NORTHWESTERN UNIVERSITY

Capabilities

Communicating the Science of Prosthetics and Orthotics

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VA Equipment Grants Spur New Research

The **Department of Veterans Affairs Research and Development** has awarded the acquisition of new equipment to researchers **Joshua Rolock**, Ph.D., and **Andrew Hansen**, Ph.D. Dr. Rolock introduces the **Stratasys 400mc Rapid Prototyping Machine** and the **Inspeck Dual Field 3-D Optical Digitizer**. These instruments will enhance the fabrication of prosthetic sockets and other 3-dimensional items. Drs. Hansen and Garrick introduce the **NeuroCom® Balance Manager® SMART EquiTest® Clinical Research System™** with a static long force plate (18-inch by 60-inch), and 8-channel electromyography (EMG) system that uses surface electrodes. This instrument will yield information about human balance and movement.

The Ins and Outs of the Three-Dimensional World: Two New Systems That Don't Fall Flat

Joshua Rolock, Ph.D.

Funding for large equipment is provided by Veterans Affairs Research and Development under Grant A4511R (Feasibility of a Zero-impingement Socket for Lower Limb Prostheses). The opinions contained in this article are those of the grantee and do not necessarily reflect those of the VA.

Over the years, I have come to learn that when I am introduced as an engineer, rightly or wrongly people will assume that I'm…two-dimensional. While the depths of my personality might not rival those of an artist perhaps, I can say with confidence that at least I do not engage in their sorts of deceptions. You see, artists are a crafty lot; they know just how to manipulate color and hue, darkness and spark to make you think that what you are looking at has depth and dimension. But in my line of work, that simply falls flat.

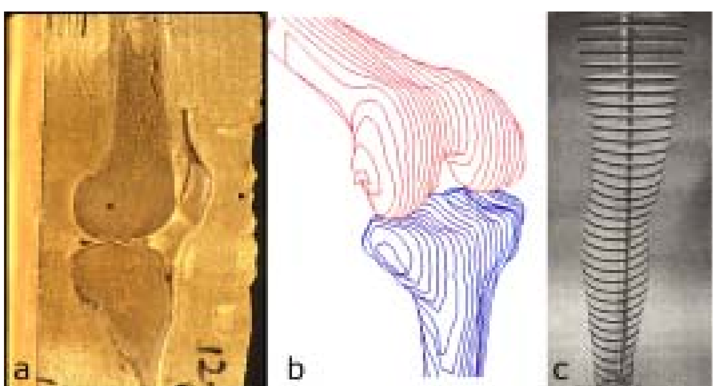

Figure 1: (a) Bones are embedded and sliced as a way to enter 3-D data into the computer. **(b)** Once measured and input, the computer-based model can be displayed, manipulated or analyzed. **(c)** This example for a leg shows how 3-D data can be extracted from the computer data by cutting 2-D sectional wafers and stacking them together.

3-Dimensional Representation

As an engineer I can easily measure a block or a gear; the diameter or the depth of a hole; the angle or the length of a bracket. These sorts of 'regular' geometric shapes are easy to measure, easy to draw, and easy to produce. Trouble arises, though, because I am actually a bio-engineer, and there is nothing 'regular' about bio. Bio is difficult to measure, difficult to draw, and it is difficult to produce its likeness. My particular brand of bio-engineering includes prosthetics, orthotics, orthopaedics and mechanics, and for me shape is quite important. The shape of bones governs the motion of a joint such as the knee or the ankle; the shape of a socket affects the comfort and performance of a prosthesis; and the shape of a prosthetic foot influences the ease and efficiency of walking. Shape is not a two-dimensional quality; it is quite three-dimensional (four-dimensional when it changes over time.)

