

# 2016 Rehab Research News

Centre for Rehabilitation Research and Development  
The Ottawa Hospital Rehabilitation Centre



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Inspired by research. Driven by compassion. Inspiré par la recherche. Guidé par la compassion.

## Table of Contents

Message from the Director of Rehabilitation Research	1
Message from the Clinical Director and Physiatrist-in-Chief	2
Centre for Rehabilitation Research and Development	3
The Ottawa Hospital COPD Outreach Project: A Program Evaluation	4
The Candrive Research Program and its Role in Enhancing the Safety of Older Drivers	6
Rehabilitation Engineering Solutions	8
Developing Pain Expertise at The Ottawa Hospital	12
The Post Concussion Research-Based Clinic	14
Rehab Technology to Enhance Mobility	16
Psychosocial Aspects of Chronic Pain and Chronic Pain Rehabilitation	20
Psychological Research in Chronic Obstructive Pulmonary Disease	22
Rehabilitation Virtual Reality: Improving Clinical Outcomes & Advancing Rehabilitation Research	24

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## Message from the Director of Rehabilitation Research

I am pleased to present the third issue of Rehab Research News. We continue to be a part of the Clinical Epidemiology Program of the Ottawa Hospital Research Institute (OHRI), under the leadership of Dr. Dean Fergusson. I thank Dr. Fergusson for his support and continuing interest in our work. The focus of our research and development efforts continues to be the ultimate improvement of the lives of the clients we serve at The Ottawa Hospital Rehabilitation Centre (TOHRC).

I would like to thank our Physiatrist-in-Chief, Dr. Sue Dojeiji, for her strong support of all aspects of our research program. Dr. Dojeiji finished her term as Chief at the end of December. We are very grateful for all her efforts. We welcome the new Chief, Dr. Shawn Marshall. Dr. Marshall is a well-known rehabilitation researcher and we look forward to his leadership in the years to come. Mr. Fred Beauchemin joined us as the Clinical Director of TOHRC in 2014. We look forward to continuing to work with Fred to advance the research effort consistent with the clinical mandate of TOHRC.

I would like to acknowledge the commitment and support of our COO, Cameron Love, the CEO, Dr. Jack Kitts, and the entire Senior Management Team of The Ottawa Hospital (TOH). There is a strong commitment to clinically relevant research at TOH, and this commitment clearly extends to TOHRC. We are particularly excited for the establishment of the new vision for TOH which puts research at the front and center, "Inspired by Research and Driven by Compassion."

All of our research projects are administered through OHRI and, as well, all of our projects are reviewed and monitored by The Ottawa Hospital Research Ethics Board. In particular, I would like to thank the President and CEO of OHRI, Dr. Duncan Stewart, for his support. In addition, I would like to acknowledge Rob Hanlon, COO, and his staff, in particular Kim Adams, for providing invaluable support and advice throughout our development.

The Ottawa Hospital Foundation has been a consistent supporter of our activities and we look forward to working closely with the Foundation in the coming years, particularly in the effort to continue raising funds for the highly successful Virtual Reality Lab and the important Post Concussion Research-Based Clinic.

I would like to thank the dedicated researchers, who balance excellent research and very demanding clinical schedules. I am certain the clinical work makes for better research and conversely, that research makes for better clinical practice. However, I am well aware of the effect that severe financial pressures place on busy clinicians in relation to finding time for research activities. We hope to develop innovative ways to meet this challenge in the future.



**Dr. Jamie MacDougall**  
Director of Rehabilitation Research  
Centre for Rehabilitation Research and Development

I am very fortunate to have a hard-working and dedicated team in the Centre for Rehabilitation Research and Development (CRRD) office to support all our activities on a daily basis. Dorothyann Curran and Carolyann Cook both do invaluable work. I would also like to acknowledge the work of my secretary, Jennifer Taillon.

Finally, I thank all of the patients and families at the hospital for their participation in our research efforts. We do our research to benefit them, and we are very pleased with their enthusiasm for and willingness to participate in our research projects.

## 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. James 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.



**Frédéric Beauchemin**  
Clinical Director  
Rehabilitation, Geriatrics and Transitional Care  
The Ottawa Hospital



**Dr. Sue Dojeji**  
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 loved 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. 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.

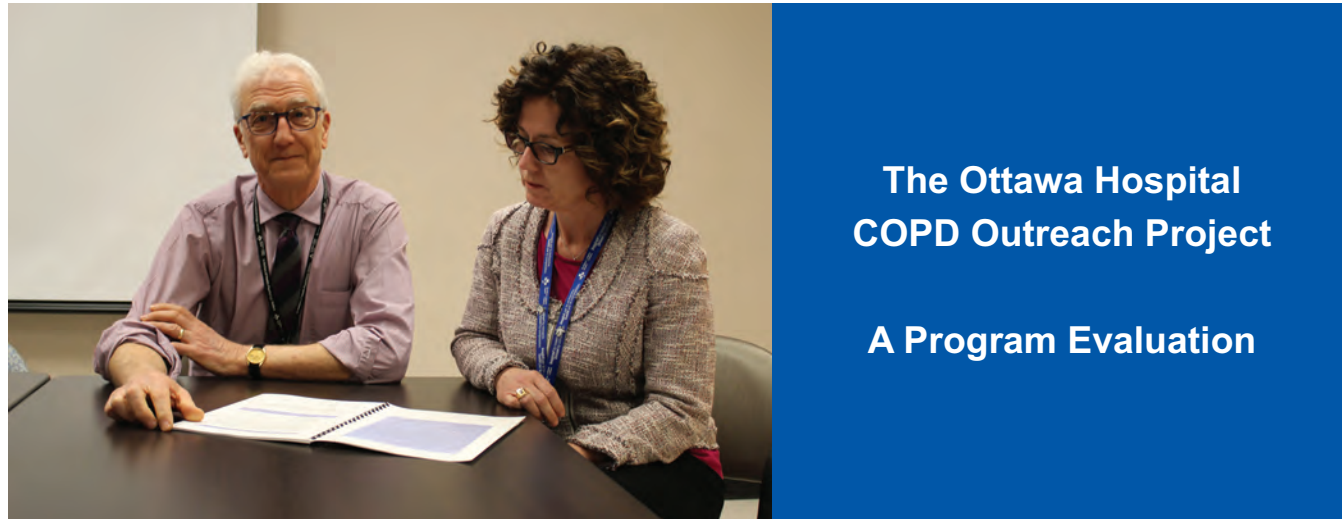
### Mandate

- 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 the 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.



## The Ottawa Hospital COPD Outreach Project

### A Program Evaluation

**Project Team Members:** Peter R. Henderson, Wendy Laframboise, Jacqueline Sandoz, Debbie Shalla and Dorothyann Curran, The Ottawa Hospital Rehabilitation Centre; Sunita Mulpuru, The Ottawa Hospital

**Students:** Dyana Castillo, School of Psychology, University of Ottawa; Adam Rocker, Faculty of Medicine, University of Ottawa

Chronic Obstructive Pulmonary Disease (COPD) is the most common cause of admission to acute care facilities in Canada. Patients are often discharged home with inadequate education, support or follow-up resulting in a repeating cycle of emergency department visits, readmission and discharge.

