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Capabilities

Communicating the Science of Prosthetics and Orthotics

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Design and Development of Appropriate Technology for Low-Income Countries:

Preliminary Field Investigation of the Shape & Roll Prosthetic Foot in El Salvador, Central America

Evaluating patients was the first step Margrit-R. Meier took as she and Michel Sam began a fitting.

By Margrit-R. Meier, Ph.D., C.P.O. (Switzerland)

Background

The World Health Organization (WHO) estimated in 1990 that approximately 0.5% of low-income countries' populations are in need of assistive devices, primarily prosthetic/orthotic devices or wheelchairs. These countries are confronted in particular with a high rate of amputations caused mainly by land mine explosions.

In 1999, the International Committee of the Red Cross (ICRC) fitted in its own centers a total of 14,346 prostheses. From these prosthetic fittings, 7833 persons (54.6%) were newly registered amputees (ICRC, 1999). Most of the injured were children or young adults requiring multiple prosthetic replacements over their remaining lifetime. On average, a prosthesis for a child has to be replaced every six months, while for an adult every three to five years (ICRC, 1998). Therefore, low-income countries require a large quantity of prosthetic components in order to satisfy their demand. However, importing components from industrialized countries is expensive and in most cases not affordable on a larger scale. Furthermore, these components, designed for the lifestyle of industrialized nations, do not necessarily meet the physical and environmental demands of a rural existence.

Disadvantaged countries must not only contend with a large number of amputated citizens, but they also have an almost chronic lack of educated personnel to provide the needed services (ISPO/WHO, 1999; O'Toole and McConkey, 1998; Perraton 2000). In 1990, the WHO estimated the number of adequately trained personnel in the orthopedic sector to be less than 2,000. Based on the assumption that the combined population of Africa, Asia and Latin America represented 4 billion persons in the year 2000, approximately 20,000 trained personnel would be required in order to have one person available for each 1000 persons in need of orthopedic devices (WHO 1990). That is, at least 18,000 additional persons would be needed to provide a ratio of one trained person for each 1,000 individuals in need of services.

The International Society of Prosthetics and Orthotics (ISPO) lists seven recognized prosthetic schools in low-income countries, each of which graduate 15 students every year on average. This results in a total of 105 persons gradu-

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ating in prosthetics and orthotics per year for all low-income countries. Even if the number of trainees were to double per year to 210, it would still take several generations to reach the required number of trained prosthetic/orthotic personnel.

Design and Development

The "Shape&Roll" prosthetic foot was developed in cooperation with the Center for International Rehabilitation (CIR), Chicago, the National Institute on Disability and Rehabilitation Research-Rehabilitation Engineering Research Center (NIDRR-RERC) for Improved Technology Access for Land Mine Survivors. The "Shape&Roll" foot incorporates biomechanical principles of the unimpaired physiological foot. Based upon preliminary results obtained during clinical testing in Chicago, it is believed that this foot provides the amputee with higher functionality than the available feet produced currently in the disadvantaged countries. In addition, its simple design allows for easy production even by personnel not necessarily trained in the prosthetics field. In other words, the "Shape&Roll" prosthetic foot combines high function with simple fabrication techniques.

Although this prosthetic foot has been developed with a focus on low-income countries, subtle nuances of the prosthetic design may have been missed. We were therefore seeking the opportunity to conduct a preliminary field investigation in a low-income country. We felt a field investigation would provide us with feedback and might help us to fine-tune the design of the "Shape&Roll" prosthetic foot (e.g. splitting the big toe from the rest of the toes). Together with CIR it was decided to preliminary field test the "Shape&Roll" prosthetic foot in El Salvador, the logistic headquarters of CIR's Central American region that includes the countries Guatemala, El Salvador, Nicaragua and Honduras.

Final Destination:
San Salvador, El Salvador Central America

In El Salvador CIR collaborates with FUNTER (Fundación Teletón Pro-Rehabilitación), a large rehabilitation center in El Salvador's capital San Salvador. FUNTER is a well-equipped outpatient medical rehabilitation center that offers a wide range of medical and social rehabilitation services mainly to persons without economic resources. FUNTER kindly agreed to give the CIR representatives access to their patient population for recruitment of interested participants. In order to be included in the study, the potential participants were expected to meet the following inclusion criteria:

- Age between 18 and 60 years;
- Unilateral transtibial amputation without serious complications that interfere with her or his walking ability;
- Six or more months experience with a definitive prosthesis;
- Able to walk unassisted at a comfortable speed without undue fatigue and without health risk.

Potential participants demonstrating partial paralysis due to stroke or traumatic injuries were excluded from the study. With the information gathered by the CIR representatives at FUNTER we were able to start production of feet in our laboratory for the planned field evaluation. Michel Sam, M.S., a research engineer in our laboratory, was in charge of producing a total of 22 "Shape&Roll" prosthetic feet, all custom hand-made and specifically designed for a particular participant. Twenty-two people would be the lowest participation number required in order to receive appropriate statistical power for the field investigation.

The experimental protocol was structured as follows: All participants, who were accepted and gave written agreement to take part in this field investigation, were requested to come to FUNTER for three different sessions:

1) **First session – Duplication of prosthetic socket:** During the first session a duplication of their current pros-

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Reflections of the 2002 NIDRR Scholar:
Applying Research in Clinical Practice

By Allison Boynton, CP

Allison studied new stance control orthotic knee joints, which she has used here to fabricate a KAFO (knee ankle foot orthosis). The new design may enable users to walk with less fatigue.

As a certified prosthetist and recent graduate of the certificate program in orthotics at Northwestern University's Prosthetic and Orthotic Center (NUPOC), I have been an active member of the P&O community for over five years. Being born with a forearm deficiency, and wearing a below elbow prosthesis on my left arm for over 26 years, I have been a consumer of prosthetics my entire life.

Despite all of this experience with P&O, I never really understood or appreciated how advancements were made in the field or how to objectively evaluate the devices that I fit to my clients until I became a National Institute on Disabilities and Rehabilitation Research (NIDRR) Scholar at the Northwestern University Prosthetic Research Laboratory (NUPRL) and Rehabilitation Engineering Research Program (RERP).

