HUMAN ENGINEERING RESEARCH LABORATORIES

HERL Quarterly Newsletter

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LETTER FROM THE EDITOR

Happy New Year! My name is Christine Heiner. I have worked as the secretary for the Human Engineering Research Laboratories for the past two and a half years. Recently I have become more involved in the areas of media and publications. In the past year, HERL has grown tremendously in grant funding and we've expanded the scope of our research. Since we're getting bigger, we felt it was important to better disseminate our progress to the people who make our research possible by participating in our studies as well as people in the community who are interested in our work.

HERL would like to thank you for taking the time to read our first quarterly newsletter. We hope you'll get to know us better and gain a better understanding of the kind of research we do. We'd also like to thank the people who continue to participate in our research studies. Because of your involvement, our work to help increase the independence of people with disabilities will only continue to grow.

We hope you find our first quarterly newsletter to be exciting and informative!

INSIDE THIS ISSUE:

CURRENT RESEARCH ABSTRACTS

Muscle Imbalance in Individuals With Multiple Sclerosis

Aaron L. Souza, MS, Michael L. Boninger, M.D., Brian T. Fay, MS

Purpose of the Work. The purpose of this study was to investigate muscle imbalance in individuals with Multiple Sclerosis that use a manual wheelchair as their primary mode of transportation. When using a manual wheelchair for mobility, the demands on the upper extremity muscle groups are great. Muscle imbalance due to manual wheelchair use places the upper extremity at a higher risk of obtaining an injury. **Subjects/Procedures.** Fifteen (7 male and 8 female) individuals with Multiple Sclerosis (MS) that utilize a manual wheelchair as their primary means of transportation and Fifteen (7 male and 8 female) anatomically matched unimpaired individuals that were free of shoulder problems volunteered for the study. The mean age, weight and height of the Multiple Sclerosis and able-bodied individuals were 50 and 37 years, 171 and 170 lbs, 5'7" and 5'7". Strength testing of both upper elbows (flexion/extension) and shoulders (flexion/extension and abduction/adduction) were done with a BioDex System 3 isokinetic device.

Strength Testing on the Biodex System

Results. The individuals with MS displayed a higher torque ratio in all movements tested when compared to the AB group. The muscle imbalance experienced by the individuals with MS may place them at risk for developing upper extremity injuries as observed in other manual wheelchair users.

Relevance to Individuals with Disabilities. Muscle imbalance may be one of the factors that cause upper extremity injuries commonly seen with manual wheelchair use. Incorporating strengthening exercises using graded resistant Thera-band and Exer-tubing into the daily routine may provide a more balanced environment for the upper extremities.

Aaron L. Souza, MS

The Characterization of Reverse Instability in Electric Powered Wheelchairs

TA Corfman, M.S., S Guo, Ph.D., RA Cooper, Ph.D., D Dan, Ph.D.

Purpose of the Work. The purpose of this study is to characterize the reverse instability of several electric powered wheelchairs (EPWs), to determine if caster (front) wheel orientation plays a role in the reverse instability, and to eventually develop control algorithms to dampen or eradicate the reverse instability. With the high occurrence of tips and falls in the reverse driving direction and the possibility of reducing this occurrence through better engineering techniques, there is a need to characterize and eventually solve the reverse instability issue among EPWs. **Procedures.** Several rear wheel drive EPWs were chosen for this study due to their popularity among the EPW user population. Each EPW was driven in reverse at one-quarter, one-half, and full reversing speed while its caster wheels were aligned at six different orientations on forceplates. In addition to forceplate data, the motion of the EPW was also recorded. Joystick and motor voltages were also measured for speed and direction. **Subjects.** No human subjects were used in this study. Instead, a crash test dummy substituted as the driver and the EPW was

controlled by remote control. **Results.** To date, only one EPW has been fully tested and the data has been visually inspected. As expected, the motor voltage is much noisier at lower speeds and caster wheel orientation at the onset of reversing seems to determine the ultimate direction of the EPW. However, force, moment, velocity, and acceleration values arestill being analyzed at this time. **Relevance to Individuals with Disabilities.** After characterizing the instability in the reversing direction of several EPWs, control algorithms will be developed to minimize the disturbance. Better control algorithms may decrease the severity and frequency of EPW tips and falls in the reversing direction.

