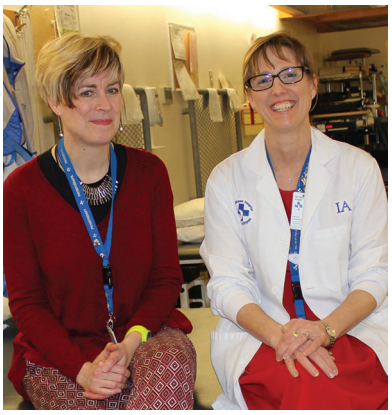

Rehab Research News

Centre for Rehabilitation Research and Development

2018

The Ottawa Hospital | L'Hôpital d'Ottawa

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Centre for Rehabilitation Research and Development
The Ottawa Hospital Rehabilitation Centre
505 Smyth Road, Room 1504
Ottawa, ON K1H 8M2

613-737-8899, extension 75321

crrd@toh.on.ca
www.ohri.ca/rehabilitation

Message from the Director of Rehabilitation Research

I am pleased to present this special edition of Rehab Research News, marking 30 years of sharing outstanding research and development efforts at The Ottawa Hospital Rehabilitation Centre (TOHRC). We celebrate a team approach that truly makes a difference in the lives of the patients we serve here at TOHRC.

I would like to sincerely thank all the clinician researchers that have dedicated so much of their time and expertise to our research program over the years. I also thank the outstanding research support team that makes it all possible. Many people have contributed to this effort over the years, but I would like to acknowledge my current team, Dorothyann Curran, Carolynn Cook and Jenn Taillon, for their dedication and effort.

Over the past 30 years I have worked closely with our chief physiatrists, all of whom have shown great leadership. In particular, I would like to recognize our first Physiatrist-in-Chief, Dr. Ron Fisher who started it all. Following in his footsteps are Dr. Gaétan Tardif, Dr. Dan DeForge, Dr. Sue Dojeiji, and most recently Dr. Shawn Marshall. Each physiatrist, in their own way, sustained and nourished our efforts in rehabilitation research. I would also like to offer a special thank you to George Langill, former CEO of the Royal Ottawa Health Care Group, who was an early supporter and provided inspiration and encouragement.

I would also like to thank the various directors of the rehabilitation program, starting with Irene Giustini and followed by Cathy Danbrook, Helen Zipes, and Fred Beauchemin. All fought for rehabilitation research through difficult administrative times characterized by financial austerity and drastic restructuring. Through it all, our research survived.

I am grateful for the clinician researchers who work tirelessly in spite of immense clinical pressure. Over the years, I have made many clinical research friends, and I have great respect for all of them. As a psychologist myself, I have formed special relationships with many outstanding psychologists, including Dr. Joyce D'Eon, Dr. Peter Henderson and Dr. Keith Wilson.

I would like to make special mention of the professionals who took on administrative roles in research, particularly Louise Seaby who was a pioneer in physiotherapy research, and Sue Balmer who continued in Louise's path. I also worked closely with Dr. Ed Lemaire and his many students over the years.

I would especially like to thank the patients who take part in research. They contribute the most to our efforts in the knowledge that even if the results of a particular study don't help them now, they give of themselves in their desire to help future patients and their families.

Dr. Jamie MacDougall

Finally, I would like to thank the administration of The Ottawa Hospital (TOH) and the Ottawa Hospital Research Institute (OHRI) for their enduring support over the years. In particular, Dr. Jack Kitts for his visionary leadership, and Cameron Love for making it all happen. I also thank Dr. Ron Worton, Rob Hanlon, Dr. Duncan Stewart, Dr. Dean Fergusson and Debra Lynkowski from OHRI for their support and leadership.

I am very proud of all that has been accomplished in this important area of rehabilitation research. I am confident that with the continued support of OHRI, and under the outstanding leadership of Dr. Shawn Marshall and the clinical/administrative leadership of Patsy McNamara, rehabilitation research will continue to thrive and flourish for at least another 30 years!

Message from the Clinical Director and the Physiatrist-in-Chief

The Centre for Rehabilitation Research and Development (CRRD) has played an integral role in assisting The Ottawa Hospital Rehabilitation Centre (TOHRC) continue to maintain its reputation as a leader in the provision of adult rehabilitation services.

As the Champlain's sole tertiary rehabilitation centre, the patients and families of the Champlain region have long benefitted from the close association of our clinical and research centres. Both are anchored by The Ottawa Hospital's (TOH) core values of compassion, a commitment to quality, working together, and respect for the individual.

Congratulations to Dr. Jamie MacDougall and his group of clinicians and staff for their hard work and outstanding achievements profiled in the report. This great partnership allows us to pursue new clinical knowledge and its translation into practice so that we can improve the care and quality of life for the patients in our community.

We would also want to thank Dr. Jamie MacDougall for his dedication, expertise and passion during the last several decades in leading research at TOHRC.

Frédéric Beauchemin
Clinical Director
Rehabilitation, Sub-Acute Transitions,
Geriatrics, and Transitional Care
The Ottawa Hospital

Dr. Shawn Marshall
Physiatrist-in-Chief
The Ottawa Hospital Rehabilitation Centre

"To provide each patient with the world-class care, exceptional service and compassion that we would want for our loves ones"

The Ottawa Hospital Vision

Centre for Rehabilitation Research and Development

Vision

The pursuit of excellence in rehabilitation research and development.

The Centre for Rehabilitation Research and Development (CRRD) of The Ottawa Hospital Rehabilitation Centre (TOHRC) is a part of the Clinical Epidemiology Program of the Ottawa Hospital Research Institute (OHRI). The centre was created to foster rehabilitation-specific research and facilitate the development of research partnerships and networking activities.

Locally, CRRD coordinates research efforts at TOHRC itself, managing everything from large longitudinal projects to program evaluation initiatives, grant applications and quality improvement reports. Nationally and internationally, CRRD researchers have collaborated with other facilities on a variety of projects and many of our researchers are recognized as leaders in their fields of expertise.