I initially became interested in P&O when I was ten years old and my prosthetist took me into the laboratory where my prostheses were fabricated. Over the years, I was fascinated with the technology that he introduced me to as he fit me with body powered hooks, myoelectric hands, and specialized devices to help me perform all of the activities that I pursued including cross country skiing, ballet, and rowing on the crew team.

After college I received my certificate in prosthetics from the Newington Certificate Program and fulfilled my residency requirements at their clinical facilities. The next year, my former prosthetist, the gentleman who introduced me to the field fifteen years prior, offered me a job and the opportunity to learn from him. Over time, he encouraged me to continue my studies and to pursue my certificate in orthotics; this led me to Chicago and NUPOC. As an orthotic student I took a research methods class, which Dr. Steven Gard from NUPRL and RERP instructed. When the call for candidates for the NIDRR Scholar program was released, he brought it to my attention and then advocated for me to receive the position. Upon receiving my certificate in orthotics, I began my summer internship as a NIDRR Scholar.

Throughout my three months at NUPRL and RERP, I have participated in various professional events. The first was the State of the Science Symposium, where an interdisciplinary team of prominent researchers, clinicians, physicians, and engineers involved in the field of P&O convened for two days to discuss what is currently being done in the field and to form goals for the future.

I also attended the Mid-West Chapter meeting of the American Academy of Orthotists and Prosthetists in Milwaukee, where new stance control orthotic knee joints were highlighted. These knee joints became the subject of my NIDRR research project. In June I attended the annual RESNA (Rehabilitation Engineering Society of North America) meeting in Minneapolis, where I learned about Universal Design, seating systems and many non-orthotic/prosthetic devices used by individuals with disabilities to assist in performing their everyday activities.

Back in Chicago, I worked daily with Stefania Fatone, PhD, P/O (Australia) learning the intricacies of rehabilitation research, motion analysis and the science of orthotics. Together, with the guidance of John Michael, a CPO who consults for Horton Technology, Inc. and trains orthotists to fit and fabricate Knee Ankle Foot Orthoses (KAFOs) incor-

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Reflections of a NIDRR Scholar

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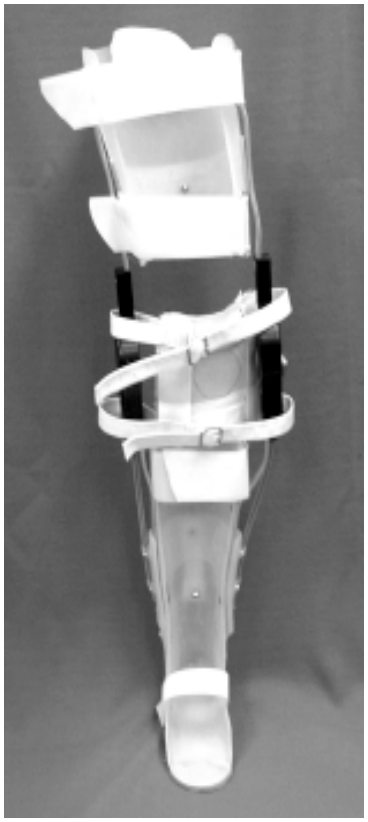
porating the Horton Stance Control Orthotic Knee Joint (SCOKJ), we fabricated and fit two KAFOs utilizing these new joints. The effect on the function of these joints was of interest to us because they are the first orthotic knee joints to reliably provide stability during stance and allow flexion for swing. In other words, they will not bend when weight is applied to them, so they are very stable, yet they flex freely during swing to allow a more natural gait pattern. We fabricated a KAFO incorporating the Horton SCOKJ initially for an able-bodied subject, and then for a person who had polio as a child and who currently walks with a locked-knee KAFO.

The first KAFO Allison made was used with a subject with no paralysis or gait limitations and was used as an initial gait analysis.



This frontal view shows a test Knee/Ankle/ Foot Orthosis made for a subject who has previously used traditional KAFOs with locking knee joints.

Preliminary data from the Veterans Affairs Chicago Motion Analysis Research Laboratory (VACMRL) indicates that these knee joints allow their wearers to walk faster and with less compensatory motions than are seen with the traditional locked orthotic knee joints that are normally given to people who wear KAFOs to compensate for weak knee extensor muscles. These knee joints appear to decrease the energy wearers must expend when walking so they can walk at faster speeds, over farther distances, and yet feel less tired.

Now that my internship as a NIDRR Scholar is over, I plan to work as a prosthetist/orthotist at a clinical facility in South Carolina. I will use the skills and knowledge that I have gained at NUPRL and RERP to be a more critical consumer of P&O research and to better assess the function and fit of the devices that I provide with the tools that are available to me. I have also come to appreciate the importance of research in the field of P&O.

Few clinicians today find the time or resources to advance the profession. In doing so, we restrict the quality of care that we provide and limit technological and scientific advancements made each year. I have learned that as a clinician and prosthetic wearer, my input into research is important whether I decide to pursue the research independently or assist with projects in a research laboratory like that at Northwestern.

In the months to come I hope to stay in touch with Drs. Gard and Fatone to continue analyzing and reporting data from our KAFO pilot study. With so few facilities dedicated to P&O research, it is rare that prosthetists and orthotists have the opportunity to learn about them or pursue research with them. I am very fortunate to have had the opportunity to spend three months at Northwestern and I appreciate all of the time, generosity and kindness that everyone there has shown me. ❖

OPUS: Orthotics and Prosthetics Users' Survey Outcome Measures of O&P Services

"If you can not measure it, you can not improve it."