I have often found that computers can be useful and intriguing tools when applied to orthopaedic engineering. Computers have

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also given me some unique challenges since the data I may wish to input might not lend itself to keyboard entry and the data I may wish to retrieve might not be suitably represented as a printout. Years ago I was involved in a study of knee joint mechanics. One element of the study involved determining the average shape of the bearing surface of the knee and then producing a model of that shape. In order to accomplish this, bones were first embedded in blocks of rigid foam material that allowed us to slice them easily into sections (**Figure 1a**). The sections then were photocopied and the profiles of the bone were carefully traced and measured. These two-dimensional sections were reassembled in the computer to produce a 3-D computer model (**Figure 1b**). Once the average shape was determined, a model could be produced by running the process in reverse: printing out section profiles, cutting wafers of material to match the profiles, and stacking the profiles to get the three-dimensional object (**Figure 1c**).

Figure 2: Composite image of Joshua Rolock, Ph.D., taken from **InSpeck 3D Mega Capturor**. Clockwise from upper right: **(a)** Photographic image (texture map); **(b)** 3-D wireframe with texture map coloration; **(c)** 3-D solid with texture map overlay, **(d)** 3-D solid with Gouraud shading.

Two New Systems

Over the years, things have changed…a lot. Getting three-dimensional data in and out of the computer can now be accomplished using a number of commercially available devices. Thanks to research funding provided by the Department of Veterans Affairs, we now have two new systems in our laboratory: one which allows three-dimensional shapes to be digitized (measured) and one which allows computer representations of 3-D models to be fabricated into physical objects.

The **InSpeck DF 3D Mega Capturor** is an optical system that projects a pattern of stripes onto the surface of an object. When observed by a camera from a different perspective, the stripes appear distorted and an analysis of the distorted patterns is used to calculate the 3-D surface shape. The time required to digitize shapes is only 0.7 seconds, so the device is useful for scanning things like arms, legs, hands, feet, torsos or heads (**Figure 2**).

Figure 3: Joshua Rolock, Ph.D., explains 3-D rapid prototyping using the StrataSys FDM 400.

The **Stratasys FDM 400mc** is a device that utilizes computerized data representing three-dimensional shapes to produce 3-D objects. The production of physical models is analogous to the stacked sections from the leg model in **Figure 1c**, except that fabrication is totally automatic and is accomplished by using a dispensing nozzle to deposit thin layers of liquefied plastic, which quickly hardens into a solid (**Figure 3**).

Future Applications

These two devices will have many applications within our laboratory. One such project is the development of new approaches for sockets and liners for prostheses. In this project, limb digitizing will be used to capture the shape of residual limbs and create three-dimensional computerized models. For socket development, FDM will be used to produce the structural elements of the sockets while for liner development, FDM will be used to produce molds that will enable customized liners to be cast from elastomeric materials. In addition to the VA project, a different study funded by NIDRR will utilize similar procedures to develop production techniques for low-cost cosmetic gloves for upper-limb prostheses.

While I may not have the eye and the talent of an artist, I now have what for an engineer is even more valuable: useful tools for measurement and production. As input and output to my computer, these tools will help us to model, design, understand, and develop new solutions to the challenges of prosthetics and orthotics.

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New VA Chicago Laboratory for the Assessment of Balance (VACLAB)

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

Funding for large equipment is provided by Veterans Affairs Research and Development under Grant A4325R (Clinical Research System with Force Plate and EMG System). The opinions contained in this article are those of the grantee and do not necessarily reflect those of the VA.

Acquisition of a **Neurocom® Balance Manager® SMART EquiTest® Clinical Research System™ (CRS)** with a static long force platform and an 8-channel surface electromyography (EMG) system allows the creation of the **VA Chicago Laboratory for the Assessment of Balance (VACLAB)** located at the **Northwestern University Prosthetics Research Laboratory (NUPRL)** within space leased by the VA. **Andrew Hansen**, Ph.D., Research Health Scientist at Jesse Brown VAMC, will direct the VACLAB where the initial focus will be the examination of standing balance of lower limb prosthesis users.

