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Elderly Falls

Literature Review

Reducing fall risk by improving balance control: Development, evaluation and knowledge-translation of new approaches

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Abstract

Problem

Falling is a leading cause of serious injury, loss of independence, and nursing-home admission in older adults. Impaired balance control is a major contributing factor.

Methods

Results from our balance-control studies have been applied in the development of new and improved interventions and assessment tools. Initiatives to facilitate knowledge-translation of this work include setting up a new network of balance clinics, a research-user network and a research-user advisory board.

Results

Our findings support the efficacy of the developed balance-training methods, balance-enhancing footwear, neuro-prosthesis, walker design, handrail-cueing system, and handrail-design recommendations in improving specific aspects of balance control.

Impact on Knowledge Users

A new balance-assessment tool has been implemented in the first new balance clinic, a new balance-enhancing insole is available through pharmacies and other commercial outlets, and handrail design recommendations have been incorporated into 10 Canadian and American building codes. Work in progress is expected to have further impact.

Keywords

Balance training; Falls prevention; Footwear; Handrails; Mobility aids

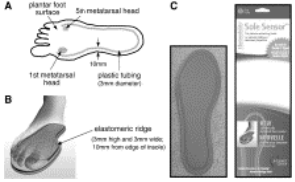

Fig. 1. Methods used to improve balance control by facilitating cutaneous sensation from the footsole: **A.** set-up used in the initial laboratory experiments, in which plastic tubing was adhered to the perimeter of the footsole (Maki et al., 1999); **B.** insole design (*SoleSensor*®) developed on the basis of the experimental findings and tested in the 12-week clinical trial (Perry et al., 2008); **C.** actual commercial product and packaging.

Figure options

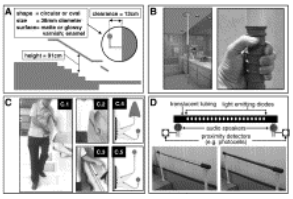

Fig. 2. Summary of handrail-research outcomes: **A.** design recommendations for conventional handrails, to optimize the ability of a wide range of users to generate stabilizing force and to reach and grasp the rail effectively (, , , and); **B.***SturdyGrip*® safety pole; **C.***LifeRail* (C.1-C.4) and double-rail (C.5) handrail systems (Gorski, 2005), in which the upper rail is intended to be " hugged " under the arm (C.1) [note: the lower rail can also be used in a conventional manner (C.2) but the upper surface of *LifeRail* is not designed for effective grasping (C.3); the double-rail system (C.5) permits both upper and lower rails to be grasped effectively, while still allowing for the upper rail to be hugged]; **D.** handrail cueing system (Scovil et al., 2007b), in which a proximity detector is used to trigger a visual cue (flashing of light-emitting diodes mounted within the translucent railing) and/or verbal prompt to use the rail (issued via speakers located in the railing or mounting brackets). Adapted from (Maki, Cheng, Corbeil, et al., 2008).

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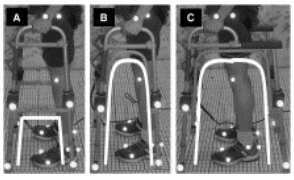

Fig. 3. Photographs showing a standard pickup walker (**A**) and the design changes that were made so as to reduce restrictions on lateral stepping reactions (Cheng et al., 2008). The overlaid line drawings highlight the arched strut that replaced the lower horizontal bar (**B**) and the extension of the walker length that served to move the rear posts away from the feet (**C**). Adapted from (Maki et al., 2008a).

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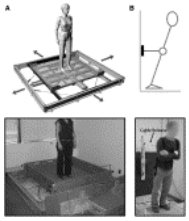

Fig. 4. Balance-perturbation methods: **A.** motion-platform system, and **B.** release-from-lean cable-release system. **A** is one example of the multi-directional platforms that we have used in our various research studies of stepping and grasping reactions (this particular platform is driven by pneumatic cylinders; our other platforms are motor driven). **B** shows the cable-release system that our clinical partners are currently using to induce forward falling motion and forward-directed compensatory stepping reactions (subjects are instructed to lean forward until the cable supports their body, and this cable is then released at an unpredictable moment in time by pulling a pin).

Figure options

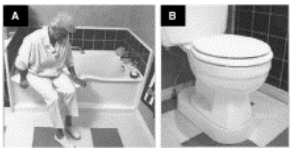

Fig. 5. Examples of other fall-prevention products that have been developed by team members and commercialized successfully: **A.***Access Bathtub* and **B.***Toilevator*® toilet raiser. In **A**, the person is sitting on the built-in transfer surface; the built-in grab-bars are mounted on the other side and at the end of the tub (behind the person). **B** shows how the device is mounted underneath the toilet, to achieve a much more stable and less conspicuous system than conventional toilet raisers, which are clamped onto the top of the toilet seat.

