The Determinants of Participation in Aerobic Exercise Early After Stroke

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Abstract

Aerobic exercise is recognized as an important part of comprehensive stroke rehabilitation in best-practice and clinical guidelines. However, many individuals remain physically inactive during their hospitalization and do not engage in physiotherapy that is intense enough to provide an aerobic training benefit. Participation in aerobic exercise may be particularly important in the subacute period of recovery, i.e. within 3-months post-stroke, given that the rate of recovery is greatest in this stage and any gains may augment all aspects of rehabilitation. The main objectives of this work were to identify: 1) patient characteristics and 2) patients’ and physiotherapists’ perceptions that influence participation in aerobic exercise within in-patient stroke rehabilitation. Overall, people with stroke and physiotherapists valued the role of aerobic training early after stroke. Patient characteristics that limited enrollment in a structured aerobic exercise program included cardiovascular and musculoskeletal comorbidities. Although physical deficits did not limit participation in aerobic exercise (study 1), both patients and physiotherapists perceived that physical impairments limited participation (studies 2 and 3). In addition, patients perceived the fear of falling, inability to perform aerobic exercise, lack of support from a spouse and family, and lack of information on how to perform aerobic exercise as barriers. Furthermore, physiotherapist perceptions differed between rehabilitation centres with
and without a structured aerobic training program. Specifically, physiotherapists reported the lack of resources and continuing education as key barriers at centres without a structured program. In contrast, physiotherapists identified concerns for patients’ cardiac and cognitive status as well as insufficient time as key barriers at centres with a structured program. Based on these perceptions there is a need to provide physiotherapists with appropriate equipment and ongoing training on assessment and aerobic exercise prescription using a standardized approach. Future work should examine ways to better educate and engage people with stroke and their caregivers in structured aerobic exercise programs.
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List of Abbreviations

BBS – Berg Balance Scale

CMSA – Chedoke-McMaster Stroke Assessment

COVS – Clinical Outcome Variable Scale

FIM – Functional Independence Measure

ICC – Intraclass Correlation Coefficient

NIHSS – National Institute of Health Stroke Scale

TRI-UHN – Toronto Rehabilitation Institute (University Health Network)
1 Introduction
1.1 Overview and objectives

Aerobic exercise is recognized as part of stroke rehabilitation best practice guidelines and is advocated for preventing recurrent stroke. However, opportunities to participate in aerobic exercise are limited and actual rates of participation remain low. It is particularly concerning that evidence has not been translated to routine care during the subacute period of stroke recovery, i.e. within 3-months post-stroke. The early period after stroke is critical for the recovery of motor function, where any gains may augment all aspects of rehabilitation, and represents an ideal time to enhance individuals’ competence and confidence toward the long-term uptake of aerobic exercise. In order to develop valuable guidelines and effective recommendations to change healthcare practice, it is important to identify factors that facilitate or prevent participation in aerobic exercise early after stroke. Therefore, the overarching goal of this dissertation was to systematically identify patient and healthcare provider perceptions that influence participation in aerobic exercise within in-patient stroke rehabilitation. The following chapters provide a description of aerobic exercise as part of stroke rehabilitation, discuss theoretical models to frame the determinants to participation and identify specific factors that may be important determinants to participation. Thereafter, evidence is provided and discussed with respect to the primary objectives of this dissertation: to identify patient characteristics that influence the safety or ability to participate in aerobic exercise; to identify patient perceptions that influence their willingness or decision to participate; and to identify physiotherapist perceptions that influence the decision to prescribe and/or implement aerobic exercise. Since the determinants to participation are specific to the context under investigation, the third study considered the characteristics of practice environments with and without structured aerobic exercise programs.

1.2 Stroke incidence and prevalence

Stroke is characterized by neurological deficits that are attributed to acute focal injury of the central nervous system by vascular disease and is defined according to objective evidence of injury in a vascular distribution and symptoms that persist for more than 24 hours (or until death, excluding other etiology; Sacco et al., 2013). Of all strokes, 87% are ischemic and are defined as neurological dysfunction caused by focal cerebral, spinal cord, and/or retinal infarction (Mozaffarian et al., 2015; Sacco et al., 2013). The remaining 13% are hemorrhagic, which are defined as neurological dysfunction caused by a focal collection of blood in the brain.
parenchyma, subarachnoid space, or ventricular system due to non-traumatic injury (Mozaffarian et al., 2015; Sacco et al., 2013). Focal ischemia with symptoms lasting less than 24 hours and without evidence of infarction in imaging or neuropathological evidence is considered a transient ischemic attack (Sacco et al., 2013). Examples of neurological dysfunction associated with stroke include hemiparesis, reduced mobility, balance and coordination deficits, reduced proprioception, spasticity, cognitive or communication impairments, and aphasia (MacKay-Lyons & Howlett, 2005).