Thomas A. Corfman, MS

An Improved Joystick Makes Power Wheelchairs Easier to Drive

DM Spaeth, MA, ATP, RA Cooper, Ph.D., S Guo, Ph.D., B Ammer

Purpose of the work. Research suggests that 40 out of every 100 persons who want to drive an electric wheelchair cannot do so. One reason for this is that many persons have problems controlling the movement of their hands. Unwanted wobbling of the joystick handle while driving can send the wheelchair crashing into walls and furniture and possibility injure the occupant. For many years, HERL has been developing a new type of joystick. On this joystick, the handle doesn't move at all; it is rigid just like the stick in a Popsicle or candy apple. Instead of moving the shaft, you press firmly against the handle. The harder you push, the faster the chair will go. **Procedures.** In order to test more subjects at clinics and in their communities, we have designed and built ten new force-sensing joysticks. Computer layout and automated manufacturing techniques were used to produce rugged and reliable units. The enclosures are all-metal construction and have moisture seals. There is a serial port for collecting data during testing. A full set of regular user controls are mounted on the enclosure. **Results**. Construction of the ten new joysticks has been completed. They plug directly into standard electric powered wheelchair. **Relevance to Individuals with Diabilities:** Several studies are under way. One study seeks to determine how much better individuals with hand impairments can drive power wheelchair with the force joystick compared to a regular movement joystick. Another study will examine whether a force joystick can be useful as a computer mouse.

Donald M. Spaeth, MA, ATP

Wheelchair Propulsion Biomechanics In Patients With Multiple Sclerosis

F Ambrosio, MS, MPT, ML Boninger, MD., B Fay, Ph.D.

Purpose: The objective of this study was to characterize wheelchair propulsion in individuals with multiple sclerosis (MS), and to identify factors contributing to an increased energy expenditure and fatigue in this population.

Materials and Methods: Biomechanical analysis of wheelchair propulsion was completed in three groups: 1. individuals with MS, 2. individuals with spinal cord injury (SCI), and 3. non-disabled group (ND). Subjects either used a manual wheelchair for mobility (MS and SCI), or were acquainted with manual wheelchair propulsion (ND). Each group consisted of fifteen subjects taken from a convenience sample. The setting was a biomechanics laboratory in a VA medical center. Three-dimensional applied forces and moments at the pushrim were measured during wheelchair propulsion. Each subject performed a self-selected speed trial for twenty seconds. The first five strokes were analyzed to determine axial moments.

Results: During the self-selected speed trial, it was found that the individuals with MS pushed the wheelchair at a greatly reduced speed when compared to either the SCI or the ND group. Overall, the individuals with MS had to produce more work **to** propel the wheelchair, and displayed a difficulty coordinating their hands on and off the pushrim.

Conclusions: Major differences in wheelchair propulsion between the three groups of subjects were observed. In general, the individuals with MS propelled the wheelchair with a decreased efficiency and increased energy expenditure when compared to the other groups. This is particularly significant in this patient population whose limitations for wheeled mobility are often a result of fatigue and weakness. Clinicians involved in manual wheelchair prescription should consider the propulsion patterns used by the patient, and provide training in energy conservation techniques when necessary.

Fabrisia Ambrosio, MS, MPT

Determining The Effectiveness Of The GAME^{Cycle} As An Exercise Device

Sean A. Reeves, B.S.; Shirley G. Fitzgerald, Ph.D.; Rory A. Cooper, Ph.D.;
Tricia Thorman, M.O.T.,O.T.R/L; Songfeng Guo, Ph.D.

The GAME^{Cycle} Exercise System

Purpose of the Work The specific objective of this research is to determine if the GAME^{Cycle} system is an effective exercise platform and if the individual will perceive that the effort is less than if they exercised with just an arm-ergometer alone. **Subjects/ Procedures** The GAME^{Cycle} system is an arm-ergometer (arm-crank) that is interfaced with a personal computer. The interface then connects to the gameport of a personal computer and controls gameplay. The game used for this study was Need For Speed II™. Thirteen participants gave written informed consent before taking part in the study. The average age was 42 years and their injury levels ranged from C5-6 to T12-L1. All were veterans. Two trials were performed. One trial consisted of using the GAME^{Cycle} while playing Need For Speed™. The second trial consisted of spinning the arm-ergometer without gameplay. After the trials the participants completed a questionnaire covering the ease of operation and if the system would help to motivate them to exercise. **Results** Significant differences occurred between trials with oxygen consumption and carbon dioxide production. Both were higher with game play. Eight individuals reported that the GAME^{Cycle} would help motivate them to exercise.

