opportunity to fill this existing gap in the care of those recovering from stroke.

References


Functional Impairments Following Stroke: Implications for Rehabilitation

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Stroke is currently the leading cause of neurological disability in adults. The incidence of first stroke ranges from 81 to 150 per 100,000 persons. When age is considered, incidence of stroke doubles each decade after age 55. In Canada, this translates to more than 50,000 strokes per year, with more than 70% of all strokes occurring among individuals over age 65. The age related risk of stroke combined with an aging population in Canada predicts an increase in the number of those who will suffer a stroke. While mortality rates have been declining since the 1950s, due in part to advances in acute stroke treatment and early symptom recognition,
the prevalence of stroke remains the same, and may even be increasing somewhat.\textsuperscript{1,2}

Approximately two thirds of stroke survivors have residual neurological deficits that impair function and approximately 50\% are left with disabilities making them dependent on others for activities of daily living.\textsuperscript{3} The specificity of impairment is quite heterogeneous and varies with the particular regions of the central nervous system (CNS) that have sustained damage. Among the more common are physical impairments in upper limb use and in functional walking. Upper limb dysfunction remains an important hurdle for many stroke survivors. Only 5\% of adult stroke survivors regain full function of the upper limb and 20\% regain no functional use.\textsuperscript{4}

Another of the most commonly cited concerns by individuals after stroke is whether they will regain independent walking. Such functional ambulation may be defined as the capacity to execute safe, efficient walking within time and environmental constraints encountered in everyday life. These limitations arise not only because of neurological impairment, but also as a result of physical de-conditioning due to inactivity.\textsuperscript{5,6,7} The latter becomes increasingly problematic given the increased energy demands associated with the performance of everyday activities among these individuals. The use of accelerometers and ambulatory physiological monitoring has quantified the lack of walking and physical activity performed outside of structured therapy.\textsuperscript{8} It is important to understand the impact of physical de-conditioning on post-stroke impairment as this may further compromise health-related quality of life and increase the risk of recurrent stroke. Behavioural changes such as avoidance of physical activity further reduce aerobic capacity and impair sensorimotor control, leading to a cycle of reduced physical capacities and limited activity participation that may reinforce one another.

**What Factors Affect Recovery?**

Following a cerebral insult, such as a cerebrovascular accident, the CNS undergoes reorganization or plasticity during the process of functional recovery. However, the degree of recovery is variable\textsuperscript{8} and the processes subserving this recovery are incompletely understood. Neurophysiological changes associated with recovery often begin very early after the onset of stroke (within 1-2 weeks) and may plateau between two and three months later, depending on the specific neurologic deficit. Historically, the recovery over the first three months is believed to be the most rapid. However, functional recovery has been shown to progress even years after the stroke event, albeit at a much slower rate. Several factors influence the rate and extent of recovery, most notably the initial severity of the stroke, which is typically quantified clinically or functionally, and the size and location of the lesion. Recovery can also be influenced by individual characteristics, particularly age, comorbidities and activity patterns of the individual, specifically their participation in formal rehabilitation training. Questions remain about the mechanisms by which such improvement is mediated but rehabilitation training may be critical in shaping reorganization within the CNS.

In both the healthy and injured CNS, the development and training of motor skills leads to rapid cortical adaptation characterised by shifts in central representation to meet new task demands.\textsuperscript{10,11} During sensorimotor recovery from stroke, these normal training-related cortical adaptations can interact with and influence cortical reorganization associated with spontaneous recovery. Electrophysiological and functional imaging techniques, such as transcranial magnetic stimulation, event-related cortical potentials and functional MRI, allow for the sensitive quantification of CNS state and provide important experimental opportunities to reveal treatment-related short-term changes as a foundation for long-term stroke recovery.

**What Approaches can Minimize Disability?**

For many deficits, the key to minimizing disability following stroke is rehabilitation to retrain patients to improve capacity. The range of these approaches is largely distinguished on the basis of the specific deficit and severity which can be quite heterogeneous. While research continues to establish specific characteristics of the most effective rehabilitation techniques, the common thread among the more successful approaches is a requirement for patients to practice “use” of the affected body part. In addition, the use needs to feature increased challenges that are task-related (as opposed to simple movement repetition). In the last decade, studies have shown that such task-related motor retraining may lead to improved recovery by facilitating brain repair.
Such brain repair may also be augmented by specific neuropharmacologic agents, the use of factors to stimulate cell growth and/or cell replacement therapies whereby endogenous stem cells are stimulated to migrate to the injury site. These approaches are still largely at the experimental stage in animal models. One of the challenges in translation is to understand why and with whom to use a specific therapeutic approach in order to maximize recovery.