At The Ottawa Hospital (TOH) patients with COPD have a high rate of readmission within 30-days of discharge following an acute exacerbation of COPD, and the cost of treating these patients is higher than any other disease.

In November 2014, TOH implemented the COPD Outreach Program, a variation of a protocol supported by the Canadian Foundation for Health Improvement (CFHI). The program was designed to prevent and shorten hospitalizations related to acute COPD exacerbations and improve care quality, effectiveness and efficiency for patients, families and providers within TOH and the community.

Patients admitted to Respirology; Medicine and Family Medicine Services at TOH with an acute COPD exacerbation were invited to participate while in hospital. Each patient was provided self-management education, including a COPD action plan, coordination with the primary care physician in the community and a home-visit appointment within two weeks of discharge by a nurse practitioner. Home visits reinforce education and, as appropriate, allow referral to pulmonary rehabilitation, community programs, or palliative care. Following discharge, patients had the opportunity to contact an information line and, in addition to home visits, receive monthly phone calls during the first three months after hospitalization, and at 12 months.

We were interested in evaluating implementation of the program and demonstrating improvement in care quality, continuity, effectiveness and efficiency. Consistency of care, and community transition at discharge were also assessed.

The TOH COPD Outreach program is ongoing and evaluation continues. To date the following results have been obtained:

- 100% of patients received self-management education (including an action plan)
- 100% of patients who smoked received smoking cessation counselling
- 73% of patients had an appointment to see their primary care physician within seven days post-discharge from hospital
- 45% of patients were referred to community resources – 41% to pulmonary rehabilitation and 4% to palliative care; 55% were not interested in a referral to community resources
- 100% of primary care providers/specialists received a fax outlining the involvement of the outreach team

A primary goal of the TOH COPD Outreach program was to reduce emergency room visits and 30-day re-admission rates by 25% in this cohort of patients. Program effectiveness was assessed by comparing patient's health care utilization in the 12 months prior to and following enrolment in the outreach program.

**COPD-Related Healthcare Utilization**

	Pre-enrolment	Post-enrolment	% Change
30-day re-admission rate	10 (14.1%)	3 (4.2%)	-70%
Emergency department visits	29	11	-62.1%
Admissions	40	22	-45.0%
Average length of stay	6.0 days	4.9 days	-18.34%

Outcomes from the first year of operation have been shared regularly within TOH, and nationally through the Canadian Foundation for Health Improvement collaborative. The TOH experience has prompted funding for a second year of operation by the Champlain Local Health Integration Network.

*Funded by the Canadian Foundation for Health Improvement and the Centre for Rehabilitation Research and Development*

## The Candrive Research Program and its Role in Enhancing the Safety of Older Drivers



**Principal Investigators:** Shawn Marshall<sup>1,2</sup> and Malcolm Man-Son-Hing<sup>1,2</sup>

**Coinvestigators:** Michel Bédard<sup>3</sup>, Paul Boase<sup>4</sup>, Jude Charlton<sup>5</sup>, Sylvain Gagnon<sup>2</sup>, Isabelle Gélinas<sup>6</sup>, Sjaan Koppel<sup>5</sup>, Linda Li<sup>7</sup>, Barbara Mazer<sup>6</sup>, Anita Myers<sup>9</sup>, Gary Nagile<sup>10</sup>, Michelle Porter<sup>8</sup>, Mark Rapoport<sup>10</sup>, Ian Stiell<sup>1,2</sup>, Holly Tuokko<sup>11</sup>, Brenda Vrkljan<sup>12</sup>, George Wells<sup>1,2,13</sup>

<sup>1</sup>Ottawa Hospital Research Institute, <sup>2</sup>University of Ottawa, <sup>3</sup>Lakehead University, <sup>4</sup>Transport Canada, <sup>5</sup>Monash University, <sup>6</sup>McGill University, <sup>7</sup>University of British Columbia, <sup>8</sup>University of Manitoba, <sup>9</sup>University of Waterloo, <sup>10</sup>University of Toronto, <sup>11</sup>University of Victoria, <sup>12</sup>McMaster University, <sup>13</sup>University of Ottawa Heart Institute

The Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive), supported through CIHR funding programs (2002-2016), is a national, multidisciplinary team focused on research pertaining to older driver safety. The program has made multiple advances in researching older driver safety, generating results that have influenced health care professionals and policy makers, both nationally and internationally. Accomplishments of this team include establishing a large Canadian prospective cohort of older drivers (928 enrolled study participants) that has been tracked for seven years across seven sites and four provinces.

This cohort, the first of its kind in the world, has been positioned for the development of a risk stratification tool that will aid clinicians and transport administrators in identifying persons who are at risk for driving due to health and medical factors. Comprehensive annual participant assessments including measures to evaluate cognition, physical ability, and driving behaviours have been collected prospectively to determine which factors are most predictive of risk for the primary outcome of at-fault motor vehicle collisions (MVCs).

To date, more than 35 million kilometres of driving data, including GPS tracking information, has been collected using in-car recording devices. This represents the largest dataset of older driver data in the world. Data collection for this study will be completed in December 2015 with plans for analysis and derivation of the risk stratification tool over the course of 2016. Further results from inter-related subprojects will continue to provide information on driving patterns, simulator evaluation, psychosocial factors of driving, and older driver vehicle preferences.

In addition to the Canadian research initiatives, a collaborative partnership has developed over the years with research teams in Australia and New Zealand. This group of researchers was successful in obtaining funding to pursue the Candrive protocol (Ozcandrive) and has collectively recruited 302 participants. As well as demonstrating the importance of older driver safety internationally, this linkage allows for the opportunity to validate the risk stratification tool on an independent and international sample, and provide insights into the generalizability of the tool.

The information gathered thus far has been presented at conferences across North America and internationally. In addition, significant efforts have been put forth to develop stakeholder relationships in preparation for mobilization of knowledge generated from this grant to end users, including physicians

and motor transportation authorities. In 2013, a special issue of the journal *Accident Analysis and Prevention* (Volume 61, pp. 233-321) featured 13 articles summarizing findings from baseline assessment data. Additionally, a special issue containing 10 articles will be published in 2016 in the *Canadian Journal on Aging*.

The hope is that the Candrive research team will continue to be successful in securing additional funding to continue its work in the area of older driver safety, thereby improving the lives of older drivers in Canada and abroad.

*Funded by the Canadian Institutes of Health Research and Auto21 Centre of Excellence*

### Selected Publications

Chiu Wai JK, Gélinas I, Benoit D, Chilingaryan G. The predictive validity of the Montreal Cognitive Assessment (MoCA) as a screening tool for on-road driving performance. *British Journal of Occupational Therapy*. 2015;78(2):100-108.

Jouk A, Tuokko H, Myers A, Marshall S, Man-Son-Hing M, Porter MM, Bédard M, Gélinas I, Korner-Bitensky N, Nagile G, Rapoport M, Vrkljan B. Psychosocial constructs and self-reported driving restriction in the Candrive II older adult baseline cohort. *Transportation Research Part F: Traffic Psychology and Behaviour*. 2014;27:1-10.