Committed to the premise that better prosthesis design coupled with balance training will lead to significantly improved balance and quality of life, VACLAB researchers will pursue dual directions: 1) balance studies of persons with lower limb amputations due to both vascular disease and trauma; and 2) the development and testing of prosthetic ankle-foot systems that provide improved function for standing balance without sacrificing a person's mobility.

Balance studies will contribute important knowledge that may help prevent falls among normal walkers and lower limb prosthesis users. Research about falling suggests that training amputees for improved balance confidence may reduce their fear of falling and relate to better mobility and social activity. Miller *et al.* [1] found that among 435 daily users of lower limb prostheses, persons with higher balance confidence values also scored significantly higher on mobility and social activity outcomes. Improved balance confidence correlated with an increase in the mobility and social activity for lower limb prosthesis users, leading to their improved quality of life.

While this outcome is valuable, it is equally important to design better prosthetic feet that contribute to improved balance that enhances balance confidence in lower limb amputees. Improved prosthetic foot design that provides better balance can lead to increased balance confidence among lower limb prosthesis users, thus resulting in their improved mobility, social activity, and quality of life. VACLAB studies will help to distinguish and quantify changes in balance that may be attributable to changes in prosthetic components or to balance training regimens.

According to the National Health Interview Survey [2], approximately 100,000 lower limb amputations (not including toe amputations) were performed during 1996 in the United States of America. According to data from the Vital and Health Statistics National Health Interview Survey [3] approximately 87% or roughly 87,000 lower limb amputations per year are due to diabetes mellitus or other vascular disease. Persons who receive amputations due to vascular disease tend to be older and in the lowest functional levels; therefore, this population may benefit substantially from prosthetic ankle-foot components that provide improvements in balance.

The Centers for Disease Control expects the annual financial toll for accidental falls to reach $54.9 billion by 2020 (See "Accidental Falls," page 4). Statistics about the aging USA population show increasing tendency toward diabetes mellitus, lower limb amputation, and risk of falling. These trends indicate the need for better designed prosthetic feet and detailed research about balance and fall prevention.

The flexibility of the **Neurocom®** system allows many detailed and hypothesis-driven investigations about the standing balance of persons using lower limb prostheses. Researchers can control the CRS software to define specific perturbations to subjects' standing balance by translating or rotating the standing surface and the visual field. Future research projects may utilize the full range of measurements provided by the system. In addition to evaluations of standing balance, this equipment will enable researchers to assess sit-to-stand, walking, and weight shifting tests. Future collaborative projects between the VACLAB and the Department of Physical Therapy and Human Movement Sciences at Northwestern University are under consideration.

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Accidental Falls: A Public Health Epidemic

R. J. Garrick, Ph.D.

Whoops!

A person might fall when walking on any surface: a sudden stumble, slip or lurch and one may crash to the ground. The incidence of accidental falls (AF) increases with old age and its accompanying decline of muscle strength, balance and sensory motor feedback. Falls also are prevalent among persons of any age who use lower limb prostheses. AF exact a heavy toll on individuals and health care systems.

National Epidemic

Statistics about public health epidemics may meet skepticism due to a trend's broader definition, more rigorous reporting or recording. By any measure, AF have emerged as a primary threat to good health. "Each year, unintentional falls in the United States account for more than 16,000 deaths and 1.8 million emergency room visits" [1]. AF resulting in serious injury are age related, occurring more frequently among "older adults," which in this text refers to persons aged >65yo. Falls are the primary cause of injury and accidental death among older adults; as well as the leading cause of injury and the third cause of accidental death among children <14yo [2].