Recent studies have also suggested that aerobic training consisting of activity that taxes the cardiorespiratory system can also promote recovery and reverse some of the deconditioning that occurs after a stroke. Although traditional rehabilitation programs have not included an aerobic component, more recent evidence strongly suggests that aerobic training is beneficial both sub-acutely after stroke as well as in the later stages (1-2 years post stroke). 12,13,14

"...the key to minimizing disability following stroke is rehabilitation to retrain patients to improve capacity..."

Why is Rehabilitation So Important?

It is important to recognize that focused patient-specific therapy is an important element to minimizing post-stroke disability. Determinants of the relative success of such therapy, beyond the specific techniques applied, include the intensity of therapy, patient motivation/participation in the program, and the timing of the therapy. It is becoming clear that more time directed at retraining following stroke, including patient-appropriate practice beyond the clinical setting, can enhance recovery. Within the first month after stroke, the standard discipline-specific therapy occurs on average three times a week for 30-60 minutes per session. While intensifying the routine at this stage of recovery may improve outcomes, there is growing evidence that a lack of long-term opportunities for rehabilitation services will, in many patients, result in progressive worsening of outcomes. For example, persisting disability in some patients leads to further disuse and musculoskeletal disorders that can further limit the ability of the individual to participate in activities of daily life, decrease their aerobic capacity and compromise their physically activity. Objectively tracking functional status over time may help to document changes and screen for and establish the need for continuing therapy to offset the consequences of persisting disability. It should also be reinforced that prescribed physical activity training, both aerobic and strength training, is essential to the rehabilitation process. The difficulty in training for stroke patients can be the suitability and/or safety of the exercise activity selected. While a walking program may seem right for some people, they must be able to safely walk rapidly enough to achieve target heart rates. For those unable to walk quickly enough or unable to walk at all, a recumbent cycle ergometer is a safe and acceptable form of training, which has been successfully used in the subacute (within 14 days) and chronic stages after stroke and can help to counter the deconditioning that occurs after a stroke. 17,18

The concern for compliance can be overcome by encouraging patients to enrol in a group exercise program, and/or monitoring of activity logs, or even by the use of inexpensive pedometers. Cardiac rehabilitation, an established model of care for individuals with cardiac disease, may also be a possible choice post stroke.

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In Summary

Here we have discussed two major classes of functional impairments that can occur following stroke; hemiparesis in the upper limb and difficulties with independent walking, as well as some principles important for recovery. Although the etiology of these may differ, the neurophysiological substrates for recovery are similar. For example, Kautz et al. have shown limited benefits to the control of walking associated with an aerobic pedaling program despite improvements in walking velocity. They concluded that to achieve gains in the control of walking ‘task-specific intervention may be required to improve coordination, consistent with principles of use-dependent plasticity’. In this way the substrates for recovery between the differing levels of impairment converge. Functional recovery may have at its underpinning training-related adaptation in the CNS that is maximized with use of the paretic limb in challenging, skilled tasks. 20 This would be optimally combined with physical activity or...
aerobic training to achieve the cardiovascular benefits associated with decreased risk factors for recurrent stroke.

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Community-Based Rehabilitation for Stroke Survivors
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Introduction
Timely access to appropriate rehabilitation services for stroke survivors is needed to optimize recovery and reduce the long-term burden of stroke for patients, families, communities, and the economy. The Canadian Best Practice Recommendations for Stroke Care (www.cmaj.ca December 2, 2008)1 includes recommendations for outpatient and community-based stroke rehabilitation based on current research. Given the marked lack of outpatient stroke rehabilitation resources in many communities, opportunities to take advantage of like services (e.g. cardiac rehabilitation) should be explored. Stroke and cardiac disease share a common set of risk factors and some similar recovery needs, therefore providing an opportunity for partnership.

Overview of the Canadian Stroke Strategy
The Canadian Stroke Strategy (CSS) was initiated under the leadership of the Canadian Stroke Network and the Heart and Stroke Foundation of Canada (www.canadianstrokestrategy.ca). It brings together a multitude of stakeholders and partners to develop and implement a coordinated and integrated approach to stroke prevention, treatment, rehabilitation and community reintegration in every province and territory in Canada.

The CSS provides a framework to facilitate the widespread adoption of evidence-based best practices across the continuum of stroke care, focusing at two levels: 1. the national