently upgraded its data capture and editing software to **Cortex**, by **Motion Analysis Corporation** (Santa Rosa, CA). Released in June 2008, Cortex is a 3D real-time motion capture program that integrates tracking, editing, scripting and modeling functions.

VACMARL researchers will use convenient, new functions such as **Motion Composer** to create presentations that include stick figures, force vectors, color videos, graphs and text documents. The built-in **Force Plate Configuration Editor** allows researchers to configure and view force plate calibrations, including the ability to support moving force plates. The improved **Sky** scripting interface is embedded and fully integrated in Cortex, offering command-line mode for greater ease in batch processing. **Rebecca Stine**, M.S., Research Engineer and Manager of the VACMARL, remarked, “The feature that I like best is the Quick Files feature. Quick Files opens the directory structure in a separate window, allowing us to sort by file extension. Also, it lets us load

and save files faster than loading them from a drop down menu. This really facilitates and streamlines our work.”

In addition to **Cortex**, VACMARL also acquired **Visual3D™ (Advanced Software for 3D Motion Analysis)** by **C-Motion, Inc.** (Germantown, MD). Some features of this product include the ability to support VACMARL’s custom marker configurations as well as a conventional gait marker set; advanced modeling capabilities; virtual markers; real-time analysis; and data management and report generators.

These two software programs will ensure that VACMARL research continues to meet or exceed the highest scientific standards for accuracy in gait and motion analysis

For more information about these software programs, see:

<http://www.motionanalysis.com/html/movement/cortex.html>

<http://www.c-motion.com>

Erin Boutwell, M.S., successfully defended her Master's thesis, "Study of Residual Limb-Prosthetic Socket Compliance in Transtibial Amputees," on May 5, 2009. **Charles C. Wang**, M.S., successfully defended his Master's thesis, "Effective Rocker Shapes and Ankle Kinematics of Able-Bodied Persons During Walking, Swaying and Standing," on May 6, 2009. Ms. Boutwell and Mr. Wang, respectively, summarize their Master's research for *Capabilities*.

Residual Limb-Prosthetic Socket Compliance in Transtibial Amputees

Erin Boutwell, M.S.

(This project was funded by VA RR&D-Dev Grant Number (A3518R). Content is solely the responsibility of the author and does not necessarily represent the official views of the VA.)

Shock absorption is often lacking in persons with lower-limb amputation because of the loss of viscoelastic tissues like the heel pad. Therefore, adding compliant materials into a prosthesis may be an effective means of increasing shock absorption and making prostheses more comfortable and functional. Two different thicknesses of gel liners were tested in the prosthetic sockets of subjects with unilateral transtibial amputation during walking and weight shifting; these liners introduced varied compliance within the prosthesis. The displacement of the socket with respect to the thigh was measured, as was pressure over certain anatomical landmarks on the residual limb. Walking speed, ground reaction forces, and joint motion data also were analyzed.



Erin Boutwell, M.S.

The thicker gel liner provided slightly greater motion between the socket and residual limb, but appeared to create a more uniform pressure distribution within the socket. However, most gait variables were unchanged with the introduction of a thicker liner. Subjects generally found the thicker gel liner more comfortable, which is in agreement with the pressure results. This was particularly true for subjects who had less soft tissue on their residual limb. Therefore, although many gait parameters remained unchanged between liners,

prescribing a thicker gel liner may yield important benefits to some users with a transtibial amputation – particularly those with less anatomical soft tissue to redistribute impact forces.

Understanding Walking, Swaying and Standing of Able-Bodied Persons

Charles C. Wang, M.S.

(This project was funded by the National Institutes of Health (NIH) Grant Number R03-HD050428-01A2. The views here are solely those of the author and do not necessarily represent the official views of the NIH.)

Recent studies have determined an invariant feature of able-bodied walking termed the roll-over shape (ROS), which is the effective rocker shape that the lower limb system conforms to during the stance phase of gait. This curved rocker characteristic may be a useful and simple target for the walking functions of prostheses. However, it is unclear what the shapes look like for swaying and standing, other important activities of daily living. It is possible that a flatter shape contributes to stability during swaying and standing, while a curved shape aids in forward progression during walking. Since falling and fear of falling are issues for many prosthesis users, a better understanding of these effective shapes could improve their stability.



Charles C. Wang, M.S.

We obtained the informed consent of eleven able-bodied subjects and measured their effective rocker shapes and ankle kinematics during walking, swaying, and standing.

We hypothesized that the ankle would adapt to preserve an invariant ROS radius while walking on different rocker shoes. Our results supported this hypothesis. We also hypothesized that the ankle would help to maintain a flatter effective shape during swaying and standing, regardless of rocker shoes. We found that, although ankle kinematics changed, the effective shape curvature during swaying also was significantly changed by the different rocker shoes. More work can be done to discover whether able-bodied persons target other features for balance.

NURERC Presentations at Midwest AAOP

NURERC researchers presented aspects of their work at the 2009 Annual Summer Symposium, the Midwest Chapter of the American Academy of Orthotists and Prosthetists held in Lake Geneva, WI, on June 12-13.