Lord Kelvin

By Camille M. O'Reilly, RN
Rehabilitation Services Evaluation Unit (RSEU)
Rehabilitation Institute of Chicago

Since October, 1998 the Rehabilitation Institute of Chicago's (RIC) Center for Rehabilitation Outcomes Research (CROR) has been creating a comprehensive set of evaluation instruments designed to measure outcomes specific to orthotics and prosthetics users. Without the help of a number of collaborators the Orthotics and Prosthetics Users' Survey, otherwise known as OPUS, would have been impossible. The instruments developed thus far include: 1) Lower Extremity Functional Status, 2) Upper Extremity Functional Status, 3) Health Related Quality of Life, and 4) Follow-up Evaluation of Clinic Services. Forms have also been developed to collect initial and ongoing patient assessment information such as health history and etiology of impairment, use of assistive devices, observational gait analysis, and clinicians' goals and treatment plans.

OPUS is being funded by a National Institute of Disability and Rehabilitation Research (NIDRR) Engineering and Research Center (RERC) grant in Prosthetics and Orthotics headed by Dudley S. Childress, Ph.D. of Northwestern University. Over the past four years RSEU researchers have worked closely with a number of orthotics and prosthetics service providers: Shriners Childrens Hospital in Chicago, POINT Health Care Centers of America, University of Michigan, Wascana Rehabilitation Centre, Regina, Saskatchewan, Amputee Services of America, Denver Colorado, and the Rehabilitation Institute of Chicago. This collaborative effort has greatly facilitated the development of valid and reliable instruments for use with both adult and pediatric patients who use either a prosthesis or an orthosis.

The core OPUS instruments are designed to evaluate patients' self-report of function, quality of life, and service and device satisfaction. In developing these instruments we have utilized Rating Scale Analysis (RSA) to assist in designing instruments that contain a collection of items spanning a sufficiently wide range of difficulty levels so as to discern improvements in the various domains, presumably due to interventions such as an orthosis or gait training.

The Lower Extremity Functional Status is a 21-item instrument that measures a subject's ability to perform a variety of lower extremity activities. The instrument asks the patient to rate the ease with which they can perform certain activities. The easiest items are: get on and off toilet, get up from a chair, and walk in-doors while the most difficult items are: walk up to two hours and run one block. Patients indicate one of six response categories to rate their level of ease: NA - not applicable; 1 - very easy/perform independently; 2 - easy/need very little or no assistance; 3 - slightly difficult/need some assistance; 4 - very difficult/need a lot of assistance; 5 - cannot perform the activity.

The Upper Extremity Functional Status is a 23-item instrument designed to measure a subject's ability to perform both one-handed and two-handed activities and uses the same six response categories as the Lower Extremity Functional Status. Because of the limited number of subjects with upper extremity impairments recruited thus far, information regarding the hierarchy of items is not reportable at this time. Further testing of the instrument is planned.

The Health Related Quality of Life is a 23-item instrument modeled after the SF-36 but also contains items geared to highlight possible depression, post-traumatic stress disorder, or other adjustment problems. The instrument uses two, five-level response categories: a frequency scale and an extent of agreement scale. The easiest items are how often during the past week have you been happy and how often during the past week have you felt calm and peaceful. The

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OPUS Measures Outcomes

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most difficult items are how often during the past week did you feel worn out *and* how often during the past week did you feel tired.

The Follow-up Evaluation of Clinic Services was inspired by the Prosthesis Evaluation Questionnaire (PEQ) and is composed of two instruments: a measure of satisfaction with the device and a measure of satisfaction with services. The device measure consists of 9 statements regarding things such as the comfort, durability, and appearance of the device and are rated according to 4 "extent of agreement" response categories. Two additional statements relate to the affordability of the device and are included for both health care policy and clinical reasons. The items easiest to assess are: " the weight of my prosthesis (or orthosis) is manageable and my prosthesis (or orthosis) is durable." and, "the most difficult items to assess are my skin is free of abrasions and irritations and my prosthesis (or orthosis) is pain free to wear."

The service measure consists of 10 statements about such things as courtesy, timeliness, and perceived inclusion in the treatment plan. The statements are also rated using 4 "extent of agreement" response categories. The items easiest to assess are: "I was shown the proper level of courtesy and respect by the staff" and "I received an appointment with a prosthetist/orthotist within a reasonable amount of time". The items most difficult to assess are: "I was a partner in decision-making with clinic staff regarding my care and equipment" and "The prosthetist/orthotist discussed problems I might encounter with my equipment".

Currently work is underway to assess each of the instruments' sensitivity to change over time and to evaluate their validity and reliability across different impairment groups. These issues are important since the OPUS instruments are intended to be used in program evaluation processes or to guide quality improvement initiatives. They could also serve as clinical outcome measures often required as part of accreditation processes. Additionally, aggregating this type of clinical outcomes data from a number of O&P providers could lay the necessary groundwork for developing clinical pathways and standards of care. ❖

To participate in evaluations or for further information regarding this project please contact Allen Heinemann, Ph.D. at Rehabilitation Institute of Chicago Center for Rehabilitation Outcomes Research, 345 E. Superior Street, Chicago, Illinois 60611-4496 or by e-mail at: a-heinemann@northwestern.edu.

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thetic socket was fabricated to minimize possible influences on their walking pattern due to a different prosthetic socket style. They also completed the first questionnaire regarding their walking abilities with their current prosthesis.

2) Second session—Gait measurement evaluation: During the second session the first gait evaluation of the participants were performed. We took the DURS (Direct Ultrasound Ranging System) with us in order to be able to quantify walking performance. The DURS was developed in our laboratory and consists of a transponder worn by the subject

Michel Sam with the DURS unit developed at NUPRL. The DURS features made it ideal for Dr. Meier to quickly assess gait characteristics.

at the approximate level of the body center of mass, a base unit infrared emitter/ultrasound receiver and a laptop computer. It measures the instantaneous horizontal velocity profile in the plane of progression. Using this profile other parameters of an individual's gait can be determined such as average walking speed, step lengths, step times, numbers of steps, cadence, average step length and overall step time. For further details, please refer to *Capabilities* publications of Weir (1997) and Weir and Gaebler-Spira (2000). The DURS with its compact, portable and easy to set-up features was for me the ideal measuring companion and its presence was much appreciated. It enabled us to assess gait characteristics in an easy and time-effective manner. We measured the participants' walking performance at three different walk-

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ing speeds: (1) at their normal, comfortable walking speed, (2) walking as slow as possible without losing balance, and (3) walking as fast as possible without running. A minimum of three trials was conducted. The participants were tested first with their current prosthesis in order to receive a baseline measurement to which we compared the walking performance with the "Shape&Roll" foot. Thereafter, they switched to their test prosthesis with its "Shape&Roll" prosthetic foot. The same gait evaluation as described previously was conducted. After the completion of this entire second evaluation session, the participants were asked to wear their test prosthesis exclusively for a three-week evaluation. Their every-day prosthesis was given to them as a safety precaution so that in case of unforeseen difficulties they would be able to switch back.