Mandate

- To conduct clinical and community research with high relevance to TOHRC and the broader rehabilitation community
- To provide advice on and assistance with research methodology and data analysis/interpretation to TOHRC staff engaged in research, program evaluation and best practice review and implementation
- To conduct research on, develop and oversee knowledge transfer within TOHRC for best practice
- To develop, plan and oversee networking activities at regional and national levels to enhance knowledge dissemination
- To exchange knowledge and expertise for the benefit of the international rehabilitation community
- To leverage the expertise, products and services of CRRD/TOHRC to generate revenue to support research and development activities and initiatives
- To develop and research new technologies that improve the lives of persons with rehabilitation needs

Facilities

TOHRC specializes in the physical rehabilitation of those who have experienced a disabling physical illness or injury, providing both inpatient and outpatient care. As such, our research focus is on the clinical and practical application of rehabilitation services.

Researchers have access to a wide variety of specialized facilities and equipment primarily used for assessment and treatment of patients including driving simulation equipment, therapy pool, and the Independent Living Unit (ILU) - an accessible apartment within the centre. Other specialized resources available for research use are the Rehabilitation Virtual Reality Lab (RVR Lab), Rehabilitation Engineering, the Rehabilitation Technology Lab, and Prosthetics and Orthotics Fabrication Services.

Rehab Technology to Enhance Mobility

Principal Investigator: Edward Lemaire, The Ottawa Hospital Rehabilitation Centre

Coinvestigators: Louis Goudreau, Patricia O'Neill, Nancy Dudek, Vidya Sreenivasan, Patrick Lebel, Ted Radstake, Rajiv Kalsi and David Nielen, The Ottawa Hospital Rehabilitation Centre; Nathalie Baddour, Marc Doumit, Patrick Dumond, Miodrag Bolic, Pascal Fallavollita and Julie Nantel, University of Ottawa; Markus Besemann, Canadian Forces Health Services; Danielle Sinden, The Perley and Rideau Veterans' Health Centre; Adrian Chan, James Green and Yu Ono, Carleton University; Jonathan Kofman, University of Waterloo; Peter Kyberd, University of Portsmouth; Man-sang Wong, Hong Kong Polytechnic University; Jacqueline Hebert, University of Alberta; Helena Burger, Marco Rudolph and Nika Goljar, University Rehabilitation Institute, Republic of Slovenia

Lower Extremity Robotic Exoskeletons

Lower extremity powered exoskeletons are intelligent assistive devices that enable people with spinal cord injuries to walk and interact with their chosen environment in an upright position. These devices are self-supporting walking frames with powered actuators at the hips, knees, and/or ankles that are controlled in real-time to create motion and resist limb collapse. The ARKE™ exoskeleton is a novel Canadian product developed by Bionik Laboratories for people with spinal cord injuries or lower extremity weakness. Recent research and development activities include the design of powered hip orthoses, modelling of human-exoskeleton interactions, and evaluating human movement when wearing a powered exoskeleton.

Stance Control Knee-Ankle-Foot Orthoses

Knee-ankle-foot orthoses (KAFOs) are prescribed for people with knee-extensor muscle weakness. To help this population achieve their mobility goals, a new hydraulic knee orthosis was developed to permit a natural gait pattern. When used in a KAFO or knee orthosis, the "Ottawalk-Speed" device allows free knee motion during swing and other non-weight-bearing activities, and resists knee flexion, while allowing knee extension during weight bearing. Collaboration with The Blatchford Group has advanced the device by adding variable hydraulic resistance, sensors, and microprocessor control to provide appropriate leg movement across most daily living surfaces (i.e., level, stairs, sitting, ramps, handling stumbles, etc.). This intelligent stance control KAFO has successfully passed evaluations within the CAREN (Computer-Assisted Rehabilitation Environment) virtual reality system, and in our Rehab Technology Lab. Results support final development of this device for translation to the marketplace.

Smartphones for Enhancing Clinical Mobility Tests

Novel methods, algorithms, and software have been developed for smartphones that use the phone's sensors, multimedia, networking, and processing power to run the Six Minute Walk Test, Two Minute Walk Test, 10 Metre Walk Test, and Timed Up and Go Test. In addition to immediate reporting of test results, biomechanical information on the person's movements during the tests is available immediately afterward (i.e., real-time reporting). These tools enhance information for clinical decision-making without increasing time and effort requirements. Biomechanics Augmented Reality (BAR) is an app that provides real-time angle measurements and posture visualization in a live video. A constant vertical line and grid, based on gravity, provides a reference for aligning or interpreting position. Lines representing the phone's orientation can also be added to enable angle measurement to the vertical gravity line. We have enhanced the app by adding marker tracking, which allows clinicians to measure body position by attaching body markers to anatomical landmarks.

Dynamic Stability Assessment within Rehabilitation Virtual Reality Environments

For people with mobility-related disabilities, health-care decision-making could be improved by having a better understanding of their dynamic stability. In addition to the potential link between fall risk and critical instability (i.e., the point where the person becomes so unstable that they cannot maintain balance), dynamic stability could relate to movement confidence and enhanced performance. Increasing confidence in a person's movement capacity might, therefore, reduce activity avoidance and enhance quality of life through adoption of a more active lifestyle. The Computer-Assisted Rehabilitation Environment (CAREN) Extended virtual reality system is an ideal tool for assessing dynamic stability within environments that are more suited to moving in the community. With this system, individuals can safely move within a progressively challenging virtual world where they work at their own mobility capacity. With the appropriate measures and analysis, a better understanding of a person's dynamic stability can be achieved, which can translate to better clinical decision-making. Projects have been completed for able-bodied, transtibial, and transfemoral amputee populations. Additionally, dynamic stability measures have been used to compare the effect of various prosthetic components on movement.

Funding Sources: Network for Aging Research (University of Waterloo), Ontario Centres of Excellence, Natural Sciences and Engineering Research Council of Canada, and Mitacs Canada

Selected Publications

Fournier, B. N., Lemaire, E. D., Smith, A. J. J., & Doumit, M. (2018). Modeling and Simulation of a Lower Extremity Powered Exoskeleton. *IEEE Transactions on Neural Systems and Rehabilitation Engineering, 26*(8), 1596-1603. doi:10.1109/tnsre.2018.2854605

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Lemaire, E. D., Supan, T. J., & Ortiz, M. (2018). Global Standards for Prosthetics and Orthotics. *Canadian Prosthetics & Orthotics Journal*. doi:10.33137/cpoj.v1i2.31371

Smith, A. J. J., & Lemaire, E. D. (2018). Temporal-spatial gait parameter models of very slow walking. *Gait & Posture, 61*, 125-129. doi:10.1016/j.gaitpost.2018.01.003