Relevance to Individuals with Disabilties Since many veterans have personal computers and exercising with an arm-crank alone is tedious this system would give the individual an exercise device that was effective and fun to use. Exercise can aid in the prevention of heart disease.

Sean A Reeves, BS

MEET THE INVESTIGATOR: ALICIA A. KOONTZ, PH.D., ATP

Dr. Koontz officially joined HERL as a Rehabilitation Health Scientist in October of 2000.

Alicia M. Koontz, Ph.D., ATP earned her B.S. and M.S. degrees in Biomedical Engineering with a concentration in Rehabilitation Engineering from Wright State University in 1993 and 1994, respectively. During her undergraduate education, Dr. Koontz was intrigued to learn that technology can have a profound impact on the lives of people with disabilities. She noticed that only a small number of individuals seemed to be receiving adequate assistance and information with respect to the quality and use of assistive technology devices and services. As a result, Dr. Koontz decided to dedicate her career to increase the awareness of, development of, access to, acquisition of, and implementation of assistive technology devices and services. From 1994 to 1997 she worked as a Rehabilitation Engineer and Program Coordinator in the Assistive Technology Department at HealthSouth Harmarville Rehabilitation Hospital in Pittsburgh, PA where she provided services to individuals with disabilities in the areas of computer access, augmentative/alternative communication, worksite and home modifications and environmental controls.

Dr. Koontz was officially hired as a Rehabilitation Scientist at the VA R&D Center of Excellence in Wheelchairs and Related Technology and the Human Engineering Research Laboratories in October of 2000. She received her Ph.D. degree in Rehabilitation Science from the University of Pittsburgh in August 2001. Dr. Koontz has participated in several research projects on overuse and cumulative trauma injuries related to wheelchair mobility and assistive technologies for joint pain and injury prevention since she began her doctoral studies at HERL in September of 1997. Recently, she has received funding from the VA for two collaborative projects involving the development of a dynamic biomechanical model for investigating upper extremity biomechanics during wheelchair propulsion and the clinical evaluation of a wheelchair mounted robotic arm. Dr. Koontz is also a member of RESNA, ASB, Tau Beta Pi, and Sigma Xi.

Braking Kinetics in Wheelchair Propulsion: Evaluation of a New Ergonomic Pushrim

Alicia Koontz, Michael Boninger, Rory Cooper, Mark Baldwin

Purpose of the Work: Wheelchair handrims have been limited to round designs for over 50 years. However, manual wheelchair users have found that the standard pushrim is difficult or uncomfortable to grasp and often rely on the tires for increased traction. They also have difficulties with controlling and braking their wheelchair. For these reasons, a new pushrim was developed which provides a larger area for grasping and braking, a special coating on the top surface for increased gripping ability, and a contoured shape for an improved fit to the hand. **Subjects/Procedures:** A study was conducted to evaluate braking ability when using the new pushrims. Four wheelchair users with paraplegia participated in the study. Their rear wheels were replaced with special wheels that could measure the forces and torques they used to push the wheelchair. The wheelchair users were secured to a roller system during the testing. They were instructed to propel their wheelchairs at a fast pace for a few seconds and then immediately bring their wheelchair to a complete stop. They performed the braking trial two times: once with their own pushrims (standard, round) and once with the new pushrims. **Results:** All the wheelchair users applied more hand force and torque to stop the wheelchairs than they did to propel the wheelchairs at a fast pace. The wheelchair users could stop the wheelchair with less physical effort when using the new pushrim design. **Relevance to Individuals with Disabilities:** The new pushrims could be of benefit to wheelchair users who have limited arm strength. They may also be safer, more efficient and more comfortable.

Alicia M. Koontz, Ph.D., ATP

RECENT HERL PUBLICATIONS AND PROCEEDINGS

Shimada SD, Cooper RA, Boninger ML, Koontz AM, Corfman TA, Comparison of Three Different Methods to Represent the Wrist during Wheelchair Propulsion, **IEEE Transactions on Neural Systems and Rehabilitation Engineering**, pp. 274-282, Vol. 9, No. 3, 2001.

Munin MC, Espejo-De Guzman MC, Boninger ML, Fitzgerald SF, Penrod LE, Singh J, Predictive Factors for Early Prosthetic Ambulation Among Lower Limb Amputees, **Journal of Rehabilitation Research and Development**, pp. 379-384, Vol. 38, No. 4, 2001.