A January 2001 earthquake damaged the main FUNTER building. This was the temporary work shop.

3) Third session—Last gait evaluation after the three-week trial: For this session, Michel Sam and I traveled a second time to San Salvador—this time however only for a few days—in order to complete our investigation. Following the three-week trial with the test prosthesis, the participants came back to FUNTER for their final gait analysis. Again DURS measurements were taken, involving trials at different walking speeds in the same way as during the first walking evaluation. The participants were also requested to fill out the second questionnaire regarding their motor ability with the "Shape&Roll" foot. This second questionnaire was constructed in two parts: Part 1 was the same as the first questionnaire, enabling us to have direct comparison with the performance of the SACH-like foot (SACH = Solid-Ankle-Cushioned-Heel); Part 2 included questions that were specifically directed to the "Shape&Roll" foot.

Because the "Shape&Roll" foot is still under development and evaluation, the participants were asked to return the test prosthesis at the end of the entire investigation.

From Our Diary

On Sunday April 28, 2002, Michel Sam and I stepped onto the airplane that carried us not only to a new destination, but also to a new world altogether. In our luggage where the neatly prepared 22 prosthetic feet, some tools, lab coats, the laptop computer, the DURS and the files for the participants containing the IRB approved consent forms and questionnaires, all written in Spanish, as well as the anthroprometric and sociodemographic information sent by the CIR representatives. We were ready for the first part of our field investigation: a four-week stay in San Salvador.

Upon our arrival at late evening the warm and very humid air reminded us that we had definitively entered the tropical zone. We passed a friendly immigration officer and entered the luggage pick-up hall. Michel's luggage arrived quickly, mine a little bit later and then—the carousel was empty and our most important piece, the special suitcase with all our feet and tools, did not appear.

Here we stood in the now totally empty luggage hall deciding on the next step. It seemed to me that they were going to close the airport for the night. No officer could be seen anywhere. But then, from one of the offices, an airport official came towards us and asked if we were missing anything. Due to my knowledge of Italian, which was a little rusty, I understood about 30%. Michel was much more successful by linking French and Spanish together. From now on he was my "translator" of those conversation parts I did not understand and it worked out brilliantly!

The airport official did not speak one word of English, nor did the second person that came to his assistance. But they were very nice and we laughed a lot together while trying to find out what each of us was saying. They tried to locate our luggage, first in the luggage-unloading zone to verify if everything has been unloaded and thereafter in the neighboring country Guatemala, where the plane had a stop over. Unfortunately, the suitcase could not be located. Hence all necessary information including photocopies of our luggage tags where taken and we were assured that the suitcase would follow in two days. Later we were informed that this was a common response to indicate that it may take a while, either a day or two days or a week or more…

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But at this evening, we were happy with the response and service received, took the rest of our luggage and stepped out of the airport into a pitch-dark night. There were no streetlights at all and the only light came from a few orange light bulbs placed high up on the ceiling of the outdoor cover that stretched over a small entrance place. The airport seemed abandoned and we steered towards the only taxi left that stood at the side curb. Out of the dark came a man with his cell-phone glued to his ear. He was waving: it was the CIR representative Fred Navarrete waiting patiently for us! At this very moment when we were stepping out of the airport hall

The waiting area for people who will be fitted with prosthetics was also temporary as a result of damages by the earthquake in 2001.

he was on his cell-phone double-checking once more with the CIR representative from Chicago, Hector Casanova, to make sure that he had not missed us. We appreciated his patience and kind welcome very much. It turned out that the airport was located roughly one hour from the capital, San Salvador. We drove into the night towards San Salvador, over a rocky street and accompanied by a warm gentle breeze filled with all kind of new animal sounds.

The next morning, after a breakfast that included fresh European-style bread, cheese, sweet tropical fruits and a delicious freshly squeezed papaya-jus, we started our first day at FUNTER. Fred Navarrete picked us up and we arrived a little bit before eight o'clock at our new workplace. Upon arrival the first group of interested participants were already sitting in lines and waiting for our introduction. I was impressed and felt sorry at the same time because we were not quite ready yet as we had to go and introduce ourselves first to the staff. Wherever we went we received a warm welcome and after the quick tour through our new workplace, we stood in front of the patient row, accompanied by the second CIR representative Cecilia Novoa. She was our main translator and stood with Fred at our sides whenever we needed assistance. The investigation to be conducted generated a lot of questions that were addressed before participant enrollment started. Enrollment, participant evaluation and copying of the prosthetic sockets went smoothly and at late afternoon Michel and I started with the first production step of the test prosthesis.

Results

In total, 14 participants agreed to take part in our study; one person did not show up for the first gait analysis session and a second person did not take part in the final gait evaluation leaving us with 12 participants who completed the study. Table 1 (next page) shows some of the basic characteristics of the participants: We had a nice age distribution with a median age of 30 years, a minimum of 19 years and a maximum of 56 years, a younger population than generally seen in the industrialized countries. Fifty percent of the participants lost their leg due to a traffic accident; roughly one third of the remaining participant lost their leg due to explosions caused by gunshots, land mines or explosion fragments. Only two participants (~16 %) lost their legs due to a disease or an infection. This is a very different picture from what I am used to when dealing with persons who lost a leg in Switzerland, Scotland or the U.S.A. In industrialized countries the majority of amputations occur as a result of a disease not as a result of traumatic incidence. Most of the participants' residual limb length were short to very short; all of them were in good overall health with relaxed muscles capable of producing full strength and a pain-free, well-nurtured skin. The every-day prosthesis of all the participants were equipped with a SACH-like foot that in most cases had been produced by FUNTER.