Smith, A. J. J., Lemaire, E. D., & Nantel, J. (2018). Lower limb sagittal kinematic and kinetic modeling of very slow walking for gait trajectory scaling. *PLOS ONE, 13*(9), e0203934. doi:10.1371/journal.pone.0203934

Sturk, J. A., Lemaire, E. D., Sinitski, E., Dudek, N. L., Besemann, M., Hebert, J. S., & Baddour, N. (2018). Gait differences between K3 and K4 persons with transfemoral amputation across level and non-level walking conditions. *Prosthetics and Orthotics International, 42*(6), 626-635. doi:10.1177/0309364618785724

Thibault, G., Gholizadeh, H., Sinitski, E., Baddour, N., & Lemaire, E. D. (2018). Effects of the unity vacuum suspension system on transtibial gait for simulated non-level surfaces. *PLOS ONE, 13*(6), e0199181. doi:10.1371/journal.pone.0199181

Drover, D., Howcroft, J., Kofman, J., & Lemaire, E. (2017). Faller Classification in Older Adults Using Wearable Sensors Based on Turn and Straight-Walking Accelerometer-Based Features. *Sensors, 17(*6), 1321. doi:10.3390/s17061321

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Lemaire, E. D., Smith, A. J., Herbert-Copley, A., & Sreenivasan, V. (2017). Lower extremity robotic exoskeleton training: Case studies for complete spinal cord injury walking. *NeuroRehabilitation, 41*(1), 97-103. doi:10.3233/nre-171461

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Capela, N. A., Lemaire, E. D., Baddour, N., Rudolf, M., Goljar, N., & Burger, H. (2016). Evaluation of a smartphone human activity recognition application with able-bodied and stroke participants. *Journal of NeuroEngineering and Rehabilitation, 13*(5). doi:10.1186/s12984-016-0114-0

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Hernandez, A., & Lemaire, E. (2016). A smartphone photogrammetry method for digitizing prosthetic socket interiors. *Prosthetics and Orthotics International, 41*(2), 210-214. doi:10.1177/0309364616664150

Howcroft, J., Kofman, J., Lemaire, E. D., & McIlroy, W. E. (2016). Analysis of dual-task elderly gait in fallers and non-fallers using wearable sensors. *Journal of Biomechanics, 49*(7), 992-1001. doi:10.1016/j.jbiomech.2016.01.015

Howcroft, J., Lemaire, E. D., & Kofman, J. (2016). Wearable-Sensor-Based Classification Models of Faller Status in Older Adults. *PLOS ONE, 11*(4), e0153240. doi:10.1371/journal.pone.0153240

Howcroft, J., Lemaire, E. D., Kofman, J., & Kendell, C. (2016). Understanding responses to gait instability from plantar pressure measurement and the relationship to balance and mobility in lower-limb amputees. *Clinical Biomechanics, 32*, 241-248. doi:10.1016/j.clinbiomech.2015.11.004

Sinitski, E. H., Herbert-Copley, A. G., Lemaire, E. D., Doyle, S. S., Besemann, M., & Dudek, N. L. (2016). Center of pressure and total force analyses for amputees walking with a backpack load over four surfaces. *Applied Ergonomics, 52*, 169-176. doi:10.33137/cpoj.v1i2.31371

Software Published

Biomechanics Augmented Reality - Google Play
https://play.google.com/store/apps/details?id=ca.irrd.bar

TOHRC Walk Timer - Google Play
https://play.google.com/store/apps/details?id=ca.irrd.walktimer

TOHRC Walk Test - Google Play
https://play.google.com/store/apps/details?id=ca.irrd.walktest2

TOHRC Timed Up and Go (TUG) - Google Play
https://play.google.com/store/apps/details?id=theottawahospitalrehabilitationcenter.tug

TOHRC Data Logger - Google Play
https://play.google.com/store/apps/details?id=ca.irrd.datalogger

Motion Analysis Tools
http://www.irrd.ca/cag/mat/

Graduate Students

University of Ottawa

Postdoctoral Fellow
- Hossein Gholizadeh

Biomedical Engineering (PhD[1], MASc[2])
- Farshad Golshan[1]
- Kristina Kuffel[1]
- Shahin Basiratzadeh[2]
- Kyle Daines[2]
- Johnny Farah[2]
- Brandon Fournier[2]
- Reeham Hammouda[2]
- Wentao Li[2]
- Connor McGuirk[2]
- Theja Ram Pingali[2]

Computer Engineering (MASc)
- Vinod Gutta

Computer Science (PhD)
- Mehdi Salehi

Human Kinetics (PhD[3], MSc[4])
- Sean Doyle[3]
- Andrew Smith[3]
- Lei Zhou[4]

Mechanical Engineering (MASc[5], MEng[6])
- Franck Tchuente Kemdjo[5]
- Rahul Kalra[6]
- Gurpuneet Singh[6]
- Matthew Tomkin[6]

University of Waterloo

Systems Design Engineering (PhD[7], MASc[8])
- Jennifer Howcroft[7]
- Scott Pardoel[7]
- Dylan Drover[8]

University of Navarra, Spain

Biomedical Engineering (MASc)
- Amaia Hernandez

Canadian Alternatives in Noninvasive Ventilation (CANVent)

Principal Investigator: Douglas McKim, The Ottawa Hospital Rehabilitation Centre

Coinvestigators: Louise Rose and Craig Dale, University of Toronto; Ian Fraser, Toronto East Health Network; Mika Nonoyama, University of Ontario Institute of Technology; David Leasa, London Health Sciences Centre; Jeremy Road, University of British Columbia; Sherri Katz and Nick Borrowman, Children's Hospital of Eastern Ontario; Judy King, University of Ottawa; Roger Goldstein and Monica Avendano, West Park Healthcare Centre; Resha Amin, The Hospital for Sick Children; Eddy Fan, University Health Network/Mount Sinai Hospital; Karen Rimmer, Peter Lougheed Centre; Andrea Gerhson and Anu Tandon, Sunnybrook Health Sciences Centre; Carole LeBlanc, The Ottawa Hospital; Nadim Srour, Université de Sherbrooke; Marie-Eve Bedard, Université Laval; Kathy Walker, The Ottawa Hospital Rehabilitation Centre

Our focus of research is on individuals with neuromuscular, thoracic restrictive or neurologic conditions who are at risk for, or are using long-term ventilatory support. We have made efforts to bring an evidence base to a host of noninvasive airway management strategies, as well as taking a programmatic approach to understanding long-term ventilator support in Canada. The latter has been in cooperation with the national CANuVENT group of clinical researchers led by Dr. Louise Rose.