In North America, stroke is a prevalent health concern. An individual experiences a first or recurrent stroke every 10 minutes in Canada (Heart and Stroke Foundation, 2014) and every 40 seconds in the United States (Mozaffarian et al., 2015). Evidence shows that stroke incidence and mortality declined between 1987 and 2011 (Koton et al., 2014), which may be attributed to advances in symptom recognition, medical technologies, and post-stroke cardiovascular risk factor modification interventions. However, the decline in stroke incidence observed among older individuals (≥60 years of age (Morgenstern et al., 2013), ≥65 years of age (Koton et al., 2014), ≥75 years of age (Kissela et al., 2012)) has not extended to those less senior. Rather, there has been an increase in the occurrence of stroke in young and middle-aged adults (45-59 years of age (Morgenstern et al., 2013), <65 years of age (Koton et al., 2014), 20-54 (Kissela et al., 2012)) and stroke risk factors remain prevalent in younger adults (e.g. diabetes, high cholesterol, and obesity; 30-50 years of age (Heart and Stroke Foundation, 2014) and 20-54 years of age (Kissela et al., 2012)). Moreover, this does not account for silent infarctions which are up to five times more prevalent than clinically apparent strokes (Brott et al., 1994; Vermeer et al., 2007). Even with reduced stroke incidence among older adults, the future demographic shift towards a large elderly population and adults with multiple comorbid conditions is reason for concern. Post stroke, patients often do not make a complete recovery and live with residual neurological deficits (Mozaffarian et al., 2015). Accordingly, stroke has been and will remain a leading cause of disability and socioeconomic burden (Di Carlo, 2009).

1.3 Reduced cardiorespiratory fitness after stroke

Early after stroke, it is common for individuals to have cardiorespiratory fitness levels that are 50 to 60% lower than sedentary age- and sex-matched (MacKay-Lyons & Makrides, 2002b, 2004) and healthy age-matched adults (Brooks et al., 2008; Kelly et al., 2003). In conjunction with
post-stroke deficits and elevated energy demands of movement (Danielsson et al., 2007; Kelly-Hayes et al., 2003), this compromised cardiorespiratory fitness requires individuals to work closer to their physiological limits to achieve even low-intensity activities of daily living (Glymour et al., 2007; Ivey et al., 2005; Mayo et al., 2002). These impairments perpetuate a cycle of inactivity that permits cardiorespiratory fitness levels to remain below the 15-18mL/kg/min required to function independently (Shephard, 2009) for many years after stroke (Smith et al., 2012). Therefore, the cardiorespiratory fitness of a person with stroke is clinically important; even minor improvements in cardiorespiratory fitness have the potential to improve life-long recovery from stroke.

1.4 Factors contributing to low cardiorespiratory fitness after stroke

Cardiorespiratory fitness refers to the ability of the cardiorespiratory system to supply oxygen (i.e. cardiac output) and the musculoskeletal system to utilize oxygen (i.e. arterial-venous oxygen difference; American College of Sports Medicine, 2006). Several factors may contribute to low levels of cardiovascular fitness after stroke and may be organized according to the three domains: the direct effects of stroke, pre-existing medical conditions, and physical inactivity (Billinger et al., 2012a; Ivey et al., 2006, 2008; MacKay-Lyons & Howlett, 2005; MacKay-Lyons et al., 2006). These domains are detailed in the following sections.

1.4.1 The direct effects of stroke

A number of changes in body structure and function can contribute to low levels of cardiorespiratory fitness and elevate energy demands of movement. These includes changes in muscle physiology such as muscle wasting and increased intramuscular fat (Ryan et al., 2002), a shift from slow-twitch to fast-twitch muscle fiber types (De Deyne et al., 2004), reduced muscle fiber capillary density (Prior et al., 2009), increased expression of inflammatory cytokines (Hafer-Macko et al., 2005), as well as insulin resistance and glucose intolerance (Prior et al., 2009; Saghizadeh et al., 1996). In addition, peripheral and central blood flow and vascular function are altered (Billinger & Kluding, 2009; Ivey et al., 2011), due to changes in metabolism, resistance, pressure, and the central regulation (parasympathetic/sympathetic activity) of cardiac function (Williamson et al., 2006). Furthermore, systemic changes that are not localized to the paretic skeletal muscle may accompany stroke and predispose to new health concerns, such as
elevated levels of circulating pro-inflammatory markers (Castellanos et al., 2002; Rodriguez-Yanez et al., 2006). For example, a decrease in the pulmonary function of individuals with stroke (tidal volume) may negatively impact their arterio-venous oxygen difference (uptake of oxygen or export of metabolic by-products; Sisante et al., 2015).