Boninger ML, Towers JD, Cooper RA, Dicianno BE, Munin MC, Shoulder Imaging Abnormalities in Individuals with Paraplegia, **Journal of Rehabilitation Research and Development**, pp. 401-408, Vol. 38, No. 4, 2001.

VanSickle DP, Cooper RA, Boninger ML, DiGiovine CP, Analysis of Vibrations Induced during Wheelchair Propulsion, **Journal of Rehabilitation Research and Development**, pp. 409-421, Vol. 38, No. 4, 2001.

Cooper RA, Fitzgerald SG, Boninger ML, Brienza DM, Shapcott N, Cooper R, Flood K, Telerehabilitation: Expanding Access to Rehabilitation Expertise, **Proceedings of the IEEE**, pp. 1174-1191, Vol. 89, No. 8, 2001.

Boninger ML, Chan L, Harvey R, Pine ZM, Helkowski W, Garrison CJ, Tran T, Levin H, Levy CE, Resident Research Education in Physical Medicine and Rehabilitation, **American Journal of Physical Medicine and Rehabilitation**, Vol. 80, No. 9, pp. 706-712, September 2001.

Boninger ML, Mobility in Multiple Sclerosis, **Multiple Sclerosis Quarterly Report**, Vol. 20, No. 3, pp. 8-11, Fall 2001.

Fitzgerald SG, Cooper RA, Boninger ML, Rentschler AJ, Comparison of Fatigue Life for Three Types of Manual Wheelchairs, **Archives of Physical Medicine and Rehabilitation**, pp. 1484-1488, Vol. 82, No. 10, Oct. 2001.

HERL IN THE MEDIA

NBC First News at Four, KNSD-TV Channel 39, San Diego, 11/09/01, 4-5pm: Smart Wheelchair: Pushrim Power Assisted Wheelchair helps alleviate shoulder and neck pain associated with manual wheelchairs

VA Research Currents, Vol. 1, No. 10, October 2001, Page 1: Robotic Walker for Vision Impaired Elderly Being Tested by VA

University of Pittsburgh Research Review, Fall 2001, Page 6: Pitt Recieves $1.6 Million Federal Grant to Establish Model Center for Spinal Cord Injury.

Pitt Magazine, September 2001, Page 5: A Model for Research.

Pittsburgh Tribune-Review, August 15, 2001, Page B-2: Newsmaker 2Day: Rory Cooper.

Medical Imaging, July 2001, Page TM-38-TM-42: MRI Joint Motion Studies: Waging War on Repetitive Strain Injuries.

KQVam Radio, May 13, 2001, 1:30pm News: Opening the Doors to Independence.

PittMed Magazine, April 2001, Page 13-16: Opportunity of a Lifetime.

UPMC NOW, January 2001: Innovations to Keep People Moving. UPMC, University of Pittsburgh are Shaping the Future of Physical Medicine and Rehabilitation.

FEATURED HERL STUDENT: COREY BLAUCH

Corey M. Blauch earned his Bachelor of Science degree in Bioengineering from the University of Pittsburgh. He joined the Human Engineering Research Laboratories in the summer of 2000 to begin his masters degree work in Rehabilitation Science and Technology. Corey has worked on several projects at HERL, including designing a forward folding collapsible ultralight wheelchair and an oblique angled suspension fork for wheelchairs. HERL has filed invention disclosures for the forward folding wheelchair and the suspension fork and they are currently in the process of being patented.

Corey expects to graduate from the University of Pittsburgh in December of 2002. Designing the folding wheelchair has opened up a new avenue of interest for Corey. He hopes to work for a major wheelchair manufacturer after graduation. In addition to working at HERL, Corey also works part time at Media Play and enjoys music, playing guitar, sports, and video games.