Levasseur M, Audet T, Gélinas I, Bédard M, Langlais, M-É, Therrien F-H, Renaud J, Coallier J-C, D'Amours M. Awareness tool for safe and responsible driving (OSCAR): a potential educational intervention for increasing interest, openness and knowledge about the abilities required and compensatory strategies among older drivers. *Traffic Injury Prevention*. 2015;16(6):578-586.

Mazer B, Gélinas I, Duquette J, Vanier M, Rainville C, Chilingaryan GA. A randomized clinical trial to determine effectiveness of driving simulator retraining on the driving performance of clients with neurological impairment. *British Journal of Occupational Therapy*. 2015;78(6):369-376.

Porter MM, Smith GA, Cull AW, Myers AM, Bédard M, Gélinas I, Mazer BL, Marshall SC, Nagile G, Rapoport MJ, Tuokko HA, Vrkljan BH. Older driver estimates of driving exposure compared to in-vehicle data in the Candrive II study. *Traffic Injury Prevention*. 2015;16(1):24-27.

Rapoport MJ, Weegar K, Kadulina Y, Bédard M, Carr D, Charlton JL, Dow J, Gillespie IA, Hawley CA, Koppel S, McCullagh S, Molnar F, Murie-Fernandez M, Nagile G, O'Neill D, Shortt S, Simpson C, Tuokko HA, Vrkljan BH, Marshall S. An international study of the quality of national-level guidelines on driving with medical illness. *Quarterly Journal of Medicine*. 2015;108(11):859-869.

Sukhawathanakul P, Tuokko H, Rhodes RE, Marshall SC, Charlton J, Koppel S, Gélinas I, Nagile G, Mazer B, Vrkljan B, Myers A, Man-Son-Hing M, Bédard M, Rapoport M, Korner-Bitensky N, Porter MM. Measuring driving-related attitudes among older adults: Psychometric evidence for the decisional balance scale across time and gender. *Gerontologist*. 2015;55(6):1068-1078.

Tuokko H, Jouk A, Myers A, Marshall S, Man-Son-Hing M, Porter MM, Bédard M, Gélinas I, Korner-Bitensky N, Mazer B, Nagile G, Rapoport M, Vrkljan B. A re-examination of driving-related attitudes and readiness to change driving behavior in older adults. *Physical and Occupational Therapy in Geriatrics*. 2014;32(3):210-227.



## Rehabilitation Engineering Solutions

**Team Members:** Louis Goudreau, Clinical Engineer; Patricia O'Neill, Research Engineer; Joao Tomas, Electronics Technologist; Tony Zandbelt, Mechanical Technologist; Jennifer 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.

### CANStep Adjustable Therapy Stairs

The CANStep adjustable therapy stairs were developed in collaboration with the Physiotherapy department at The Ottawa Hospital Rehabilitation Centre (TOHRC). Fixed steps are usually four or six inches high and most clients are unable to accomplish this in the early stages of rehabilitation. The CANStep adjustable staircase provides a safe and quick method for training patients to climb and descend stairs. Four variable height stair risers allow for small uniform increases in step height from three to 10 inches. In addition, there is enough space and weight capacity on the stairs and top platform to accommodate both patient and therapist, if necessary. When step height is increased gradually from one training session to another, patients feel motivated by the sense of accomplishment in completing a full set of stairs, even if at a reduced height. Patent applications have been filed with assistance from the Ottawa Hospital Research Institute (OHRI) Technology Transfer Office.



### Improved Trolleys for the Hyperbaric Chamber

The existing stretcher trolleys for the hyperbaric chamber at TOH did not roll smoothly, requiring two people to push them. Furthermore, the trolleys would not stay straight, making it difficult to align them



with the opening of the chamber. In addition to these design issues, the need for a trolley that could accommodate patients in a seated position was identified, and nothing suitable was commercially available. An economical solution was devised using two new stretcher trolleys as the basis. The top stretcher portions were



removed and rails were built so the stretcher or seat would align and slide smoothly into the chamber. With this improved version, one person can easily manoeuvre the trolley, and align and disengage it from the machine. The changeover from old to new equipment was accomplished without closures or negative impact on patient care.

### The Stairwell Chair

Hospital stairs are often used to assess patients during treatment and prior to discharge. A chair should be available if a patient needs to rest, but leaving a chair in a stairwell landing is contrary to fire regulations. Having a clinician carry a chair up and down a flight of stairs for each assessment is also not a safe practice.

Physiotherapy and Rehabilitation Engineering worked together to develop a cost effective seat for patients to rest on that would also meet all hospital requirements including clinical needs, fire regulations, infection control, and occupational health and safety standards. To meet fire code requirements, the seat was constructed entirely of metal and was mounted on the wall. In addition, it was designed to automatically fold to a depth of less than five inches from the wall to keep the stairway clear when not in use.

Complete with armrests and back support, the chair has the capacity to support patients up to 450 lbs. Minimal joints, edges and openings allow for easy cleaning and disinfecting.

The initial prototype was reviewed by the fire marshal, clinical leaders, and infection control staff, after which improvements were made. Two evaluation prototypes have been installed at TOHRC and the Civic Campus of TOH. Initial feedback from clinicians has been very positive. If deemed successful after the full evaluation period, seats will be fabricated and installed in stairways at all campuses of TOH.



## Ergonomic Modifications to Floor Scrubbers



Occupational Health and Safety approached us to modify their existing floor scrubbers to make it easier for staff to get on and off the equipment. Steps were added to the tubular side bumpers, and handles were added alongside the steering column to assist with boarding. In addition, modifications were made to safely increase the depth adjustment of the seat.

## Lung Volume Recruitment (LVR) Practice Monitors

Muscle weakness in conditions with spinal nerve or muscle dysfunction results in respiratory complications including atelectasis, pneumonia and hypoventilation. Lung volume recruitment (LVR) therapy is a means of stacking breaths to achieve greater lung volumes and assist airway clearance.



We designed a low-cost digital monitor to objectively measure patients' adherence to a home based LVR therapy program, in order to better correlate frequency of use and clinical improvement. The monitoring device incorporates two pressure sensors, a one way valve, and a digital data logger, and is designed to register a count only when proper LVR technique is detected. The device interfaces with standard LVR equipment, can monitor and retain data for several months without intervention, is low cost, compact, durable and lightweight. After use in several smaller studies at TOHRC and the Children's Hospital of Eastern Ontario, the monitor has been further developed for use in a large international study involving ten centres across Canada, as well as a study in Australia.

## CANVent Arm

The CANVent Arm Kit, now available across Canada, was created in collaboration with the CANVent Program at TOHRC to support non-invasive ventilation. A simple inexpensive flexible modular mouth piece holder was developed for a ventilator breathing tube. One end of the arm is fixed to the frame of a wheelchair, while the other end is shaped to bring the mouth piece close to the mouth.



## Cost Effective Improvements on Patient Equipment

Working with Biomedical Engineering and Nephrology, improvements were made to several different pieces of patient equipment that previously required frequent, time consuming and costly repairs, or where patient safety was potentially compromised. Weak components were redesigned and replaced on multiple units resulting in significant cost savings for the hospital.