The Rising Cost of Falling

The cost of fall injuries increases with age. According to the **Centers for Disease Control and Prevention (CDC)**, each year one in three older adults falls. In 2000, fatal falls among older adults cost $200 million, while non-fatal falls cost $19 billion. Traumatic brain injury (TBI) caused 78% and internal injuries caused 28% of fall fatalities. Hip fractures were the most frequent non-fatal injury, incurring 44% of direct medical costs. Women fell more frequently than men and their direct medical costs were two to three times higher than men. The sequelae of fracture also include significant indirect costs such as disability, dependence, lost work, and poor balance confidence that may result in self-imposed reduction of mobility, social activity, and reduced quality of life. By 2020, the annual cost of accidental falls in the aging US population is projected to reach $54.9 billion [3].

Falls Are No Accident

Falls are complex events generated by internal and external factors. Many conditions contribute to falls, including arthritis, diabetes, pain, Parkinson's disease, multiple sclerosis (MS), Menière's disease, brain dysfunction from TBI and cerebral vascular accidents (CVA) resulting in motor dysfunction and attention deficit, cognitive impairment, hemiplegic spatial dysfunction, aphasia, cardiovascular disease, and others. Falls may occur after dosage changes in medicine or from pharmacological ototoxicity during chemotherapy. AF also may be related to biomechanical changes due to amputations and use of assistive devices, or due to apparently avoidable environmental risks like uneven or ramped surfaces, water, snow, ice, walkway obstacles, or poor lighting. The phenomenon of AF is complicated further by risky, impulsive and non-compliant human behaviors.

Generally, AF are associated with impairments in 1) vestibular system (balance); 2) musculoskeletal strength; 3) central nervous system (CNS) processing (e.g., somatosensory-motor feedback, coordination and reflexes based on CNS processes that require appropriate and timely motor response to realign the center of gravity (COG) relative to the base of support (BOS)); and 4) vision.

Risk Assessment and Prevention

The USA, as well as Canada, Australia, Europe and Japan, have mobilized vast resources to evaluate risk and prevent AF. Research about AF focuses primarily on older, community-dwelling adults in independent living, assisted living, and nursing homes; older adults who live unassisted in their own homes; hospital residents; and persons with lower limb amputation(s). In the USA, interagency programs have been established by the **CDC, Department of Veterans Affairs (VA), Administration on Aging (AoA), National Institutes of Health (NIH), National Safety Council (NSC)**, and others to reduce injury and death from AF, particularly among older adults.

Results of evidence-based interventions indicate that it is difficult to lower the incidence of AF. The rate of falls among independently living older adults was not reduced, even when individualized education, individualized health and home risk reduction, and supportive human service follow-up were accompanied by physician and therapist education. Slightly better results emerged from evidence-based interventions that emphasized physical exercise to improve strength, balance and mobility: measures of physical function showed significant improvement, but AF were reduced by only 25%. More research is needed to prevent AF.

Balance Studies May Prevent Falls

Data about AF are collected from self-report and subjective assessments of balance. Miller [4] collected self-report data about AF from subjects using the **Activities-specific Balance Confidence (ABC) Scale**, a subjective measure that evaluates balance confidence in **Activities of Daily Living (ADL)**. ABC has been used to evaluate AF in both amputee and non-amputee subjects. Analyses examined balance confidence, age, gender, cause of amputation, e.g., dysvascular or traumatic. Other balance confidence measures include the **Falls Efficiency Scale (FES), the Sensory Organization Test (SOT)**, and the **Dizziness**

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Thomas Karolewski Selected Director of Prosthetics Education

R. J. Garrick, Ph.D.

Thomas Karolewski, CP, FAAOP, has been selected Director of **Prosthetics Education** at the **Northwestern University Prosthetics Orthotics Center (NUPOC)**. A participant in NUPOC’s growth during the successful introduction of distance learning (See *Capabilities* 14(4) 2006), Mr. Karolewski expressed his enthusiasm and determination to develop the future Master’s of Science in Prosthetics and Orthotics (MSPO) program, *“My goals are to maintain the tradition of excellence here at NUPOC while we build a new future through the MSPO.”*

Thomas Karolewski

Mr. Karolewski is a Clinical Instructor in the Department of Physical Medicine and Rehabilitation of Northwestern University’s Feinberg School of Medicine and a consulting prosthetist for the Rehabilitation Institute of Chicago. He teaches two on-line classes and an on-campus prosthetics practicum. In addition to daily on-site duties, Mr. Karolewski works with off-campus prosthetics students who are enrolled in the distance learning program. Enthusiastic and approachable, he conducts community education and outreach for NUPOC. Recently, **Elmhurst College** invited him to represent the field of prosthetics and orthotics at **Career Expo 2008** (November 11).