According to the responses received from our questionnaires, the "Shape&Roll" prosthetic foot improved the participants walking distance: With the "Shape&Roll" foot 42% of the participants were now able to walk more than 1 ½ miles. Twenty-five percent were even able to walk more than 3 miles, a result that was not achieved when wearing the SACH-like foot.

The "Shape&Roll" prosthetic foot seemed not to have affected the participants' confidence despite the fact that it

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is a quite different foot when compared to the SACH-like foot: None of the participants claimed that they had to pay special attention while walking indoors or outdoors with the "Shape&Roll" foot. Regarding walking ability without taking a rest, the "Shape&Roll" prosthetic foot appears not to expand walking time. However, the "Shape&Roll" foot demonstrated a clear tendency to improve fast walking capabilities. Sixty-six percent of the participants were now able to

Dr. Meier fine tunes the test prosthesis on one of the subjects in the study.

walk fast without any difficulties while wearing the "Shape&Roll" foot compared to 50% while wearing the SACH-like foot.

Walking with non-amputees is always a challenge also for good ambulators as this group represented. In general, persons with trans-tibial traumatic amputations walk about 18-30% slower than non-amputees (Bateni and Olney, 2002; Hermodsson et al. 1994). With the "Shape&Roll" foot, an overall improvement was observed as 92% of the participants stated that they were able to keep up with non-amputees' walking speed without difficulties or only with some difficulties.

This stance in contrast with the SACH-prosthetict foot where only 75% of the participants could walk with non-amputees without difficulties or with some difficulties. These are encouraging results that may confirm that the principles

Anthropometric Data of the El Salvador Participants

Variables	Participants (n = 12)
Age (Years)	30[a] (19 56[b])
Height (m)	1.60 (1.43 - 1.78)
Weight (kg)	66 (53 - 91)
Post-amputated (years)	10.0 (0.5 -43.0)
Amputation Reason	
Traffic Accident	6 (50.0)[c]
Landmine	1. (8.3)
Explosion Fragment	1 (8.3)
Gunshot	1 (8.3)
Shooting Accident	1 (8.3)
Gangrene	1 (8.3)
Osteomyelitis	1 (8.3)1 (8.3)
Current Prosthetic Feet	
SACH	12

[a] *Median;* [b] *Minimum/Maximum;* [c] *Frequency (Percentage)*

Table 1. The participants of the El Salvador field investigation were a young population group with the great majority of them having lost one of their legs due to traumatic incidences.

behind the "Shape&Roll" foot seem to be correct, at least in the plane of progression.

The "Shape&Roll" foot has been designed in order to be similar to the natural roll-over characteristics of the physiological foot-ankle complex. The foot seems to provide these characteristics as the roll-over was considered natural and smooth by 75% of the participants. For me an unexpected result was the responses given to the question related to handling inclined slopes. Slopes and sidewise inclines were easier to walk when wearing the "Shape&Roll" foot than when wearing the SACH-like foot. It was one of my concerns that the relatively stiff forefoot of the "Shape&Roll" foot might cause difficulties when walking over slopes or uneven ground. This seems not to be the case. An additional question—waling performance over uneven ground—was responded to in favor for the "Shape&Roll" foot.

In summary it can be said that the "Shape&Roll" foot seemed to have improved the participants' walking performance in several ways such as increasing walking distance,

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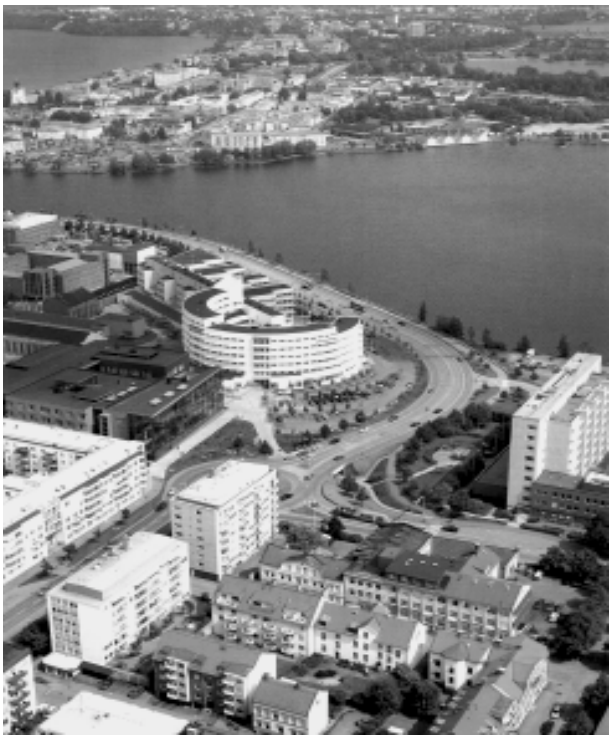
NUPOC NEWS

NUPOC Directors of Education are Keynote Speakers at the International Prosthetics and Orthotics Educators Meeting

In August 14-18, Bryan Malas, CO, Director of Orthotics Education and Mark Edwards, Director of Prosthetics Education attended the first International Prosthetics and Orthotics Educators Meeting in Jönköping, Sweden. In attendance at the meeting were educators and administrators from 13 different countries representing certificate, diploma, and degree programs in prosthetics and orthotics from around the world.

Mr. Malas presented a keynote address on the use of standardized patients in clinical assessments. Mr. Edwards gave a keynote address on the unique entry-level curriculum offered at Northwestern University and discussed the standards used in the United States that all CAAHEP/ NCOPE accredited programs must meet.

The hosts of the meeting were the faculty and administrators of the Jönköping University School of Allied Health. They provided the participants with an excellent environment to meet and discuss with colleagues important educational issues that are common to all educational programs.