## Custom Devices & Equipment for Patients

### Adaptive Equipment for Drumming

Working with Prosthetics and Orthotics at TOHRC, specialized equipment was developed for an amputee to allow him to continue performing with his band. With a prosthetic leg, the client was having difficulty stopping the drum kit from gradually moving away while playing. A portable floor, equipped with custom made locking brackets, was made to keep the drum pedals in a pre-set position. In addition, a custom drumstick holder was designed that incorporates quick release with a single locking action. The length and angle of the drumstick are adjustable, and it is held securely in place by a custom glove.



### Swing-Away Joystick Holder



Some clients need joysticks positioned more toward the midline, but midline mounts often break and need to be replaced repeatedly. A custom swing-away joystick holder was created for a client and mounted on the seat base of his power wheelchair. The angle of the joystick and the lateral position can be adjusted, and the swing-away arm slowly moves the joystick along an angled pathway ending between the rear wheel and front caster, providing ample room for transfers.



## Developing Pain Expertise at The Ottawa Hospital



### Burn Pathways

In 2011, physiotherapists and occupational therapists at The Ottawa Hospital Rehabilitation Centre (TOHRC) identified a need to develop a more coordinated care plan for patients with burns. At that time, TOHRC was admitting an increasing number of patients with burns, who were being repatriated to Eastern Ontario from Sunnybrook Hospital in Toronto, following acute care management.

Clinicians at TOHRC wanted to ensure that patients were receiving the best evidence based care possible in order to maximize their outcomes with available resources. An interdisciplinary group of inpatient and outpatient clinicians, representing all disciplines of care, developed pathways that are currently being used in clinical care.

These pathways consist of a triage tool with specific assessment findings to identify the best pathway of care for inpatient rehabilitation, day hospital rehabilitation, and outpatient rehabilitation. Each pathway has multidisciplinary targets to address needs and maximize outcomes for patients who have sustained significant burns.

The pathways have been shared nationally with physiotherapists at the Canadian Physiotherapy Association national congress in 2014, and are currently being updated following the initial pilot phase.

Team Members: Locomotor Care Stream, The Ottawa Hospital Rehabilitation Centre; Barbara d'Entremont, The Ottawa Hospital

### Complex Regional Pain Syndrome Task Force

An interdisciplinary task force was organized in response to an increase in the number of referrals for patients who were seeking evidence based care for the management of Complex Regional Pain Syndrome (CRPS). At the time, services were being provided in a non-integrated fashion, leading to delays in the identification of needs for some disciplines.

Team members were concerned that length of stay and outcomes were being negatively impacted by these delays. Consequently, the task force met to identify what the needs of the clients were and what treatments could be offered in a coordinated manner. The group is currently looking at an algorithm to be used for triage of appropriate clients, based on needs and flags.

The task force also felt there was a need to use community partners for patients with uncomplicated CRPS. However, it was important to ensure that patients who were referred to community partners received the same evidence based care as those treated within TOHRC. A community educational component need was identified, and a course was held in November 2015 for community providers to share expertise for the less complex CRPS patients.

The task force is currently developing a clinical pathway for this population in order to quickly identify potential barriers for progress, select the right intensity of therapy, and use community resources efficiently. Each pathway uses a self-management recovery approach to treatment, and has multidisciplinary outcome targets to address the immune, neuroinflammatory, and maladaptive neuroplastic changes that occur in CRPS.

Task Force Members: Locomotor Care Stream, The Ottawa Hospital Rehabilitation Centre; Barbara d'Entremont, The Ottawa Hospital

### Physiotherapy Corporate Pain Task Force

Early identification and prevention of long term pain is vital to the rehabilitation process. The goal is to determine the ideal moment at which a focussed assessment can detect the early signs of maladaptive neuroplasticity and optimally, reverse it with appropriate treatment.

A task force comprised of physiotherapists from across The Ottawa Hospital (TOH) identified factors that lead to persistent pain, and established a management strategy for prevention. Assessment tools and treatment approaches were then developed based on best practices, followed by education sessions for physiotherapists and occupational therapists working with patients experiencing complex pain.

Task Force Members: Janet Holly and Sandy MacLeod, The Ottawa Hospital Rehabilitation Centre; Eric Thériault, Shelly Bercovitch, Martine Hadley, Tina Alverez Wiest and Chantal Lauzon, The Ottawa Hospital

### Presentations

Holly J. Clinical pathways for the management of burns. Canadian Physiotherapy Association Congress; June 2014; Edmonton, Alberta.

Holly J. What to do with the "pain patient" in acute care. American Physical Therapy Association Combined Sections Meeting; February 2015; Indianapolis, Indiana.

Holly J, Thériault E. TED Talk: But I do not treat pain patients - why do I need to know this? Ontario Physiotherapy Association Annual Conference; May 2015; Ottawa, Ontario.





## The Post Concussion Research-Based Clinic

**Team Members:** Jamie MacDougall, Shawn Marshall, Deanna Quon, Laura Rees and Dorothyann Curran, The Ottawa Hospital Rehabilitation Centre; Andra Smith, University of Ottawa, Santanu Chakraborty, The Ottawa Hospital

The Ottawa Hospital Rehabilitation Centre (TOHRC) sees many people who have experienced concussions from a wide range of etiologies, such as motor vehicle collisions, work related injuries, sports injuries, and falls. Often, these individuals have predictable symptoms including headache, dizziness, difficulties with cognition, and sleep disturbance. Typically these symptoms resolve within the first month post injury, however, for a significant minority of patients (10 to 15%), symptoms persist much longer, leading to disability. Persisting symptoms can prevent return to school, work, and sporting activities.

Since April 2009, The Ottawa Hospital (TOH) has seen almost 3,000 people presenting to the Emergency Department with concussion or post concussion syndrome. The rate has steadily increased from about 350 in 2009 to over 650 in 2015. Rehabilitation is of critical importance in the continuum of care for this condition, and in October 2013 the research-based Post Concussion Clinic was opened at TOHRC. Two of our psychiatrists, Dr. Shawn Marshall and Dr. Deanna Quon, are responsible for assessing patients who have persisting symptoms more than three months post injury.

The need for post concussion research is becoming widely recognized as a priority in Ontario. Recent media coverage of severe concussion outcomes, and of professional athletes with chronic symptoms has augmented public and professional awareness of this condition. Our multidisciplinary post concussion research team includes psychiatry, psychology, neuropsychology and radiology. Since the clinic opened, there have been four main initiatives that team members have undertaken to enhance the provision of care to our patients.

1) An electronic mailout process for a set of clinical questionnaires has been created and successfully implemented. This process is designed to gather the most relevant clinical information and enhance the consultation process with the psychiatrist and nurse by having patients arrive at the clinic with completed questionnaires. This process was developed in collaboration with St. Michael's Hospital in Toronto, which is also using the same questionnaire package in their concussion clinic.

2) An informed consent process has been established to allow the clinical questionnaires to be stored in a database. This database will be used to better understand the patient population being served by the clinic, and may ultimately be available to other researchers wishing to collaborate with our research team on future post concussion projects. To date, over 90 questionnaires have been entered into the database.