THE DESIGN OF A FORWARD FOLDING ULTRALIGHT WHEELCHAIR

Corey Blauch; Rory Cooper; William Ammer; Mark McCartney; Tom Corfman

Objectives: The purpose of this project is to design an ultra light wheelchair that is able to collapse and fit into an overhead compartment of an airplane. This would eliminate the need to transfer out of one's own wheelchair when boarding an airplane because the wheelchair could be stored in the overhead compartment. Also, a collapsible wheelchair would make storage and handling easier either in the home or in the car. Some of the design parameters were the wheelchair must be lightweight, durable, adjustable, stable, comfortable, and cost effective. **Methods:** Preliminary drawings and sketches for the Forward Folding Ultra light Wheelchair (FFUWC) were made taking into account anthropometry and basic configurations of wheelchairs. The first prototype was built so that by removing two fasteners from the chair, it can fold forward much like a lawn chair. The second prototype was then built with a similar folding design but with adjustable backrest angle, adjustable backrest height, adjustable seat pan angle, and adjustable wheel axle. **Results:** Presently, the first prototype is being used by a 55 kilogram experienced wheelchair user who has successfully traveled around the world and boarded many planes without having to transfer into a temporary wheelchair. The second prototype is now being tested according to the ANSI/RESNA standards, which are used by the VA in selecting appropriate wheelchairs. **Relevance to Individuals with Disabilities:** Wheelchair users who travel will often find that they cannot take their wheelchair onto the airplane with them. They must transfer into an airport wheelchair and then check their wheelchair with their other luggage. Also, wheelchair users may find wheelchairs cumbersome and lifting and storing a wheelchair at home or in the car can be very challenging.

The FFUWC collapses and folds to fit in storage areas .

Corey M. Blauch, B.S.

Interested in Participating in a HERL Research Study?

Currently, we are actively recruiting participants for a number of different research studies. Participation is based upon inclusion criteria specific to each study. We have studies that include individuals who utilize manual or power wheelchairs as a means for mobility. The majority of our studies involve a visit to the Human Engineering Research Laboratories located at the VAMC- Highland Drive, however, some of our studies are survey based and do not involve a trip to the VAMC and there are a few exceptions. Recruitment remains ongoing for these studies and future studies. At this time we are actively seeking participants who have a spinal cord injury of above C7 for studies that involve the testing of a push rim activated power assist manual wheelchair (PAPAW) and the testing of an FDA approved wheelchair mounted robotic arm. We're also looking for people who use an electric powered wheelchair as their primary means of mobility to help test a newly developed force sensing joystick. We are actively recruiting individuals with multiple sclerosis, cerebral palsy, and SCI into additional research studies. If you would like to more information regarding the research studies or if you would like to know what studies you would qualify for, please feel free to contact the Clinical Coordinators at HERL for complete details regarding the current and future research studies.

If you're interested in participating in a HERL Research Study, Contact Rosemarie Cooper or Tricia Thorman at (412) 365-4850.

Tricia Thorman, MOT, OTR/L

CURRENT EVENTS

The HOPE Network will conduct the annual **Healthsports Ski Classic,** an adaptive ski program for individuals with disabilities, on January 20-23, 2002. The event will take place at the Hidden Valley Resort near Somerset, Pa. HOPE is looking for both both skiing as well as non-skiing volunteers to participate. If you are interested in participating, please contact the HOPE network at (412) 826-2772. The registration deadline in January 15, 2002. Volunteers from the Human Engineering Research Laboratories will be participating in the Healthsports Ski Classic. Hope to see you there!

There will also be an **Adaptive Ski Instructor/Volunteer Workshop Clinic** at the Hidden Valley Resort on February 16-17th, 2002. The program, sponsored by the Three Rivers Adaptive Sports chapter of Disabled Sports, USA, will offer clinics in adaptive skiing instruction techniques. If you'd like to participate or volunteer, call the TRAS Line at (412) 808-3339. The registration deadline for the clinic is February 1st, 2002.

If you know of a current event that you would like to post in the HERL Quarterly Newsletter, please contact Christine Heiner at (412) 365-4854 or by e-mail at heinercm@pitt.edu

Easter Seals of Western Pennsylvania will be holding their **16th Annual Cotillion** on Saturday, February 23, 2002. The event will take place at the Omni William Penn Hotel in Pittsburgh, starting with a reception at 6:30 p.m. and a dinner at 7:30 p. m. Dr. Rory Cooper, HERL's director, and Rosemarie Cooper, HERL's Clinical Coordinator, are the homorary chair and co-chair of the 2002 Cotillion. For more information on the Cotillion, please contact Easter Seals at 1-800-587-3257.

The Human Engineering Research Laboratories will be holding it's **Annual Advisory Board Meetings** on March 14th and 15th, 2002. The meetings were originally scheduled for September of 2001, but were cancelled due to national events.

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HUMAN ENGINEERING RESEARCH LABORATORIES

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