Jönköping, Sweden was the site of the first International Prosthetics and Orthotics Educators meeting.

The hosts also gave all participants a wonderful experience in the culture and countryside of Sweden. One evening was spent at the Jönköping county governor's mansion for dinner. The next evening found us on a ferry ride to an island in the middle of Lake Vättern, the second largest lake in Sweden. Once on the island, a horse and buggy ride took the group around the island enjoying a beautiful sunset and looking at finely painted cottages. The evening ended with everyone singing traditional Swedish folk music.

Other well-known participants in the conference included representatives from the University of Strathclyde, in Glasgow, Scotland, LaTrobe University in Melbourne, Australia, and Honk Kong Polytechnical University.

The program planning committee worked hard to create a format that allowed room for much debate and discussion. Reed Williams, PhD, from Southern Illinois University School of Medicine was the keynote speaker for the meeting. Dr. Williams brought to the conference years of experience in medical education and program development. The participants debated topics that included: professional identity, entry-level curricula, modes of delivery in teaching, applied, practical, and clinical curricula, post-graduate education, and collaboration.

At the conclusion of the meeting the group discussed the positive benefits of gathering together with our international colleagues. A lengthy discussion focused on the future of the next meeting and plans to establish a more permanent organizatiuon. ❖

NorthwesternUniversity PRL&RERP&NUPOC NEWS

NOTE: The Capabilities date designation has been changed from "January, April, July and October" to "Winter, Spring, Summer and Autumn" to more accurately reflect our quarterly nature. Volume and number designations remain the same.

Childress Attends Taiwan Meeting

Dudley S. Childress, PhD, attended the first Anniversary Conference and celebration for the National Rehabilitation Center in Taipei, Taiwan. The meeting was held September 29 to October 2.

NUPRL & RERP Hosts Gait Course

NUPRL & RERP in conjunction with the American Academy of Orthotists and Prosthetists (AAOP) held the second Advanced Training Course: Overview of Gait Analysis for Prosthetists and Orthotists at the Rehabilitation Institute of Chicago on September 19 - 21, 2002. Seventeen prosthetist/orthotists from around the USA attended the course. The Advanced Training Course focused on increasing knowledge of gait analysis technology, terminology and data interpretation. Work in the VA Chicago Motion Analysis Research Laboratory and lectures enabled the prosthetists and orthotists to becme familiar with gait analysis procedures and the type of data produced. Lectures and case study presentations increased awareness of both the strengths weakness of gait analysis and what it can and cannot do to help in clinical P&O practice. Faculty for the course included Dudley Childress, PhD, Steven Gard, PhD, Stefania Fatone, PhD, Margrit Meier, PhD, Andrew Hansen, PhD, and Rebecca Stine, MS from NUPRL & RERP; Bryan Malas, CO, Mark Edwards, CP, Laura Miller, MS, CP and Robert Lipschutz, CP from NUPOC and Robert Novak, MS from the Motion Analysis Center at Children's Memorial Hospital, Chicago.

Weir, Ajiboye and Farrell Attend Myoelectric Control Symposium

Richard F. *ff* Weir, Ph.D led the sessions on Prostheses and Hardware at the 2002 Myoelectric Controls (MEC) Powered Prosthetics Conference held August 21-23, 2002 on the University of New Brunswick campus, New Brunswick, Canada. Abidemi Bolu Ajiboye, also of the NUPRL & RERP staff, presented a report on his studies of "Neuro-Fuzzy Logic as a Control Algorithm for an Externally Powered Multifunctional Hand Prosthesis". Todd Farrell presented a paper entitled, "Real-Time Computer Modeling of a Prosthesis Controller Based on Extended Physiological Proprioception (EPP)".

Steven Gard Presents at IEEE Conference

Steven Gard, Ph.D., presented "The Effect of Shock Absorbing Prosthetic Components on the Gaits of Persons with Lower-Extremity Amputations, 2nd Joint Conference of the IEEE Engineering in Medicine and Biology Society (EMBS) and Biomedical Engineering Society (BMES), held in Houston, Texas on October 23-26, 2002. The presentation" was based upon work that Dr. Gard completed with Ms. Regina Konz, a Ph.D. which investigated how a shock absorbing prosthetic component--the Endolite Telescopic-Torsion (TT) Pylon--affected walking in ten persons who had a unilateral below-knee amputation. Data was collected using instrumentation in the VA Chicago Motion Analysis Research Laboratory (VACMARL), and from questionnaires administered to research subjects to document their feelings about walking with the shock absorbing component. Dr. Gard and Ms. Konz found that most subjects preferred walking with the Endolite TT Pylon for reasons related to comfort. Measurements from VACMARL revealed that many of the subjects demonstrated a decrease in force under the prosthesis related to loading of the limb during walking. Dr. Gard is currently working on a VA-funded project to investigate the effect of two shock absorbing components in persons with above-knee amputations.

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Heckathorne Participates in Skills for Life Workshop

Craig Heckathorne, NUPRL & RERP Research Engineer and Upper-limb Prosthetics Specialist, attended Skills for Life: A Functional Workshop for People who Have Both Arms Amputated. The workshop, held in Denver, Colorado, September 20-22, 2002, was co-organized by Amputee Services of America and Hanger Prosthetics and Orthotics, Inc. The event focused on providing formal and informal opportunities for information exchange among persons having bilateral arm amputations, spouses, caregivers, and allied health professionals.

Robert H. Meier, III, MD and Director of Amputee Services of America, said that the idea for the workshop originated when he and other physicians, therapists, case managers, and persons with amputations noticed that cost-saving efforts in rehabilitation funding often meant that a person with bilateral upper-limb amputations did not have access to the level of rehabilitation services found to be beneficial to people with similar amputations in the past. This has frequently resulted in less familiarity with various alternatives for upper limb prosthetic systems and less training with the system that the individual receives, resulting in less proficiency in the use of the prostheses and greater difficulty managing daily activities.