3) A process-mapping exercise has been initiated, with three main goals identified: i) to establish the current process (who, what, when, why, how), ii) to create timelines for what happens when a patient is referred, and iii) to provide a baseline for the development of new processes related to research activities.

4) Two research projects specific to people with post-concussion syndrome are currently recruiting participants:

i) A Pilot Project Using Technology and Neuropsychology to Evaluate Concussion and Post Concussion Syndrome

This pilot project is designed to address an existing gap in concussion literature by evaluating both technological (MRI) and neuropsychological data on individuals who have had a concussion. The goal is to determine relationships between functional and behavioural issues and physiologic findings.

ii) Development of a Simple Clinical Prediction Rule for Identifying Vestibular Dysfunction in Patients with Persistent Post-traumatic Dizziness

This study is looking at developing an office-based prediction rule to identify which patients with persistent post-traumatic dizziness or imbalance will have functionally important vestibular deficits. This will allow clinicians to streamline individual care options and referrals.

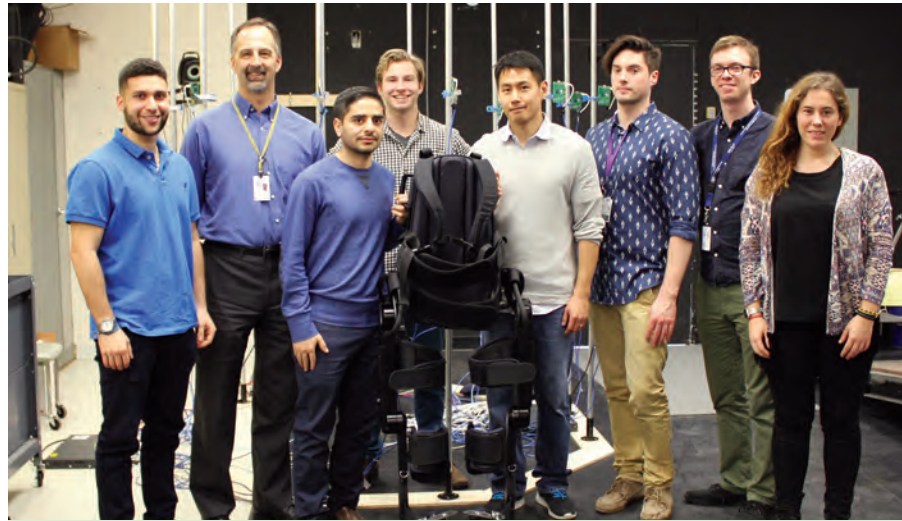
### Future Goals

Future goals include establishing more comprehensive collaborations with other partners in the Concussions Ontario network; a partnership led by the Ontario Neurotrauma Foundation (ONF). The Concussions Ontario network facilitates partnerships and information sharing for professionals, patients and the general public regarding concussion.

Improving access to information for patients on the waitlist is another priority for the post concussion clinic. A feasibility project has been developed which involves providing best practice, patient-specific information, through an internet-based feedback process as soon as a patient is placed on the specialized care wait-list. Both the patient and primary health care provider will receive a report, generated from individual health status information entered online as part of the referral process. Patient-centred care will be improved by providing immediate, targeted recommendations to the patient and their primary care provider at the same time.

### Conclusion

There has been an urgent need in our catchment area to have a dedicated post concussion research-based clinic to provide timely care for people suffering with persistent symptoms. This clinic is now well established and provides the ideal setting to ensure optimal timing and innovative methods for delivery of clinical care, as well as engaging in research into diagnosis, prognosis and intervention.



## 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 and David Nielen, The Ottawa Hospital Rehabilitation Centre; Nathalie Baddour, Marc Doumit and Reza Samadi, University of Ottawa; Jonathan Kofman, University of Waterloo; Peter Kyberd, University of New Brunswick; Laurent Frossard, Université du Québec à Montréal; Markus Besemann and Pauline Godsell, Canadian Forces Health Services; Adrian Chan, James Green and Yu Ono, Carleton University; Man-Sang Wong, Hong Kong Polytechnic University; Jorge A Vélez, Colombian Telemedicine Centre; Fangwei Zeng, International Society for Prosthetics and Orthotics; Jacqueline Hebert, University of Alberta; Helena Burger, Marco Rudolf and Nika Goljar, University Rehabilitation Institute, Republic of Slovenia

### Development of a Miniature Ultrasonic System Embedded with Allevia Peripheral Nerve Stimulator for Monitoring Regional Anesthesia

The iNano peripheral nerve stimulator (APNS) helps anesthesiologists precisely locate nerves when administering regional anesthesia by using extremely accurate electrical current and automatic detection of muscle responses. However, a better way is needed to verify the anesthesia's effectiveness (i.e., no movement when a nerve is stimulated) since small responses might not be visible. A successful system must be able to detect nonvisible muscle contractions during nerve stimulation. This project will develop and assess an ultrasound method for measuring small muscle movements, thereby providing a directly measurable method for verifying that the anesthesia is working.

### 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. A partnership between the Ottawa Hospital Research Institute (OHRI), the University of Ottawa, and Bionik Laboratories is underway to provide a cost effective and highly functional device for people with spinal cord injuries or lower extremity weakness. This exploratory study will evaluate the effectiveness of ARKE to improve physical capacity in a physical rehabilitation environment. This information can then be used to refine ARKE so that it is ready for everyday use.

### Smartphones for Enhancing Clinical Mobility Tests

In a healthcare environment, exercise capacity measurement is important for understanding a person's current status and evaluating rehabilitation improvement. The 6 minute walk test (6MWT), where the distance walked in 6 minutes is measured, is a common clinical tool

for this purpose. A smartphone with integrated sensors provides a viable platform for wearable biomechanical applications. For the 6MWT, wearable analysis can derive additional information with minimal setup, providing clinically useful and immediate output for evaluating physical function and gait characteristics at the point of patient contact, without the need to purchase specialized medical equipment. This project developed novel methods, algorithms and software for BlackBerry and Android smartphones that use the phone's sensors, multimedia, networking, and processing power to run the 6MWT, as well as 2 minute and 10 metre walk tests. By providing real-time results on outcomes such as total distance walked, step timing, gait symmetry, and walking changes over time, these applications have the potential to improve clinical decision-making.

### 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 their quality of life through adoption of a more active lifestyle. The objective of this study is to develop dynamic stability measures that will generate clinically useful information for assessing mobility. 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. 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. Individuals undergoing rehabilitation for lower extremity amputations will be evaluated using

state-of-the-art virtual reality technology, real-time movement analysis, plantar pressure measurement and analysis, and assessments of movement confidence and mobility. Results obtained with this group of patients will be potentially transferrable to other populations with mobility deficits.

### Wearable Mobility Monitoring Using BlackBerry Smartphones

Monitoring the mobility of people with physical disabilities is an important part of rehabilitation medicine. A wearable mobility monitoring system (WMMS) that can monitor mobility for extended periods both in the home and the community would be a valuable tool for clinical professionals. New smartphones provide a variable platform to create such a system. Our research uses all available BlackBerry sensors and multimedia capabilities to create a WMMS that can be easily used by the practitioner and client, without the need for external hardware. This system identifies activities and the context of the mobility state by fusing the sensor information (acceleration and global positioning system) to determine a change of state and then using the smartphone camera to record video for analysis. Custom software has been developed to assist the operator in coding the video output, and to allow secure data transfer between the smartphone and a central server. This enables users to analyze mobility anywhere appropriate Internet access is available. Current research activities include: WMMS evaluation with able-bodied, elderly, amputee, and orthosis user populations; automated video analysis to improve activity classification and extract the context of the activities; and development of improved user-specific calibration methods to enhance sensor-based change-of-state identification.