As a result of our efforts over the last few years, we have written the first Canadian home ventilation guidelines, supported through the Canadian Thoracic Society (CTS). We have established evidence for (long practiced) noninvasive airway strategies, particularly lung volume recruitment (LVR), both in terms of its acute and longer term effects on lung mechanics. We have developed a digital monitoring device to measure adherence with LVR. The device is currently being used in a Canadian multicenter randomized controlled trial, as well as an international randomized controlled trial in Melbourne Australia. We have published our unique experience with 24-hour noninvasive ventilatory support, using mouthpiece ventilation during the day and mask noninvasive ventilation at night, both in individuals with Duchenne muscular dystrophy and with ALS.

We have obtained funding from a number of sources including CIHR, the International Ventilator Users Network (IVUN) and Muscular Dystrophy Canada (MDC), among others. Our research has informed us, for the first time, of significant information regarding long-term ventilatory support in Canada. This includes the definition of transitions through the continuum of care for ventilator assisted individuals, and the incidence of long-term ventilated individuals in the community, in long-term care facilities, and in critical care. We have been able to document the frequency, nature and cost of healthcare utilization for individuals with neuromuscular conditions in Ontario. In addition, we have evaluated the experience of individuals using ventilatory support in their transition from hospital to home, and for young people transitioning from pediatric to adult care. We have also recently assessed adherence with the airway clearance recommendations of the Canadian Home Ventilation Guidelines, both in Canada and the United Kingdom.

We are currently evaluating the impact of our CANVent website (www.canventottawa.ca) on educational outcomes and patient care, and developing a web-based program providing peer support to caregivers of ventilator supported individuals in the community. We are also working on an update of the Canadian Home Mechanical Ventilation Guidelines. The updated guidelines for respiratory management of ALS, supported by the CTS, will be published in early 2019. In addition, we are evaluating the educational requirements, and real-life clinical practice, surrounding the use of the CoughAssist device for individuals with neuromuscular disease, provided and coordinated through the Ontario Ventilator Equipment Pool. Future work will focus on the assessment of a web based program for self-management in individuals with chronic respiratory conditions including ventilatory support.

Selected Publications

Dale, C. M., King, J., Nonoyama, M., Carbone, S., McKim, D., Road, J., … Rubenfeld, G. (2018). Transitions to Home Mechanical Ventilation. The Experiences of Canadian Ventilator-assisted Adults and Their Family Caregivers. *Annals of the American Thoracic Society, 15*(3), 357-364. doi:10.1513/annalsats.201708-663oc

Nonoyama, M. L., McKim, D. A., Road, J., Guerriere, D., Coyte, P. C., Wasilewski, M., … Rose, L. (2018). Healthcare utilisation and costs of home mechanical ventilation. *Thorax, 73*(7), 644-651. doi:10.1136/thoraxjnl-2017-211138

Rose, L., McKim, D., Leasa, D., Nonoyama, M., Tandon, A., Bai, Y. Q., … Gershon, A. (2018). Patterns of healthcare utilisation for respiratory complications of adults with neuromuscular disease: a population study. *European Respiratory Journal, 52*(3), 1800754. doi:10.1183/13993003.00754-2018

Rose, L., McKim, D., Leasa, D., Nonoyama, M., Tandon, A., Bai, Y. Q., … Gershon, A. (2018). Respiratory health service utilization of children with neuromuscular disease. *Pediatric Pulmonology, 53*(10), 1378-1386. doi:10.1002/ppul.24145

Rose, L., McKim, D., Leasa, D., Nonoyama, M., Tandon, A., Kaminska, M., … Road, J. (2018). Monitoring Cough Effectiveness and Use of Airway Clearance Strategies: A Canadian and UK Survey. *Respiratory Care, 63*(12), 1506-1513. doi:10.4187/respcare.06321

Bédard, M.-E., & McKim, D. A. (2017). Continuous Mouthpiece Daytime Amyotrophic Lateral Sclerosis in Noninvasive Ventilation: Definitive Solid Therapy?—Reply. *Respiratory Care, 62*(3), 387-388. doi:10.4187/respcare.05453

Dale, C. M., King, J., Amin, R., Katz, S., McKim, D., Road, J., & Rose, L. (2017). Health transition experiences of Canadian ventilator-assisted adolescents and their family caregivers: A qualitative interview study. *Paediatrics & Child Health, 22*(5), 277-281. doi:10.1093/pch/pxx079

Molgat-Seon, Y., Hannan, L. M., Dominelli, P. B., Peters, C. M., Fougere, R. J., McKim, D. A., … Road, J. D. (2017). Lung volume recruitment acutely increases respiratory system compliance in individuals with severe respiratory muscle weakness. *ERJ Open Research, 3*(1), 00135-2016. doi:10.1183/23120541.00135-2016

Rose, L., Adhikari, N. K., Leasa, D., Fergusson, D. A., & McKim, D. (2017). Cough augmentation techniques for extubation or weaning critically ill patients from mechanical ventilation. *Cochrane Database of Systematic Reviews*. doi:10.1002/14651858.cd011833.pub2

Bédard, M.-E., & McKim, D. A. (2016). Daytime Mouthpiece for Continuous Noninvasive Ventilation in Individuals With Amyotrophic Lateral Sclerosis. *Respiratory Care, 61*(10), 1341-1348. doi:10.4187/respcare.04309

Rose, L., Adhikari, N. K., Poon, J., Leasa, D., & McKim, D. A. (2016). Cough Augmentation Techniques in the Critically Ill: A Canadian National Survey. *Respiratory Care, 61*(10), 1360-1368. doi:10.4187/respcare.04775

Solomon, B. K., Wilson, K. G., Henderson, P. R., Poulin, P. A., Kowal, J., & McKim, D. A. (2016). Loss of Dignity in Severe Chronic Obstructive Pulmonary Disease. *Journal of Pain and Symptom Management, 51*(3), 529-537. doi:10.1016/j.jpainsymman.2015.11.007

The Rehabilitation Virtual Reality Laboratory

Team Members: Sandra MacLeod, Clinical Leader; Courtney Bridgewater, Operator; Louis Goudreau, Clinical Engineer; Edward Lemaire, Clinical Researcher; Patricia O'Neill, Research Engineer; Andrew Smith, Operator; Tony Zandbelt, Mechanical Technologist; The Ottawa Hospital Rehabilitation Centre Physiotherapy and Occupational Therapy Departments

The Rehabilitation Virtual Reality Laboratory (RVR Lab) is the product of a successful partnership between The Ottawa Hospital Rehabilitation Centre (TOHRC) and the Canadian Forces Health Services Group (CF H Svcs Gp). The RVR Lab uses the CAREN (Computer Assisted Rehabilitation Environment) Extended System for patient assessment, treatment and research.