Figure options

Table 1. Organizations represented on the team's research-user advisory board.

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Table 2. U.S. and Canadian building codes influenced by findings from the team's handrail studies.

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Brian E. Maki is Director of the Centre for Studies in Aging (CSiA) at Sunnybrook Health Sciences Centre in Toronto, Canada. He is also a Senior Scientist at Sunnybrook, a Senior Scientist at the Toronto Rehabilitation Institute and a Professor at the University of Toronto. He has been affiliated with CSiA since 1982. He trained in mechanical and biomechanical engineering at the University of British Columbia (BASc, 1979), Massachusetts Institute of Technology (SMME, 1982) and University of Strathclyde (PhD, 1987). His primary research interests involve the biomechanics and neural control of human posture and movement, with a focus on understanding age-related deterioration in balance and developing improved methods for assessing balance and preventing falls in older adults. He has been the leader of a Canadian Institutes of Health Research mobility & aging team since 2002.

Kathryn M. Sibley is a Post-Doctoral Fellow at the Toronto Rehabilitation Institute and a Lecturer in the Department of Physical Therapy at the University of Toronto. Her research interests focus on understanding the basic neurophysiological mechanisms that contribute to the ability to maintain balance and control walking, and translating this knowledge to optimize the treatment of populations with impaired mobility and falls, such as older adults and stroke. Kathryn received her BSc (Kinesiology) from the University of Waterloo and MSc (Rehabilitation Science) and PhD (Medical Science) from the University of Toronto.

Susan B. Jaglal is the Vice-Chair Research and Professor in the Department of Physical Therapy at the University of Toronto with cross-appointments to the Graduate Department of Rehabilitation Science and Departments of Health Policy, Management & Evaluation and Public Health Sciences. She is a Senior Scientist at the Toronto Rehabilitation Institute and holds the Toronto Rehabilitation Institute Chair at the University of Toronto. She is a Senior Scientist at the Institute for Clinical and Evaluative Sciences and Senior Researcher at the Women's College Research Institute in the Osteoporosis Research Program. Dr. Jaglal has published and lectured widely in her areas of research, which include osteoporosis and rehabilitation health services with emphasis on utilization, appropriateness, effectiveness of services and knowledge transfer. She has a PhD in Epidemiology from the University of Toronto. She is currently the Vice-President of the Canadian Society for Epidemiology and Biostatistics.

Mark Bayley is a specialist physician in Physical Medicine and Rehabilitation. Dr. Bayley is currently the Medical Director and Clinician Scientist at the Neurorehabilitation Program at the Toronto Rehabilitation Institute. He is also an Associate Professor at the University of Toronto. He has research interests in: Knowledge Translation, Development of Best Practice Guidelines, Rehabilitation Outcome Measurement and Neurological Recovery after Stroke and Acquired Brain Injury. Currently he is one of the Principle investigators on the Canadian Stroke Network SCORE (Stroke Canada Optimization of Rehabilitation by Evidence), and Getting on With Life after Stroke projects. He is co-chair of the Best Practices committee and author of the Best Practice Guidelines for the Canadian Stroke strategy. Recently, he took on the role of evaluation champion and Chair for the Stroke Evaluation Advisory Committee of the Ontario Stroke Network.

Dina Brooks Dina Brooks holds a Canada Research Chair in Rehabilitation for individuals with chronic obstructive pulmonary disease. She is an Associate Professor in the Department of Physical Therapy, University of Toronto. She is trained as a physical therapist and a physiologist with a specific interest in respiratory and cardiovascular physiology. Her research includes a strong focus on exercise training in individuals with respiratory and/or cardiovascular disease.

Geoff R. Fernie is Vice President of Research at the Toronto Rehabilitation Institute. He is a professor in the Department of Surgery at the University of Toronto with cross-appointments that include the Institute of Biomaterials and Biomedical Engineering and the Graduate Department of Rehabilitation Science. His personal research interests are primarily focused on the development of technology to help people continue to live in their own homes. He emphasizes the transfer of his research findings into products available in the marketplace and knowledge applied to health service delivery. Geoff was the recipient of the 2002 Jonas Salk Award and the 2003 recipient of the MEDEC (Canada's association of medical device manufacturers) annual

award for medical achievement. He was inducted into the Terry Fox Hall of Fame in 2008 and became a Fellow of the Canadian Academy of Health Sciences in 2009.