### 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. Functional and bench tests have been conducted and demonstrate that the orthotic system can handle large forces, provide free knee motion during walking, engage upon knee collapse, and support body weight while an individual recovers to a safe body position.

Evaluation with the Computer-Assisted Rehabilitation Environment (CAREN) Extended virtual reality system showed that people with knee extensor weakness can recover from a stumble perturbation. New research has resulted in a prototype intelligent, variable resistance control of the hydraulic knee to further improve mobility.

*Founding Sources: Canadian Forces Health Services, Natural Sciences and Engineering Research Council of Canada, Ontario Centres of Excellence and Slovenian Research Agency*

## Selected Publications

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Capela NA, Lemaire ED, Baddour N. Novel algorithm for a smartphone-based 6-minute walk test application: Algorithm, application development, and evaluation. *Journal of NeuroEngineering and Rehabilitation*. 2015 Feb 20;12:19. doi: 10.1186/s12984-015-0013-9.

Howcroft J, Kofman J, Lemaire ED. Review of fall-risk assessment in geriatric populations using inertial sensors. *Journal of NeuroEngineering and Rehabilitation*. 2013 Aug 8;10:91. doi: 10.1186/1743-0003-10-91.

Howcroft J, Lemaire ED, Kofman J, Kendell C. Understanding dynamic stability from pelvis accelerometer data and the relationship to balance and mobility in transtibial amputees. *Gait & Posture*. 2015;41(3):808-812.

Kendell C, Lemaire ED, Kofman J, Dudek NL. Gait adaptations of transfemoral prosthesis users across multiple walking tasks. *Prosthetics and Orthotics International*. Epub 2015 Feb 24, doi: 10.1177/0309364614568410.

Lemaire ED, Samadi R, Goudreau L, Kofman J. Mechanical and biomechanical analysis of a linear piston design for angular-velocity-based orthotic control. *Journal of Rehabilitation Research and Development*. 2013;50(1):43-52.

Sinitski EH, Lemaire ED, Baddour N, Besemann M, Dudek NL, Hebert JS. Fixed and self-paced treadmill walking for able-bodied and transtibial amputees in a multi-terrain virtual environment. *Gait & Posture*. 2015;41(2):568-573.

Sinitski EH, Lemaire ED, Besemann M, Dudek NL, Baddour N. Evaluation of motion platform embedded with force plate-instrumented treadmill. *Journal of Rehabilitation Research and Development*. 2015;52(2):221-234.

Wu HH, Lemaire E, Baddour N. Combining low sampling frequency smartphone sensors and video for a Wearable Mobility Monitoring System. *F1000Research*. 2014;3:170. doi: 10.12688/f1000research.4790.1.

Young JL, Lemaire ED. Linking bone changes in the distal femur to functional deficits. *International Journal of Osteoarchaeology*. 2014;24(6):709-721.

## Software Published

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

TOHRC Walk Test - Android Apps on Google Play  
<https://play.google.com/store/apps/details?id=ca.irrd.walktest>

TOHRC Data Logger for BlackBerry 10 - BlackBerry World  
<http://appworld.blackberry.com/webstore/content/32013891/?lang=en&countrycode=CA>

TOHRC Biomechanics Augmented Reality - BlackBerry World  
<http://appworld.blackberry.com/webstore/content/31059732/?lang=en&countrycode=CA>

TOHRC Video Event Recorder - BlackBerry World  
<http://appworld.blackberry.com/webstore/content/31049888/?lang=en&countrycode=CA>

TOHRC Wearable Mobility Monitoring System (WMMS) Acc - BlackBerry World  
<http://appworld.blackberry.com/webstore/content/60746/?lang=en&countrycode=CA>

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

## Graduate Students

### University of Ottawa

Biomedical Engineering (MAsc)  
Brandon Fournier  
Nicole Capela  
Andrew Herbert-Copley  
Emily Sinitski  
Marco Tundo  
Human Kinetics (PhD)  
Andrew Smith  
Sean Doyle

### Carleton University

Systems and Computer Engineering  
Payam Moradshahi, PhD  
Bruno Trindade, Post-doctoral Fellow

### University of Waterloo

Systems Design Engineering  
Dylan Drover, MAsc  
Jennifer Howcroft, PhD

## Psychosocial Aspects of Chronic Pain and Chronic Pain Rehabilitation



**Principal Investigator:** John Kowal, The Ottawa Hospital Rehabilitation Centre  
**Coinvestigators:** Keith Wilson and Peter Henderson, The Ottawa Hospital Rehabilitation Centre; Lachlan McWilliams, University of Saskatchewan; Patricia Poulin, Cathy Smyth and Howard Nathan, The Ottawa Hospital; Dean Fergusson, Ottawa Hospital Research Institute

Our program of research focuses on psychosocial aspects of chronic pain and chronic pain rehabilitation. One line of inquiry has examined suicidal ideation in individuals with chronic pain by testing relationships from the Interpersonal Theory of Suicide. This novel theory emphasizes the importance of two interpersonal constructs as precursors to suicidal thinking, namely perceived burdensomeness (the belief that one has become a burden to others) and thwarted belongingness (a lack of social integration or connection). Results to date indicate that suicidal ideation is significantly reduced following participation in interdisciplinary chronic pain rehabilitation. Of the variables studied, perceived burdensomeness appears to be the strongest predictor of suicidal ideation, even after adjusting for other known or putative risk factors related to pain, mental health, and social support.

Another line of inquiry has examined clinically important change in insomnia severity following participation in an interdisciplinary chronic pain rehabilitation program. Findings indicate that, although insomnia improves overall following treatment, most patients with clinical insomnia continue to have a significant sleep problem, and a small number of individuals may get worse. Interventions to alleviate persistent insomnia comorbid with chronic pain are likely to require a more intensive focus on sleep itself.

A third line of inquiry focuses on interdisciplinary treatment, including mindfulness-based stress reduction, psychosocial function, disability, and quality of life in breast cancer survivors with chronic neuropathic pain. A randomized controlled trial is currently under way, with preliminary results indicating that mindfulness mitigates the impact of pain experiences in cancer survivors experiencing chronic neuropathic pain at post-treatment. Specifically, two facets of mindfulness, namely acting with awareness and non-judging of inner experience, appear most closely associated with favourable outcomes.

In addition, program development/evaluation initiatives have focused on creating and assessing a corporate, centralized referral process for all patients with chronic pain, as well as integrating chronic pain services within The Ottawa Hospital. As part of the training mandate of the institution, psychology students and residents have been actively involved in all of the projects listed above.