CAREN is a versatile tool that immerses patients in a variety of visually stimulating environments. The system uses a 180° screen and a dual-treadmill platform and that can be modified to simulate different terrains. It is also interactive, allowing people to wear special markers on their hands or feet to kick or catch things on the screen. This provides a rich environment for patients and research participants to test their abilities and responses to different stimuli and different scenarios. A 3-D motion-capture system, force plates, and the ability to incorporate other electronic measurements (e.g., heart rate) means that measurement of movement, balance and other physical functions can be captured and analyzed later.

Since opening in 2011, the RVR Lab has:

- Conducted 3,650 clinical sessions with 497 patients
- Participated in 21 research projects
- Developed over 35 customized CAREN applications
- Published five papers in refereed journals
- Delivered over 37 presentations
- Hosted 160 tours/education sessions for employees, students, government officials and military dignitaries
- Highlighted/promoted clinical and research activities through news articles, radio interviews and television coverage

Research Projects

Unity Sock

For people with lower limb amputations, the interface between the prosthetic socket and the amputated limb is critical for comfort, walking efficiency, skin integrity and confidence in movement. A new elevated vacuum suspension system for prosthetic sockets was developed by an industry partner (Össur) and tested by patients at TOHRC.

The RVR Lab was used to assess the performance of this new prosthetic socket in various simulated walking scenarios. Results provided our industry partner with information on how the socket impacted the way participants walked, balanced, and put pressure on their limbs, which then allowed them to improve the design of the sockets.

Funded by Mitacs Canada

Slow Walking

It is known that users of lower limb exoskeletons walk at very slow speeds; between 0.2 and 0.45 m/s. The effect of speed on walking trajectories should be considered when programming device gait trajectories because “extremely” slow walking velocities affect kinematics, joint function, and stability.

We designed a study to evaluate the biomechanics of healthy controls walking at extremely slow walking velocities in a virtual reality (VR) environment. The CAREN system was programmed to control the treadmill at walking speeds between 0.2 m/s and 0.8 m/s. Gait data was collected from 20 able-bodied participants with no existing gait or health issues that could affect their ability to walk on level ground or inclines.

Results from this project were used to improve the system function of the ARKE™ exoskeleton. In addition, our findings contribute to a growing body of evidence that exoskeletons are safe and functional devices suitable for use in future clinical trials. Kinematic and kinetic data collected for this study is available for other groups investigating slow walking gait.

Funded by Bionik Laboratories

Using Machine Learning to Investigate Sympathetic Activation of the Autonomic Nervous System

Many rehabilitation patients experience one or more of the following complex medical conditions:

- Post Traumatic Stress Disorder (PTSD)
- Chronic Pain
- Mild Traumatic Brain Injury (mTBI)

These conditions are often associated with intractable symptoms that do not respond to traditional treatments. This is partly because patients often experience continual sympathetic activation of the autonomic nervous system (SAANS), which is a stress response that negatively impacts the effect of therapy.

Using the CAREN system, this project will collect and consolidate a series of non-invasive whole-body biological measurements from patients undergoing immersive therapy sessions. Machine learning algorithms will then be developed to flag real-time estimators of SAANS that can be used to understand when patients reach optimal therapy conditions in the lab. High-performance computing and machine learning will be provided by the Southern Ontario Smart Computing Innovation Platform (SOSCIP), in partnership with IBM Canada, to provide access for this project.

The ability to reliably identify when patients are becoming too stressed during treatment (or conversely, when they are not experiencing enough stimulation) will allow clinicians to create individualized treatment plans, thereby maximizing rehabilitation benefits and avoiding costly setbacks.

Funded by the Canadian Institute for Military and Veteran Health Research (CIMVHR)

Motion-Assisted, Multi-Modal Memory Desensitization Reconsolidation (3MDR)

Patients who have Post Traumatic Stress Disorder (PTSD) can experience anxiety and depression, and have a very difficult time functioning socially and managing avoidance behaviours. The impact of PTSD on military personnel extends from work issues to reduced quality of life. This treatment incorporates known therapeutic elements from Virtual Reality Exposure therapy (VREt) and Eye Movement Desensitization and Reprocessing (EMDR), while adding a motion-based component (walking on the treadmill).

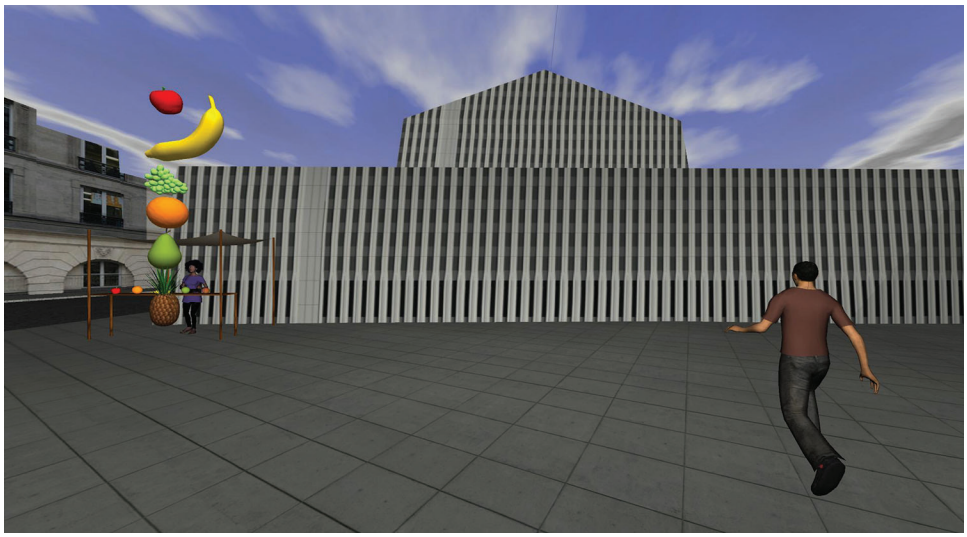
Five Canadian Armed Forces (CAF) members were treated through this modality. The main outcome measure was symptom severity, as measured by the PTSD Checklist (PCL). The mean absolute difference pre and post treatment was 13 (range 2-22). All participants were receptive to the treatment, and both participants and therapists gave positive feedback for the intervention. Findings suggest this treatment can be effective for patients who do not benefit from conventional therapy, offering new pathways for treating PTSD and other mental health disorders.