During NUPOC’s on-site prosthetics practicum, Mr. Karolewski gives individual attention to every student. He visits each workbench, swiftly appraises the details of each plaster model, and explains how the student should reduce or build up areas to fit a residual limb. When a student’s best effort falls short, Mr. Karolewski deftly reshapes a plaster cast, simultaneously explaining how the modifications will improve prosthetic fit.

Mr. Karolewski’s thoroughness and good humor when correcting and improving his students’ work promote learning and elicit positive responses. Recent student evaluations concur that Mr. Karolewski effectively addressed the course objectives and was readily available to help students by appointment, phone, email and/or instant message: “*He came in early or stayed late to help the students excel at their studies and projects.*” “*He really loves teaching and it shows*.” “*He is a truly gifted teacher with great passion for teaching.*”

A seasoned and committed educator, Mr. Karolewski was honored by the **American Academy of Orthotists and Prosthetists (AAOP)** with the **Outstanding Educator Award (2005)**. This award recognized his teaching and laboratory skills, as well as his ability to guide and mentor students. The award is granted to an AAOP member who teaches at a **National Commission on Orthotic and Prosthetic Education (NCOPE)** accredited educational program.

Mr. Karolewski is a member of many professional associations, including the Illinois Society of Prosthetists and Orthotists, the **International Society of Prosthetics and Orthotics (ISPO)**, and the AAOP. He served as President of the Midwest Chapter (1998) of the AAOP, was named a Fellow of the national AAOP in 2002, and is a member of the self-study committee for NCOPE. He obtained his bachelor’s degree with emphases in Physical Education, Special Education, Adapted Physical Education, and Kinesiotherapy. He is a Licensed and Certified Prosthetist in the State of Illinois, and a Licensed Educator in the State of Illinois with a current Type 10 Teacher’s Certificate. While fulfilling his duties as Director of Prosthetics Education at NUPOC, Mr. Karolewski is pursuing a master’s degree in education at Concordia University.

Continued from page 4

Handicap Inventory (DHI). Pavol and Pai [5] perturbed balance to produce AF in both younger and older adult subjects. Subjects who fell showed lower stability and lower hip height at first step touchdown. Researchers at **VACLAB** will use the **NeuroCom®** to examine **Limits of Stability (LOS)**, another standardized measurement, to analyze the functional base of support and its role in AF.

References

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2.National SAFE KIDS Campaign (NSKC). Falls Fact Sheet. Washington (DC): NSKC, 2004.

3. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, Division of Unintentional Injury, Falls Fact Sheets, Atlanta, GA.

4. Miller, W. Standing strong. *Rehab management The Interdisciplinary Journal of Rehabilitation*, August/September 2003. Available at http://www.rehabpub.com/features/892003/5.asp

5. Pavol, M and Pai, Y. Deficient limb support is a major contributor to age differences in falling. *Journal of Biomechanics*, 40:1318-1325, 2007.

On-line Resources for Falls Prevention

http://www.stopfalls.org/resources/index.shtml
http://www.profane.eu.org/
http://www.cdc.gov/ncipc/factsheets/adultfalls.htm

Pinata Sessoms, Ph.D., Defends Dissertation

Pinata Hungspreugs Sessoms, Ph.D., successfully defended her doctoral dissertation (*Step by Step: A Study of Step Length in Able-bodied Persons, Race Walkers, and Persons with Amputation*) on November 11. Dr. Sessoms measured step length and modulations of step length while walking, such as increasing hip flexion and extension, increasing ankle-foot rollover arc length, increasing stance foot heel rise to further extend the trailing limb, and increasing pelvic rotation. She collected temporospatial and kinematic data, ankle-foot roll over shapes and **Segment Contributions to Step Length (SCSL)** during gait analyses on able-bodied persons, race walkers, persons with bilateral transtibial amputation, and persons with partial foot amputation.