*Funded by the Canadian Institutes of Health Research and the Canadian Breast Cancer Foundation  
Principal Investigator: Dr. P. Poulin*

## Selected Publications

McWilliams LA, Kowal J, Wilson KG. Development and evaluation of short-form versions of the Pain Catastrophizing Scale and the Pain Self-efficacy Questionnaire. *European Journal of Pain*. 2015; 19:1342-1349.

Kowal J, McWilliams LA, Péloquin K, Wilson KG, Henderson PR, Fergusson DA. Adult attachment insecurity predicts responses to interdisciplinary treatment for chronic pain. *Journal of Behavioral Medicine*. 2015;38:518-526.

Kowal J, Wilson KG, Henderson PR, McWilliams LA. Change in suicidal ideation following interdisciplinary treatment of chronic pain. *Clinical Journal of Pain*. 2014;30:463-471.

Emery PC, Wilson KG, Kowal J. Major depressive disorder and sleep disturbance in patients with chronic pain: A prospective study. *Pain Research & Management*. 2014;19:35-41.

McWilliams LA, Kowal J, Sharpe D, Dick BD. Psychometric refinement and evaluation of the Pain Response Preference Questionnaire. *Pain Research & Management*. 2014;19:42-48.

Wilson KG, Kowal J, Henderson PH, McWilliams LA, Péloquin K. Brief report: Chronic pain and the Interpersonal Theory of Suicide. *Rehabilitation Psychology*. 2013;58:111-115.

## Selected Presentations

Kowal J, Wilson KG, Henderson PR, McWilliams LA. Psychotherapeutic factors and treatment outcomes in chronic pain rehabilitation. Poster presented at: Annual Meeting of the Canadian Pain Society; May 2014; Quebec City, Quebec.

McWilliams LA, Dick BD, Verrier MJ, Kowal J. The role of pain-related support and pain-related support preferences in chronic pain patients' reports of disability and relationship satisfaction. Poster presented at: 7th World Congress of Cognitive and Behavioural Therapies; July 2013; Lima, Peru.

McKinnon J, Kowal J, Wilson KG, McWilliams LA, Henderson PR. Program evaluation of an interdisciplinary outpatient chronic pain management program. Poster presented at: Annual Meeting of the Canadian Psychological Association; June 2013; Quebec City, Quebec.

Wilson K, Kowal J, Henderson P, McWilliams L, Péloquin K. Chronic pain and the interpersonal theory of suicide. Poster presented at: 32nd Annual Scientific Meeting of the American Pain Society; May 2013; New Orleans, Louisiana.

## Students/Trainees

Katherine Péloquin, Psychology Resident  
Jacqueline McKinnon, Psychology Resident  
Brahm Solomon, Graduate Student  
Isabelle Ares, Psychology Resident  
Andrew Lumb, Psychology Resident

Jonathan Blasberg, Psychology Resident  
Adam Heenan, Psychology Resident  
Alison Welsted, Psychology Resident  
Dyana Castillo, Research Assistant  
Emma Ferguson, Undergraduate Student



## Psychological Research in Chronic Obstructive Pulmonary Disease

**Principal Investigators:** Brahm Solomon, University of Ottawa and Keith Wilson, The Ottawa Hospital Rehabilitation Centre

**Coinvestigators:** Peter Henderson, John Kowal and Doug McKim, The Ottawa Hospital Rehabilitation Centre; Patricia Poulin, The Ottawa Hospital

Keith Wilson has a long-standing interest in two areas of research in health and rehabilitation psychology. One of these areas is palliative care and the other is chronic pain. Recently, Keith and graduate student Brahm Solomon teamed up with other clinicians at The Ottawa Hospital Rehabilitation Centre (TOHRC) to conduct research with patients who have health-care needs that involve both of these areas.

Chronic obstructive pulmonary disease (COPD) is the 4th leading cause of death and the 6th leading cause of years lived with a disability, so both palliative care and rehabilitation are important considerations. For many years, TOHRC has been at the forefront of pulmonary rehabilitation for COPD in the Champlain region.

Brahm's doctoral thesis in psychology consisted of two studies, one grounded in the rehabilitation literature and one in palliative care.

The first study derived from a body of research in chronic pain. Some patients with chronic pain become very apprehensive about triggering flareups of their painful condition. They can become quite focused on physical symptoms, and they worry a lot about pain. Clinicians sometimes refer to this state of mental preoccupation as "catastrophizing".

In many studies, catastrophizing has been a better predictor of functional limitations than is the actual severity of pain. Like chronic pain, COPD is a medical condition that has an especially prominent physical symptom – in the case of COPD, the symptom is dyspnea, or breathlessness.

Just as people with chronic pain sometimes catastrophize about their pain problem, we wondered whether some patients with COPD might catastrophize about breathlessness. Hence, Brahm developed and validated a self-report questionnaire to assess the extent to which patients with COPD catastrophize.

He found that the Breathlessness Catastrophizing Scale was reliable and correlated well with measures of anxiety and depression, but not with pulmonary function tests or performance in standardized physical assessments of walking and stair-climbing. The scale was also sensitive to improvements with rehabilitation. Hence, although it was apparent that some patients did catastrophize about breathlessness to a considerable extent, they were still able to participate fully in the rehabilitation process. We concluded that breathlessness catastrophizing is a relevant concept in COPD, much as it is in chronic pain, but high levels of catastrophizing are not necessarily a barrier to rehabilitation success.

The second study had its conceptual basis in palliative care. Palliative care is an area that places particular significance on an individual's existential concerns, such as the preservation of dignity. For example, the popular term "death with dignity" is often considered a core value of palliative care. Surprisingly, however, there have been relatively few empirical studies of the prevalence and correlates of the loss of dignity, and all of those have taken place in the context of palliative cancer care.

As part of ongoing clinical assessment, patients entering the pulmonary rehabilitation program for COPD are interviewed by a clinical psychologist. The interview protocol includes a structured inquiry into the loss of dignity, focussing in particular on whether the patient experiences loss of dignity to be a significant ongoing problem.

In an analysis of interviews with 195 patients with severe COPD, Brahm found that 13% acknowledged a clinically significant concern with loss of dignity. This loss of dignity was correlated with measures of anxiety and depression, but not with pulmonary function measures. Interestingly, loss of dignity was experienced much more frequently by women with COPD (20.5%) than men (6.5%). When patients were re-interviewed after participating in pulmonary rehabilitation, 88% of those who initially experienced a significant loss of dignity reported that their dignity had been restored.

In the current healthcare climate, the concept of "death with dignity" has become, in some debates, a rallying cry for social action around the legalization of euthanasia and physician-assisted suicide. Interestingly, this study shows that the loss of dignity is not necessarily an irreversible condition. Rather, it is a psychological construct associated with other aspects of psychological distress, which is amenable to change with appropriate treatment. The pulmonary rehabilitation program at TOHRC clearly offers an effective treatment in this regard for patients with severe COPD.

### Selected Publications

Solomon BK, Wilson KG, Henderson PR, Poulin P, Kowal J, McKim DA. A Breathlessness Catastrophizing Scale for chronic obstructive pulmonary disease. *Journal of Psychosomatic Research*. 2015;79:62-68.