Topics of the workshop primarily addressed activities of daily living and recreation, including toileting, bathing, dressing, food preparation and eating, and computer access. Non-prosthetic functional options included use of feet and mechanical adaptations within the home. Workshop attendees had the opportunity to see, handle and learn about a variety of prostheses, including body-powered, electric-powered, and hybrid systems. Recognizing that life includes many facets, other sessions in the workshop dealt with work options, emotional wholeness and wellness behavior, caregiving, recreational options, sensuality, sexuality, and body image.

Individuals presenting at the workshop included Randy Alley, CP, Diane Atkins, OTR, Howard Belon, PhD, Troy Farnsworth, CP, Annaliese Furlong, CP, Robert H. Meier, III, MD, Eric Nelson, Wendy Stoeker, OTR, Jeffrey Tiessen, and Jack Uellendahl, CPO. In addition to the presentations by Mr. Tiessen and Mr. Nelson, who both have bilateral arm amputations, functional demonstrations were provided by several other persons with bilateral arm amputations including Ken Fenstermacher, Joe Ivko, and John Newbold. Prosthetic evaluations were made available to all participants with arm amputations. Craig Heckathorne participated in the evaluations as a design consultant.

Several companies co-sponsored the workshop with Amputee Services of America and Hanger Prosthetics and Orthotics. These companies included Hosmer Dorrance Corp., Liberating Technologies, Inc., Motion Control, Inc., Otto Bock Health Care, Texas Assistive Devices, and TRS, Inc. Most of the co-sponsors had information and exhibits available at the workshop.

For more information on the Skills for Life workshop, contact:

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CIR Demonstrates Dilatancy Method

The Center for International Rehabilitation (CIR) main web site (htttp:www.cirnetwork.org/) now includes a short movie clip demonstrating how to duplicate a plaster model in less than a minute using sand and vacuum rather than using the traditional methods.

According to Yeongchi Wu, M.D., of CIR, the steps used to make a plaster model in the dilatancy method takes about 50 seconds, rather than the 2 hours needed to use the more conventional approach. The CIR Dilatancy Casting System utilizes sand or other grains encased in a flexible container. Air is removed from the flexible container by vacuum and the granules become packed and solid in form. A negative mold is made of the residual limb and the same method is used to make a positive mold for the socket. Modifications for pressure relief can be made by pressing down areas in the sand. Dr. Wu also says that breaking up a plaster model after a socket is made in the traditional method takes 15 minutes or more while the dilatancy method requires on seconds.

Training in the dilatancy method is part of the CIR effort to provide prosthetic components and methods that are more cost effective and easily accomplished in developing nations. ❖

Design and Development of P & O in Low Income Countries

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faster walking abilities and better handling of uneven surfaces like slopes and side inclines. In particular, the roll-over characteristics of the "Shape&Roll" foot was perceived as natural and very smooth.

Leisure Time…

During the weekends Michel and I took the advantage to explore El Salvador, a beautiful, volcanic country right on the Pacific Ocean. Due to the volcanic earth the vegetation is very rich and diverse. The beaches are mostly covered with fine sand ranging in colors from light brown to a deep dark brown, almost black. To Michel's delight the waves were perfect for surfing. Michel's surf talent impressed me as much as the waves. These were high and especially their strength was something I have not experienced before. Even small waves were so strong that they knocked me down and turned me around in a way that I felt it must be like this in a washing machine. And there, Michel stood on the surfboard, riding along on those waves as if it were a piece of cake whereas I had difficulties keeping my feet on the ground as instructed to avoid to being drifted away…. The water was clear and very warm, wonderful for relaxing. Beach time—a time we enjoyed very much.

At the end of our first stay in San Salvador we had not only produced test prostheses in the given time frame and thus initiated the field investigation successfully, but also discovered a beautiful place with very warm-hearted people. We made good friends.

End Note

Michel Sam left our laboratory shortly after the second part of the field investigation in order to pursue a medical education. I would like to take the opportunity to thank him very warmly for having taken part in this investigation. As a non-prosthetist and thus not very familiar with the clinical environment of prosthetic fitting, he managed upcoming challenges in an admirable manner. In addition, his engineering knowledge was of great assistance to me when new material combinations and new fabrication methods had to be tried out. Michel was not only an excellent worker but also a wonderful colleague. I wish him all the very best for his future career and send him a big *Thank you*!

Acknowledgments

First of all, I would like to thank my mentor Dr. Dudley Childress and CIR Chicago, in particular Dr. William Kennedy Smith and Hector R. Casanova, for initiating this field investigation that gave Michel Sam and me the opportunity to experience something totally different. I would like to expand these thanks to the medical director, Dr. Sonia Maribel Minero and the administrative director, María Dolores de Nobs, at FUNTER for having agreed to collaborate with CIR. Without their agreement to share FUNTER's database and resources we would not have been able to conduct our investigation. In particular we would like to thank Fred Navarrete and Cecilia Novoa for their excellent support, not only in preparing all the necessary arrangements for our stay but also for their translation assistance and for being "tour guides" whenever their time permitted it. Their presence was very much appreciated. A special thank you to the production manager Norma Díaz. Her patience with us while using the FUNTER workshop and thus sometimes interfering with the daily routines was much appreciated as well. Many warm thanks go to the three FUNTER technicians: Rene Estevez for assisting with socket duplication, Victor Leiva and Juan Ventura for their invaluable help during the fabrication of the testing prosthesis. Whenever unforeseen challenges came up, they assisted us with problem solving. We also spent great weekends together that will last in our memories. Last but not least, a warm "Thank you" to all participants. Some of them came from rural areas and had to start their journey into the capital around 4 AM in order to be able to reach FUNTER in the morning. Their enthusiasm for the field investigation and their kindness and cooperation towards us was simply fantastic. ❖

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News from the Department of Veterans Affairs

VA uses Cad/Cam Foot Orthotics Technology to Improve Patient Care

By Daniel Gnatz, M.A., VPR, VISN 19

Coordinated by Robert M. Baum
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As many things continue to change throughout the VA Healthcare System, one thing has remained constant; the VA is continually seeking ways to provide the best possible healthcare for the dollars that it spends. One technology that many VA facilities and a few Veterans Integrated Service Networks (VISNs) have successfully used to provide a high level of care at the best price is CAD/CAM scanning and fabrication of custom foot orthotics.