Pinata Sessoms, Ph.D.

She introduced SCSL as a tool to analyze step length contributions and compare the differences in segment contributions between subject groups. SCSL examines how each of the lower limb segments contributes to the overall step length and how these contributions vary for different walking conditions (e.g. different speeds or prosthetic devices).

Dr. Sessoms' results showed that able-bodied walkers maintained a constant percent contribution of lower limb segments over a range of step lengths. Persons with normal effective foot lengths (e.g. intact feet) used the ankle-foot segment to modulate step length, while those with shorter effective foot lengths displayed higher percent contributions from other lower limb segments. The shank and thigh segments represented the largest contributions for all subjects; however, differences existed in contribution by the trailing and leading limb between subject groups. Identifying differences in segment contributions of persons with gait pathology can help determine training or treatment that improves gait.

Liz Klodd, M.S., Defends Master's Thesis

Liz Klodd, M.S., successfully defended her master's thesis (*The Effects of Prosthetic Foot Roll-Over Shape Radius on Gait of Unilateral Transtibial Prosthesis Users*) on December 4. Ms. Klodd used the Shape&Roll Prosthetic Foot (SRPF) to determine the effects of different roll-over shape radii on gait and oxygen cost of ten unilateral transtibial prosthesis users. Each subject walked overground with each of five experimental prosthetic feet having roll-over shape radii designed to be approximately 15%, 25%, 35%, 45% and 55% of their anthropometric leg length.

Liz Klodd, M.S.

Subjects' ankle flexion moments increased as roll-over shape radius increased, probably due to the greater moment arm about the ankle joint when walking with feet having larger roll-over shape radii. All subjects had an increase in prosthetic ankle range of motion with decreasing roll-over shape radius; and an increase in the effective foot length ratio with increasing radius. No differences were found in cadence, step length, or vertical displacement of the body center of mass. During treadmill walking, no significant difference was found in oxygen cost among the different feet.

Some parameters of gait were changed by roll-over shape radius, but these changes were not significant enough to change the prosthesis users' oxygen cost. Further research is needed to determine the effects of roll-over shape radius on oxygen cost during overground walking.

NURERC NEWS

Meetings

Stefania Fatone, Ph.D., BPO(Hons), attended a meeting of the **Orthotics and Prosthetics Outcomes Initiative Steering Committee**, held in Chicago, IL, on September 10, 2008. On October 17-18, she attended a one day course hosted by the **American Academy of Orthotists and Prosthetists (AAOP)** on "Designing Single-Subject Research Studies in P&O," which emphasized how to design and conduct single-subject research. On November 6-7, 2008, Dr. Fatone participated in an **NIH** review panel (Special Emphasis Panel/Scientific Review Group ZRG1 MOSS-F(15)) in Seattle, WA.

As part of NURERC's collaborative project with **AgrAbility**, **Craig Heckathorne**, M.Sc., and **Kathy Waldera**, M.S., Research Engineers, attended the annual **National AgrAbility Workshop** in Wichita, KS, from November 10 through 13, 2008. They presented **"Options in Upper and Lower Limb Prosthetics: Where Are We and What Needs To Be Done?"** Also, they discussed device failure with farmers who use a prosthesis. Other program topics included trends in disability and rehabilitation; assistive technology for agricultural settings; service strategies for farmers with disabilities; and information about AgrAbility projects.

In the Media

The article "NIDRR Grant Funds Five-year RERC for P&O at NUPRL & RERP" appeared in the Northwestern University Feinberg School of Medicine's *FSM Research Newsletter* (October, page 4).