Solomon BK, Wilson KG, Henderson PR, Poulin PA, Kowal J, McKim DA. Loss of dignity in severe chronic obstructive pulmonary disease. *Journal of Pain and Symptom Management*. doi: 10.1016/j.jpainsymman.2015.11.007. Epub 2015 Nov 24.

## Rehabilitation Virtual Reality Improving Clinical Outcomes & Advancing Rehabilitation Research



Ron de Vries Photography ©

**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; Joao Tomas, Electronics Technologist; Tony Zandbelt, Mechanical Technologist; The Ottawa Hospital Rehabilitation Centre Physiotherapy and Occupational Therapy Departments

The Rehabilitation Virtual Reality Lab (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.

The CAREN system is comprised of a dual belt treadmill positioned within a moving platform, and at the centre of a three meter high curved screen that displays different virtual environments. Users interact with the system in real time through motion capture technology, providing clinicians and researchers with data on how the user is moving. The system has a secure safety mechanism, which allows patients the freedom to push their boundaries by trying new activities earlier in their rehabilitation.

Since the RVR Lab opened in 2011, approximately 300 patients have used the system as part of their rehabilitation therapy program. With a focus on balance, gait and multi-tasking re-training, and multi-sensory neuroplasticity and desensitization, the RVR Lab has helped patients with a wide range of disabilities such as orthopedic injuries, brain injuries (including concussion), complex regional pain syndrome, spinal cord injuries, and other neurological disorders.

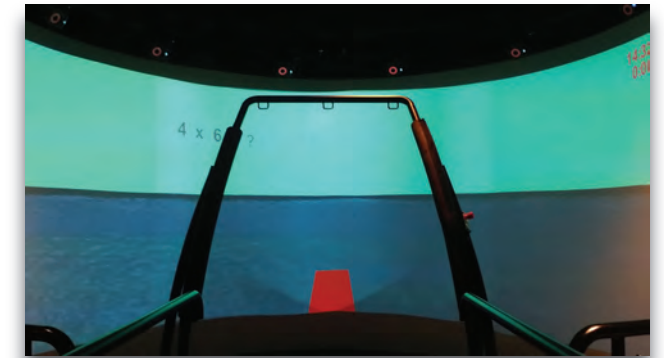
A unique advantage of the CAREN system is the ability to tailor research or treatment sessions to each individual's specific needs. RVR Lab staff work with researchers and clinicians to create new and innovative CAREN applications for research studies and to meet patient therapy requirements. All applications are created with multiple uses in mind, to fulfill treatment and research goals that are universal across patient groups. Over the past four years, we have developed and upgraded over 20 new applications. In addition, we have exchanged content with our partners at the Glenrose Rehabilitation Centre in Edmonton, and with the CF H Svcs Gp.

### Clinical Applications

Clinical applications are designed to supplement traditional physiotherapy and occupational therapy by providing treatment options that cannot be duplicated safely in the traditional therapy setting. Three of the newest programs are highlighted below.

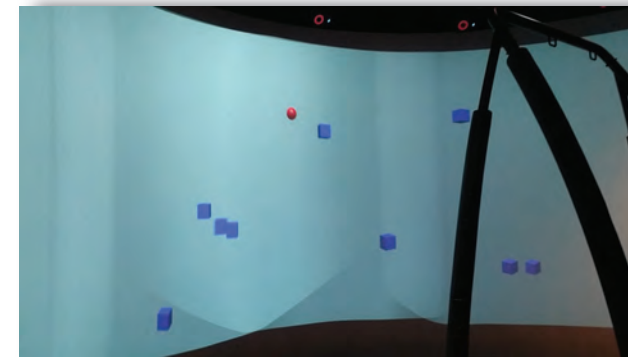
#### Paddle Boarding/Surfing

The 'Paddle Boarding/Surfing' application was developed to help patients work on their standing balance as the platform moves continuously under their feet. The application mimics the feeling of standing on a floating object in the water, and if the patient leans too much to one side, the platform will also tilt, simulating real-world scenarios. With several difficulty settings available, clinicians are able to evaluate balance in a variety of situations. In addition, there are options to include secondary cognitive tasks (e.g., naming objects, identifying words, or answering math questions) and sensory tasks (e.g., visual exercises such as tracking a randomly moving object).



#### Smooth Pursuit Task

Many patients who have sustained a brain injury or who have other sensory dysfunctions find it challenging to process multiple moving objects. This, in turn, can hinder their ability to function in crowded, busy environments. The 'Smooth Pursuit' application requires patients to complete a target tracking task by visually following an object that is moving on the screen. For added difficulty, the task can be completed in a sitting position, a standing position, or while walking. There is also an option to introduce distractions, with multiple objects moving around the screen at the same time as the target. The targets and distracters can be set against a blank screen or added to our other applications. Over repeated sessions, patients can process moving objects with increasing levels of difficulty, and ultimately regain their ability to participate in daily activities.



#### Moving Train

The third application, which simulates walking on a busy, moving train, incorporates multiple layers of difficulty and can address a wide range of treatment goals. Balance can be challenged by creating physical perturbations with platform movement, as well as by altering visual perceptual cues within the environment. For example, a patient can be walking forward in the train while the scenery outside the train is moving backward. The program can also add objects and people to 'clutter' the train in order to help patients adapt to busy environments.



## Hardware Modifications

The RVR Lab and Rehabilitation Engineering have worked together to further develop the hardware infrastructure of the CAREN system. Three projects have been completed to date.

1. To improve data collection during research studies, a signal box was created that allows the CAREN software to remotely trigger our motion analysis software, ensuring that data acquisition is synchronized between the two systems.
2. To increase the efficiency of motion capture from the cameras, RVR Lab staff redesigned the camera layout, and Rehabilitation Engineering staff created a new camera holder that hangs from the ceiling. This increases the field of view by allowing the camera to be placed further away from the system.
3. The CF H Svcs Gp requested the integration of a mock rifle with the CAREN system. Rehabilitation Engineering modified the mock rifle to create a trigger movement that could be recognized by motion capture sensors. Following this, a custom software subroutine was developed to identify when the trigger is pulled, and whether the rifle is pointed in the proper direction to hit a target.

## Research Initiatives

Research conducted in the RVR Lab aims to develop methodologies and best practices to improve patient care delivered through our physical and mental health rehabilitation programs. Areas of focus include device evaluation (knee-ankle-foot orthoses, lower limb prostheses, and an exoskeleton), non-level gait biomechanics with a dynamic stability focus, and a CAREN-based gait training program. These studies have been led by TOHRC staff, as well as research teams based at Defense Research & Development Canada (DRDC) in Toronto, and CF H Svcs Gp in Ottawa.

Future research plans include the development and assessment of CAREN-based therapies for post traumatic stress disorder and post concussion syndrome, and continued evaluation of the exoskeleton with patients who have spinal cord injury. In addition, a collaborative effort with the Department of Anthropology at the University of Victoria will examine CAREN's effectiveness in treating patients with multiple disabilities.

Presentations of the research, clinical and technical work conducted in the RVR Lab have been held at the Canadian Institute for Military and Veterans Health Research Forum (2012-2015), the World Congress on Medical Physics and Biomedical Engineering (2015), the Motek User Group Meeting (2014), and the IEEE International Symposium on Medical Measurements and Applications (2013).