Steven A. Gard, Ph.D., director of NURERC, together with **Mark Geil**, Ph.D. (Associate Professor and director of the Biomechanics program at Georgia State University), and **John W. Michael**, M.Ed., CPO, FISPO, FAAOP (President, CPO Services, Inc.), presented a two-part session on “Evidence Based Practice (EBP): Justifying Patient Care.” The first session defined EBP, identified ways to refine questions, search sources and assess evidence. The second session discussed how to access patient specific literature, critically evaluate evidence, apply information, and write letters of medical necessity.

Stefania Fatone, Ph.D., BPO(Hons), presented “Randomized Cross-over Study of AFO Ankle Components in Adults with Post-stroke Hemiplegia.” Her work assessed the effect of different ankle components on the gait of adults with post-stroke hemiplegia who wore articulated AFOs. She analyzed kinematic and kinetic data that were collected from subjects

walking in four conditions: a baseline shoe only condition; 90 degree plantar flexion stop/free dorsiflexion; plantar flexion limiter/free dorsiflexion; and 90 degree plantar flexion stop/dorsiflexion assist. (This project was funded by VA Merit Review #A3573R.)

Erin Boutwell, M.S., presented “Study of Residual Limb/Prosthetic Socket Compliance in Transtibial Amputees” (See page 6). She collected data from unilateral transtibial amputees who walked and performed a side-to-side loading exercise while wearing one of two commercially available liners: a 3mm liner and a 9mm liner. She analyzed kinematic and kinetic changes between the two liners using displacement of the residual limb within the socket, together with simultaneous force plate data, to estimate compliance within the socket during the loading experiment. (This project was funded by VARR&D-Dev Grant Number A3518R.)

Kathy Waldera, M.S., provided a brief overview of the collaborative project between NURERC and the National AgrAbility Project. She described some problems faced by farmers and ranchers with amputations and invited prosthetic providers in the audience to share their experiences serving farmers and ranchers.

NURERC News

Honors

Stefania Fatone, Ph.D., BPO(Hons), accepted an invitation to chair the 2009 International Society for Prosthetics and Orthotics (ISPO), Australian National Member Society (ANMS), Research Grant Committee. Dr. Fatone served as a reviewer on this committee in 2007.

Presentations

Craig Heckathorne, M.Sc., and **Kathy Waldera**, M.S., conducted an Upper Limb Focus Group in Marion, IN, as part of the NURERC-AgrAbility project on April 3.

Craig W. Heckathorne, M.Sc., was guest lecturer for the Biomedical Engineering (BME) Department course “Rehabilitation Engineering—Prosthetics, Orthotics, Seating & Positioning” at Marquette University (Milwaukee, WI) on March 30. He presented “Myoelectric Control and Electric-powered Upper-limb Prostheses.” NU BME/NUPRL graduate (1991), **Barbara Silver-Thorn**, Ph.D. (Associate Professor, BME and Mechanical Engineering, Marquette University), issued the invitation.

On March 27, Mr. Heckathorne was an invited participant at the **AAOP State of the Science Conference on Upper Limb Prosthetics Outcome Measures** held at the **Rehabilitation Institute of Chicago** where he presented “Research Engineer’s Perspective: Assessment Tools Used in Upper-limb Prosthetics R&D.” This retrospective literature review analyzed 25-years of assessment tools that lacked validated outcome measures and were used in human trials for prosthetic device development.

Mr. Heckathorne also was an invited speaker at the **Illinois AgrAbility Ambassadors Training Program**, where he presented “Assessing and Responding to the Prosthetic Needs of Farmers and Ranchers” in Effingham, IL, on March 11 and in Peoria, IL, on March 12.

Meetings

Stefania Fatone, Ph.D., BPO(Hons), attended a planning committee meeting for the State of the Art Conference sponsored by the Department of Veterans Affairs Office of Research & Development in Washington, D.C., on June 16.

Steven A. Gard, Ph.D., and **Stefania Fatone**, Ph.D., attended the annual National Institute on Disability and Rehabilitation Research (NIDRR) RERC Project Director’s meeting in Arlington, VA, on May 14 and 15.

Visitors

Visitors from the **University of Malaya** (Kuala Lumpur, Malaysia) toured the Jesse Brown VA Motion Analysis Research Laboratory (VACMARL) on April 21. Director of NURERC, **Steven A. Gard**, Ph.D., welcomed the group to the Prosthetics Research Laboratory. **Rebecca Stine**, M.S., discussed VACMARL and its projects.

NUPOC prosthetics and orthotics students toured the laboratory at **NURERC** where they learned about prosthetics engineering research projects conducted in foot-ankle components and the Shape&Roll prosthetic foot for low income countries; upper limb; CAD/CAM fabrication; and the Jesse Brown VA Chicago Motion Analysis Research Laboratory.

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NURERC IN THE NEWS

Dudley S. Childress, Ph.D., is recognized as an inspirational mentor by **Scott B. Elliott**, CP, in a "FACEtoFACE" interview in *O&PEdge*, June 2009:56. Read online the current and archived issues of *O&P Edge* at www.oandp.com/edge.

Brian Ruhe, M.S., and his research are featured in the April 2009 issue of the *VA Research Currents*, edited by **Mitch Mirkin**. Read online the current and archived issues of *VA Research Currents* at: http://www.research.va.gov/resources/pubs/research_currents.cfm.

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