Alastair J. Flint is a Senior Scientist in the Toronto General Research Institute and Adjunct Scientist at the Toronto Rehabilitation Institute. He is the head of the Geriatric Psychiatry Program at the University Health Network. He is also a professor of psychiatry and faculty member of the Institute of Medical Science at the University of Toronto. Dr. Flint's research interests include depression and anxiety in the elderly, including the complex relation between depressive disorders and fear of falling in the elderly. He is principal investigator of a study funded by the National Institute of Mental Health to investigate the pharmacologic treatment of psychotic depression.

William Gage is an Assistant Professor in the School of Kinesiology and Health Science at York University (Toronto, Canada). He also holds appointments at the Heart and Stroke Centre for Stroke Recovery, and at the Toronto Rehabilitation Institute as a member of the Mobility Team. Dr. Gage's expertise is in the areas of biomechanics and neuromuscular control, and his research interests are associated with mobility and factors related to aging, injury, and disease which impair mobility. Specifically, he is interested in the control of human movement, and how such control is impaired with musculoskeletal injury and pathology.

Barbara A. Liu is an Associate Professor of Medicine at the University of Toronto. She obtained her medical degree from the University of Toronto in 1987 and has specialty qualifications in Internal Medicine, Geriatric Medicine and Clinical Pharmacology. Her research interests include the appropriateness of drug therapy in the older patient and adverse drug reactions in the elderly, particularly falls and their relationship to medication use. She is a consultant in Geriatric Medicine and Clinical Pharmacology at Sunnybrook Health Sciences Centre and Executive Director of the Regional Geriatric Program of Toronto.

William E. McIlroy is a Professor in the Kinesiology Department at the University of Waterloo (Waterloo, Canada), Senior Scientist and Mobility Team Leader at the Toronto Rehabilitation Institute, and a Senior Scientist at Sunnybrook Health Sciences Centre (Toronto, Canada), where he is Site Leader of the Sunnybook site of the Heart and Stroke Foundation Centre for Stroke Recovery. His research involves developing understanding leading to new treatments and technologies that will improve safe mobility among older adults and those who have had a stroke.

Alex Mihailidis is an Associate Professor in the Department of Occupational Science & Occupational Therapy at the University of Toronto. He received his PhD in Bioengineerng from Strathclyde University (Glasgow, Scotland) in 2002. His research is focused on the development of intelligent homes and assistive technologies for older adults with cognitive impairments, and other people with disabilities. Current projects include the development and testing of prompting systems for older adults through the application of artificial intelligence and computer vision, the development of fall detection and emergency response systems that use advanced sensing and speech recognition, and the development of new rehabilitation technologies that use robotics and haptics.

Stephen D. Perry is an Associate Professor within the Department of Kinesiology & Physical Education at Wilfrid Laurier University in Waterloo, Canada. He received his PhD in biomechanics/neuroscience from the University of Toronto in 2000. His research is focused upon the neuro-mechanical aspects of the foot and footwear and their role in dynamic movement control. Current projects range from studying the application of the ‘SoleSensor’ insole in specific populations to the effects of footwear modifications (design and orthotics) on dynamic balance control.

Milos R. Popovic is the Toronto Rehabilitation Chair in Spinal Cord Injury Research, Professor in the Institute of Biomaterials and Biomedical Engineering at the University of Toronto, and Senior Scientist and Activity Team Leader at the Toronto Rehabilitation Institute. Dr. Popovic received his Ph.D. degree in mechanical engineering from the University of Toronto in 1996, and the Dipl. Electrical Engineer degree from the University of Belgrade in 1990. His fields of expertise are functional electrical stimulation, neuro-rehabilitation, brain machine interfaces, modeling and control of linear and non-linear dynamic systems, robotics, power systems, signal processing, and safety analysis. His interests are in the areas of neuro-rehabilitation, physiological control systems, assistive technology, and brain machine interfaces (www.toronto-fes.ca).

Jay Pratt in a Professor and Chair of the Department of Psychology at the University of Toronto, and is cross-appointed as Scientist at Toronto Rehabilitation Institute. He received his PhD in psychology from Washington University (St. Louis) in 1996, the same year he arrived at the University of Toronto. Dr. Pratt is a cognitive neuroscientist who studies how people acquire information from the visual field and then use that information to plan and produce actions.

John L. Zettel is an Assistant Professor in the Department of Human Health & Nutritional Sciences at the University of Guelph (Guelph, Canada), with appointments at the Heart and Stroke Centre for Stroke Recovery and the Toronto Rehabilitation Institute. His research is centered on balance and mobility, examining basic mechanisms of postural and motor control, as well as applications to the immense problem of impaired mobility and falls in older adults and other clinical populations (e.g. stroke).