Sponsored by the Surgeon General

Customized CAREN Applications

The “Market” application features an outdoor urban environment for patients to explore. They can navigate freely while either standing or walking on the treadmill. The complexity of the setting can be scaled to match the abilities of individual patients.

Used clinically, this application provides an excellent challenge for multitasking in a busy environment with various objects moving within the field of view. An additional way-finding task requires patients to navigate themselves by scanning their surroundings to find specific buildings.



We have developed new research applications for measuring balance and weight shifting in people with concussion and complex regional pain syndrome. One application requires that the user shift their centre of mass (i.e., pelvis) to targets located on both sides, as well as in front and behind them. The distance to the targets is scaled to each user’s base of support.

A second application requires the user to control the position of their pelvis in response to a target moving side to side, or front and back.

A third version of the application scales the movement of the scene on the screen to the user’s movement while standing still. This provides a visual challenge to the user’s balance. This series of applications has been adapted for use in patient treatment as well.

Identifying Barriers and Facilitators to Skin Care in People with Spinal Cord Injury

Principal Investigator: Jeremy Grimshaw, The Ottawa Hospital Research Institute

Coinvestigators: Justine Baron, The Ottawa Hospital Research Institute; Toba Miller, Dorothyann Curran and Vidya Sreenivasan, The Ottawa Hospital Rehabilitation Centre

People with a spinal cord injury (SCI) are at risk of developing pressure ulcers; sometimes called pressure injuries or bed sores. Pressure ulcers develop because the skin breaks down from constant pressure on certain parts of the body (e.g., sacrum or ischial tuberosities). Research suggests that approximately 90% of people with an SCI experience a pressure ulcer at least once in their lifetime.

The burdens associated with pressure ulcers are considerable. From an economic standpoint, it is estimated that the cost associated with caring for a stage 3 pressure ulcer over three months amounts to $27,632 CAD, half of which is paid by the patient. The human burden associated with pressure ulcers is also high. A review of the impact of pressure ulcers on people with SCI showed they have a significant effect on physical, social, psychological, and financial aspects of health-related quality of life. In addition, the physical pain related to dealing with a pressure ulcer is a major concern for people with an SCI.

Sometimes people are in the hospital for months with a pressure ulcer. This impacts the health care system in general, as well as the health of the patient, due to restricted movement and limited socialization. There are skin care behaviours that a person with a spinal cord injury can perform to help prevent and manage existing pressure ulcers. Adherence to these behaviours is low, and there is not much known regarding the reasons.

Funded by the Rick Hansen Foundation, a group of researchers at the Ottawa Hospital Research Institute (OHRI) and The Ottawa Hospital Rehabilitation Centre (TOHRC) designed a study to identify factors influencing the performance of skin care in people with spinal cord injuries. We developed an interview template and interview guide using a Theoretical Domains Framework (TDF).

Over a one year period, a post-doctoral student interviewed 35 participants; recording and transcribing the interviews for later analysis. Two reviewers coded the transcripts into 14 domains, representing a list of 14 behavioural determinants.

1. Knowledge
2. Skills
3. Social/Professional Role and Identity
4. Beliefs about Capabilities
5. Optimism
6. Beliefs about Consequences
7. Reinforcement
8. Intentions
9. Goals
10. Memory, Attention and Decision Processes
11. Environmental Context and Resources
12. Social Influences
13. Emotions
14. Behavioural Regulation

A set of specific patient beliefs was then generated for each TDF domain. Beliefs were worded in a way that carried a meaning common to several utterances made in the interviews. Finally, the two reviewers identified high-priority TDF domains by considering 1) the frequency of a belief across transcripts, 2) the presence of conflicting beliefs, and 3) the strength of a belief impacting skin care.

- Participants were unaware of frequency recommendations for skin checks and pressure relief (Knowledge).
- Awareness of susceptibility to pressure ulcers was present (Knowledge), but often only became salient after experiencing pressure ulcers, and/or hearing pressure ulcers horror stories (Reinforcement).
- Participants did not believe that skin checks require skills (Skills), but there were some differences in the quality of care received (Environment).
- Some intended to perform skin checks everyday (Intention), while others relied on sensory cues (Behavioural Regulation) and situations (Memory, Attention and Decision Processes) to guide their skin checks.
- For pressure relieving behaviours, the location of adoption varied (Behavioural Regulation; Environment) and they were sometimes thought to interfere with activities (Beliefs about Consequences).
- Having alternate reasons to engage in pressure relief was an enabler (Intention) and the use of effective equipment considered crucial (Environment).

Health care providers can use these findings to facilitate their efforts to increase pressure relieving behaviours in persons with spinal cord injuries, to reduce the incidence of pressure ulcers, and to improve quality of life.

The Ottawa Hospital Rehabilitation Centre Clinical Psychology Outpatient Program: Outcome Evaluation of the Group Psychotherapy Program

Principal Investigator: Louise Balfour[1,2,3,4]

Coinvestigators: Monique Lefebvre[1,2,3] and Danijela Maras[1,2]
[1]School of Psychology, University of Ottawa; [2]The Ottawa Hospital Research Institute; [3]Psychology, The Ottawa Hospital; [4]Faculty of Medicine, University of Ottawa

The Clinical Psychology Outpatient Program at The Ottawa Hospital Rehabilitation Centre (TOHRC) helps outpatients cope with disabilities and chronic health conditions. In the past, service delivery focused on individual therapy, with some group-based sessions available as well. In recent years, changes to staffing have led to longer wait-lists for services. To better meet patient needs, we restructured the program to primarily offer evidence-based group psychotherapy.