Liz Klodd Attends SWE Meeting

Liz Klodd attended the 2008 Annual Conference of the **Society of Women Engineers (SWE)** on November 6-8 in Baltimore, MD. SWE was founded in 1950 as a not-for-profit educational and service organization that promotes engineering as a career for women. SWE supports education, career development, leadership skills and professional networking for women engineers.

The 2008 SWE conference theme, *Women Leading a Technical Revolution*, featured seminars about professional development. Ms. Klodd attended ten workshops, including *Strategies for Innovation, A Closer Look at Medical Devices*, and *Medical Device Regulation in a Global Market*. Ms. Klodd noted, "My favorite presentation was the seminar on *The Power of Passion: Taking the Road Less Traveled*. Two women engineers who work in industry explained their participation in the design and development of deep brain stimulation (DBS), a new and effective treatment for severe Parkinson's disease. They also discussed how a passion for one's career can lead to greater success."

NURERC supports local SWE efforts by participating in the Annual Career Day for Girls that is hosted jointly by SWE and Northwestern University **Robert R. McCormick School of Engineering and Applied Science**, where NUPRL laboratory staff present NURERC's P&O research projects to high school girls who are interested in engineering as a career.

Education and Dissemination Activities

Approximately 45 advanced placement science, anatomy and physiology students and 3 teachers from **Crystal Lake South High School** (CLSHS) visited the laboratory for a didactic tour of research facilities and projects on December 2. **Steven A. Gard**, Ph.D., Director of NURERC, welcomed the group and explained the scope of NURERC's prosthetics and orthotics research projects.

Students rotated among five work stations where **Craig Heckathorne**, M.Sc., discussed upper limb prosthetics; **Liz Klodd**, M.S., presented the Shape&Roll Prosthetic foot; **Kerice Tucker**, M.S., discussed CAD/CAM fabrications; **Chris Robinson**, CO, MBA, ATC, spoke about careers in prosthetics and orthotics; and **Stefania Fatone**, Ph.D., **Rebecca Stine**, M.S., and **Brian Ruhe**, M.S., discussed gait and motion analysis.

Steven A . Gard, Ph.D. (left) explains rehabilitation engineering and its application to prosthetics and orthotics research. CLSHS science teacher **Rich Marrano** (right) listens.

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Inside This Issue:

Brian Ruhe Introduces Biomechanics to Students

R. J. Garrick, Ph.D.

As part of NURERC's mission to educate the public about prosthetics and orthotics research, on November 21, **Brian Ruhe**, M.S., introduced the biomechanics of walking with prostheses to students from **Frances Xavier Warde School** (Chicago) and their 8th grade teacher, Ms. **Katie Huston**. Wearing casual shorts that allowed students to study his prosthetic legs, Mr. Ruhe explained that he decided to work in rehabilitation engineering and lower limb prosthetics partly because he has bilateral amputations. He encouraged students to examine hands-on models of prosthetic knees, feet and sockets while he explained biomechanical principles. Mr. Ruhe referred to daily objects, such as the hydraulic mechanism on heavy doors, to explain how some prosthetic knees work during flexion and extension.

Brian Ruhe, M.S., explains the biomechanics of walking.

Students responded to Mr. Ruhe's candid and informative manner by unreservedly asking questions such as, *"Can you walk up steps?"* and *"Does it hurt to walk with prostheses?"* In answer to the query, *"Can you play sports?"* Mr. Ruhe related his experience playing on the USA sledge ice hockey team during the winning game at the 2002 Salt Lake City Paralympics (See *Capabilities* 15(3)5:2007). Students enjoyed seeing a video of Mr. Ruhe and his team competing against Norway to win the event. They passed around his gold medal, surprised by its weight and luster.

Ms. Huston remarked, *"Mr. Ruhe really helped the students connect familiar scientific principles with new information about prosthetics and engineering."*