VISN 19 (the VHA Rocky Mountain Network) covers a widely dispersed geographical area, including the states of Colorado, Montana, Utah, and Wyoming. Because of the great distances, with spans as wide as 800 miles between Network facilities, transporting of patients for orthotic insole fabrication was not a viable option. Instead, VISN 19 placed scanners in every facility and trained clinicians to perform foot scans.

The Network has been using CAD/CAM technology to provide orthotics since July of 2000. Prior to the implementation of the CAD/CAM system, prices for custom foot orthotics were running as high as $400.00 at some rural facilities, and the average cost for foot orthotics in VISN 19 was $129.00. The quality of these insoles also varied greatly in VISN 19 leading to disparity of care issues within the Network. Smaller, rural stations within the Network were not often equipped to cast for foot orthotics and had to outsource the entire job. There was little competition in the rural areas, which ultimately meant much higher prices. With the implementation of CAD/CAM technology in the Network, the average cost of insoles has been brought down to $29.00 per pair, including labor.

The contact scanner chosen by VISN 19 uses air pressure that pushes up an array of piston posts against the bottom of the patient's foot, taking the contour. The pneumatic posts compress the soft tissue and reveal the underlying bony structures of the patient's foot "rendering a remarkably good picture of their position"[1]. The system then creates a topographical map of the plantar surface of the foot. Patients can be scanned in full, semi, or non-weight bearing modes, and mechanical adjustments can be made in the scanning process, which makes the system very versatile in its application.

After the scan is made, the clinician can add more adjustments using editing software. Once all adjustments are complete, the scan is sent via email to Salt Lake City, Utah, where the insoles, made of EVA, are milled, and the finished product is shipped back to the facility to be issued to the patient.

The system gives a great deal of control over the foot orthotics back to the clinicians that are most familiar with the patient's condition. This technology has helped VISN

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CAD/Improves Foot Orthotics

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19 move the locus of control closer to the point at which patients are receiving care; thus, it ultimately brings more of that control back to the patient. It is a good example of one way that the VA has used technology to lower costs while improving patient care. ❖

1 Kevin Miller and Steven D. Funk: "A Case for Corrective Assessment for Custom Foot Orthotic Fabrication" Presented at the 2002 Academy of Prosthetics and Orthotics CEC Meeting, New Orleans, LA

Credit for the VA Presents Article in Summer 2002 Capabilities

We neglected to credit Edmond Ayyappa, MS, CPO, FAAOP for the article in the last issue of Capabilities which described the fitting of the C-Leg in VA facilities.

Mr. Ayyappa is an associate clinical professor at the School of Physical Medicine, University of California at Irving and founder of National VA Prosthetics Gait Lab.

Please send us your articles, success stories, comments or suggestions for future issues in the VA Presents. E-mail: *Robert.Baum@hq.med.va.gov* ***Address: PSAS SHG (113), 810 Vermont Ave., NW, Washington, DC 20420. Phone (202) 273-8515. Fax: (202) 273-9110.***

In Memorium

Robert Thompson, MD, Leading Orthopaedic Surgeon

Robert Thompson, M.D., 87, died on September 22, 2002. Dr. Thompson was a leading orthopaedic surgeon in Chicago--highly respected and trusted. He was also highly regarded in the prosthetics field and was in charge of the prosthetics clinic at VA Westside Hospital for many years. He, along with the late Dr.Robert Keagy, headed the prosthetics clinics at the Rehabilitation Institute of Chicago.

Thompson was the medical director of the Prosthetics Research Laboratory and the Rehabilitation Engineering Research Program for a number of years and he taught amputation surgery in the Prosthetic/Orthotics Center up until a few years ago.

Dudley Childress said, "I believe he joined the Compere-Schnute-Compere orthopaedic office about 1955. This prestigious office was located at 737 North Michigan Avenue. It was one of the most influential offices connected with Wesley Hospital and with Northwestern University. Dr. Thompson was active in the Rehabilitation Institute of Chicago as a Consulting Staff Physician and was on the Emeritus Staff when he died. I remember Dr. Thompson for his honesty and integrity. He was a wonderful human being who never pushed himself forward but who was always there when needed, serving with humility and effectiveness. We have lost a solid citizen, surgeon, and friend." ❖

Charles Fryer, Pioneer at NUPOC

Charles Fryer, 78, former Director of NUPOC, died August 28, 2002. Fryer, who spent 26 years at NUPOC, came to Northwestern University after having taught prosthetics and orthotics at both the New York University (NYU) and the University of California at Los Angeles (UCLA). He earned his Bachelor's degree in biology from NYU and his Master's degree in Physical Therapy.

Fryer then became Director of Physical Therapy at the Hospital for Joint Diseases in Manhattan. He was invited to give lectures in anatomy and biomechanics for physicians attending NYU so frequently that he joined the faculty, where he taught for five years. He then accepted an invitation to lecture at UCLA.

However, those who knew Fryer often heard how he and his wife didn't like the west coast. They decided to move back to the east coast. They stopped at the west coast of Lake Michigan and Fryer joined the Northwestern staff in 1962, four years after NUPOC was established, and taught until 1988.

Those who knew Fryer — known as Charlie to his friends — respected his quiet manner and depth of knowledge of the field of prosthetics and orthotics. In his years of teaching at Northwestern, hospitals in New York and at UCLA Charles Fryer taught thousands of orthotists and prosthetists from across the country and foriegn lands. ❖

Betty Fryer (Lucrecia Istueta Fryer)

Betty Fryer, 82, died Septembeer 27, 2002. Betty and Charlie were a charming couple who frequently hosted P & O students, staff and faculty in their Mies Van der Rohe apartment. Betty was the Consul General in Chicago for Argentina for many years. She was vivacious and energetic and always interested in her guests. She was a great gift from Argentina to the USA. ❖

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