Group-Based Cognitive Behavioural Therapy (GCBT): Coping with Disability/Health Conditions

The intervention was developed by health and rehabilitation psychologists at TOHRC (Drs. Louise Balfour and Monique Lefebvre), and was designed to accompany the self-management workbook called Positive Coping with Health Conditions: A Self-Care Workbook (Bilsker, Goldner, & Anderson, 2012). The psychologist-led group intervention comprises eight weekly sessions, each of 120 minutes with a 15-minute break. Using principles of cognitive-behavioural therapy, the group addresses the following topics:

1. Introduction to the stress, health, and self-care management model
2. Managing worry
3. Activating your life (goal-setting, pacing, and self-care)
4. Solving problems
5. Managing depressive thinking
6. Managing anger
7. Relationship building and healthy communication
8. Mindfulness and relaxation training

Group Psychodynamic Interpersonal Psychotherapy (GPIP): I-ADAPT

This psychologist-led psychotherapy group is based on an interpersonal psychotherapy approach to treating depression. The group includes 16 weekly sessions of group interpersonal psychotherapy, and is administered in a rolling format with new members entering the group as new spaces become open. Each session is 90 minutes in length.

To date, approximately 90 patients have consented to participate in this program evaluation study. We look forward to continuing participant recruitment, and examining outcome data from the group psychotherapy interventions. We hope to add to the limited research on group psychotherapy for rehabilitation populations, and increase our understanding of how to best support the psychosocial needs of adults living with a disability or chronic health conditions.

Selected Presentations

Syed, S., Maras, D., Wiebe, S., Lefebvre, M., & Balfour, L. (2017, June). *Exploring health behaviours and psychological factors in rehabilitation patients*. Poster presented at the 78th Canadian Psychological Association National Convention, Toronto, Ontario.

Maras, D., Balfour, L., Kowal, J., Wiebe, S., Farinon, L., & Tasca, G.A. (2016, November). *Group-based psychotherapies at a rehabilitation centre: Preliminary examination of patient characteristics and treatment uptake*. Poster presented at the North American Society for Psychotherapy Research Conference, Berkeley, California.

Wiebe, S., Balfour, L., Kowal, J., Henderson, P., Maras, D., Farinon, L., & Tasca GA. (2016, November). *Group psychodynamic interpersonal psychotherapy (GPIP) for depression in a rehabilitation psychology context: Pilot study examination of group process and changes in depression*. Poster presented at the North American Society for Psychotherapy Research Conference, Berkeley, California.

Students/Trainees

Danijela Maras,
PhD Student in Clinical Psychology, University of Ottawa (supported by a studentship from Mental Health Research Canada)

Shaezeen Syed
BSc Student in Health Sciences, University of Ottawa

Dr. Stephanie Wiebe
Post-Doctoral Fellow, University of Ottawa

References

Bilsker, D., Goldner, E. M., & Anderson, E. (2012). Supported Self-Management: A Simple, Effective Way to Improve Depression Care. *The Canadian Journal of Psychiatry, 57*(4), 203–209. doi:10.1177/070674371205700402

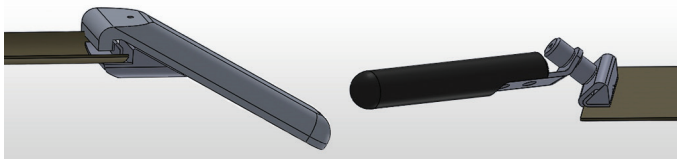
Rehabilitation Engineering Solutions

Team Members: Louis Goudreau, Clinical Engineer; Patricia O'Neill, Research Engineer; Tony Zandbelt, Mechanical Technologist; Jenn Taillon, Secretary

Rehabilitation Engineering collaborates with many areas of The Ottawa Hospital (TOH) to create engineering solutions for unique problems related to rehabilitation therapy, patient safety, and customized assistive devices, as well as rehabilitation technology prototyping and assessment. The following are highlights of our activities over the past two years.

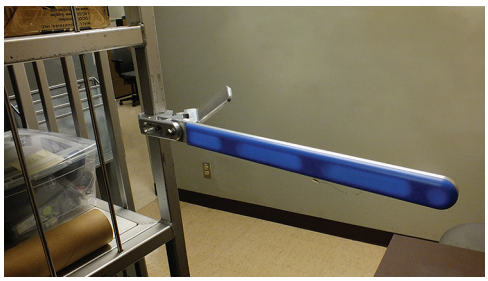
Rasp Handles

Rasps are hand tools used to shape plaster positive models when making orthoses. Typically, the flat edge of the coarse wood file sits between the thumb and index fingers of each hand. This can lead to repetitive strain injuries for some orthotists and prosthetists. Working with Occupational Health and Wellness, and the Prosthetics and Orthotics department, we developed two ergonomic handles that to attach to existing rasps. One design has a sturdy handle that fits well in the palm of the hand. The other design has round handles that are adjustable from a horizontal to a vertical position. These handles are removable and interchangeable. The user has the option to attach two of the same handles, or one of each at either end of the rasp.



Push Cart Handle

Working with Occupational Health and Wellness, we developed a quick release clip-on handle to help employees maintain proper posture while pushing heavy carts. The goal is to prevent back and shoulder injuries from occurring, and to help those already experiencing pain caused by prolonged use of heavy carts.

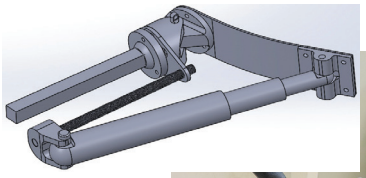


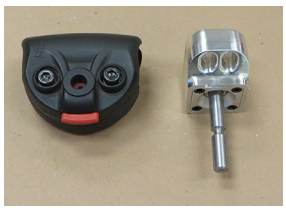
Length Adjustable Motorized Headrest

In collaboration with the Occupational Therapy department, we designed a compact motorized headrest that can be adjusted forward or backward by four inches. The design keeps the headrest horizontal and takes up minimum space behind the backrest. With the touch of a switch, the client can independently adjust the headrest to a position that provides optimum support to minimize neck pain and fatigue.

Motorized Headrest

Some clients need frequent headrest repositioning to reduce neck strain and improve comfort. In collaboration with Occupational Therapy at TOHRC, we designed a motorized headrest for a client to independently change the orientation. A metal band is fixed behind the headrest, where a mini electrical actuator and pivot assembly are inserted. With the touch of a button, the client controls the position of his headrest, changing the angle horizontally from left to right. This configuration can be used with almost all commercial headrests.





Spinner Knob for Hook Prosthesis

We designed a clip-on spinner knob for a client to operate a steering wheel while wearing his hook prosthesis. A ball joint is embedded inside the spinner knob, allowing proper freedom of movement for the hand prosthesis. By inserting his hooks inside the spinner holes, the client is able to maintain a secure grip on the steering wheel while driving. The spinner knob is transferable to other vehicles that have steering wheels instrumented with a commercial clip-on adaptor (e.g., truck, farming equipment). This work was completed in collaboration with Lynn Hunt, Senior Occupational Therapist at The Ottawa Hospital Rehabilitation Centre (TOHRC).

Power Lift Platform

We designed and installed a power lift platform for technicians working on power wheelchairs in the Occupational Therapy department. A built-in self-retractable ramp allows technicians to drive the wheelchair from the floor to the landing platform and raise it up to the proper height. When the platform is elevated, the ramp retracts and is suspended at the front edge of the lift, allowing technicians to work freely around it. When the platform is lowered back to ground level, the ramp extends itself outward so the wheelchair can be driven off the platform.

Physiotherapy Treatment Using Virtual Reality Applications

Investigators: Janet Holly[1,2], Courtney Bridgewater[1,2], Jennifer McDonald[2] and Andrew Smith[2], The Ottawa Hospital Rehabilitation Centre; James Green[2] and Adrian Chan[2], Carleton University; Markus Besemann[2], Rakesh Jetly[2] and Gaurav Gupta[2], Canadian Forces Health Services; T Packham[2], McMaster University

Treatment of Pseudo-Neglect in Patients with Complex Regional Pain Syndrome[1]

Physiotherapists have been using the Computer Assisted Rehabilitation Environment (CAREN) Extended System at The Ottawa Hospital Rehabilitation Centre (TOHRC) for the treatment of Complex Regional Pain Syndrome (CRPS). Clinicians have achieved many successes, even in individuals who have had no response to traditional CRPS treatments. The greatest success in using virtual reality clinically has been in addressing body perception disturbances and pseudo-neglect exhibited in this condition.

Neglect is a cognitive disorder secondary to lesions in one cortex. Patients affected by neglect have difficulty orienting, exploring and reporting sensory events from one side of space. Despite the lack of cortical lesion, patients with CRPS commonly experience neglect. These body perception disturbances are disruptions or alterations of the cortical representation of the body, or body schema used for sensory integration and motor planning.

We developed a series of virtual applications to specifically target sensory inputs. The virtual world provides an ideal scenario for manipulating sensory inputs to target specific areas of the vestibular system, allowing for the development of tailored treatments. This study is a pilot proof of concept to collect data for submission for funding to conduct a larger study.

A secondary, lower technology trial is being planned to translate this treatment into the community. A head-mount virtual reality system will be used to deliver specific applications that are tailored by a CRPS informed clinician. The head-mount technology has been trialed and the next step will be a series of ten trials.

Using Big Data Analytics and Machine Learning to Investigate Sympathetic Activation of the Autonomic Nervous System[2]

Physiotherapists at TOHRC have been using real time signs and symptoms of autonomic nervous system (ANS) activation as a key marker to determine treatment intensity and therapeutic benefit in patients with mild traumatic brain injury, chronic pain, and post-traumatic stress disorder. We discovered that therapists with more experience using the CAREN system had greater expertise at picking up subtle signs of ANS sympathetic activation, and tailoring treatments more effectively.

In some applications, therapists need to sit on the platform to observe their patients closely enough to target therapeutic “sweet spots”. This is not an ideal situation. Using big data analytics and machine learning, our goal is to more accurately pinpoint signs of activation during applications, allowing less experienced clinicians to improve patient outcomes.

A partnership between Carleton University’s Department of Systems and Computer Engineering and TOHRC has been formed to conduct this study. A tablet application is being created by Carleton University to facilitate data collection of time stamped ANS signs of symptoms in real time. Clinicians

will use the tablet application to capture moments of ANS activity while treating patients in the CAREN virtual reality world. Funding for the project is through a partnership between the Canadian Institute for Military and Veterans Health Research (CIMVHR) and IBM.

A sub-study is also planned in partnership with McMaster University School of Rehabilitation Science. During treatment in the CAREN virtual reality system, it is not uncommon for patients to comment that they see or hear things in the virtual reality world that do not actually exist as part of the application. The comments occur in moments of heightened ANS fight and flight activity, and the patients have no prior history of mental or physical health conditions with hallucinatory components.

A qualitative analysis of comments involving benign visual or auditory hallucinations will be carried out using time stamped data recordings of ANS physiological stress. Findings from this study will be knowledge translated to clinicians who work in low technology environments treating conditions with ANS sympathetic activity. Awareness of possible implications for strange comments during regular treatment techniques will help with tailoring treatment programs within patients' actual real baselines.

Selected Publications

Bostick, G., Kowalzcyk, M., & Holly, J. (2018, January 31). *Pain Neuroscience Education: Practical Perspectives from our Guest Panel: Part 1* [Audio podcast]. Retrieved from https://ignitephysio.ca/podcasts/episode-31-pain-neuroscience-education-practical-perspectives-from-our-guest-panel-part-1/

Bostick, G., Kowalzcyk, M., & Holly, J. (2018, January 31). *Pain Neuroscience Education: Practical Application Using a Case Study: Part 2* [Audio podcast]. Retrieved from https://ignitephysio.ca/podcasts/episode-32-pain-neuroscience-education-practical-application-using-a-case-study/

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Gobeil, F., Holly, J., & Packham, T. (2018). Mechanism-informed management for complex regional pain syndrome. *Canadian Journal of Pain, 2*(1), A4–A45. doi:10.1080/24740527.2018.1476310

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Holly, J. (2018). Does technology such as virutal reality have a role in the treatment of pain? *e-News Somatosens Rehab, 15*(3), 90-93. Retrieved from http://www.neuropain.ch/sites/default/files/e-news/e-news_somatonsens_rehab_15_3.pdf

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Packham, T., & Holly, J. (2016). Complex regional pain syndrome: Measurement matters. *Manual Therapy, 26*, e1. doi:10.1016/j.math.2016.07.012

Thirty Years of Sharing Outstanding Research and Development