1.4.2 Pre-existing medical conditions

People with stroke commonly have pre-existing medical conditions that are associated with low levels of cardiorespiratory fitness. Of particular concern is the high prevalence of cardiovascular comorbidities (Chimowitz et al., 1997; Roth, 1993), which are important longitudinal predictors of cardiovascular health outcomes (Roth, 1994); predisposing individuals to recurrent stroke and increased risk of mortality (Hackam & Spence, 2007; Kernan et al., 2014; Meschia et al., 2014; O'Donnell et al., 2010). In fact, cardiac disease represents the greatest risk for mortality than any other cause, including recurrent stroke (Roth, 1994). The complex health history of people with stroke commonly inculdes coronary artery disease, hypertension, atrial fibrillation, asymptomatic carotid stenosis, hyperlipidemia, metabolic syndrome, diabetes, and obesity (Kernan et al., 2014; Meschia et al., 2014). Such co-morbidities may contribute to low fitness in several ways. For example, the loss of atrio-ventricular synchrony in people with atrial fibrillation may negatively impact their cardiac output (reduced end-diastolic filling time, chamber volume, and downstream filling pressure; Ostermaier et al., 1997).

1.4.3 Physical inactivity and cardiorespiratory fitness

The American Heart Association/American Stroke Association recognizes physical inactivity as an independent contributor to first (Meschia et al., 2014) and recurrent stroke (Kernan et al., 2014). The literature has well established that physical inactivity can predispose individuals to cardiovascular dysfunction (Physical Activity Guidelines Advisory Committee, 2008) and is associated with more severe post-stroke outcomes (Krurup et al., 2008). Although well recognized as an important modifiable risk factor, physical inactivity is common after stroke during hospitalization (Gage et al., 2007; Janssen et al., 2014; Moore et al., 2013; Prajapati et al., 2013; West & Bernhardt, 2012). For example, individuals can spend up to 40% of a typical 10.5 hour day (i.e. waking hours) inactive (Janssen et al., 2014). Even during physiotherapy sessions, patients can be physically inactive for 42% of the time (MacKay-Lyons & Makrides, 2002a). On their return to the community, people with stroke remain physically inactive (Brown et al., 2014;
Hornnes et al., 2010; Tieges et al., 2015) as they engage in fewer physical activities compared to before stroke (Hartman-Maeir et al., 2007; Mayo et al., 2002). Evidence has demonstrated that ambulatory individuals with stroke take between 2,837 and 6,400 steps per day (Baert et al., 2012; Katoh et al., 2002; Michael et al., 2005); below the 6,500 to 8,500 steps per day recommended for those with disability or chronic disease (Tudor-Locke et al., 2011; Tudor-Locke et al., 2009) and target heart rates for cardiovascular training benefits (Baert et al., 2012). These levels of physical activity are even lower than older adults with cardiovascular or musculoskeletal comorbidities (Ashe et al., 2009).

1.5 Physical activity and aerobic exercise after stroke

1.5.1 Definitions

Regular physical activity that is beyond activities of daily living is essential to improve and maintain physical fitness and health (Caspersen et al., 1985; Garber et al., 2011). By strict definition, physical activity is any bodily movement produced by skeletal muscles that results in energy expenditure above resting (basal) levels (Garber et al., 2011). As a subset of physical activity, exercise is deliberately planned, structured, and repetitive and that has as a final or intermediate objective that is the improvement or maintenance of one or more components of physical fitness (Caspersen et al., 1985; Garber et al., 2011). This thesis is focused on aerobic exercise, which refers to activities that: 1) involve dynamic movements and large-muscle groups (e.g. stepping, walking, cycling) with or without the use of mechanical devices (e.g. treadmill, ergometer, stepping machine); 2) are conducted at moderate-to-high intensity over a prolonged period of time (relative to the individual’s cardiorespiratory fitness); and 3) have a primary objective of improving or maintaining cardiorespiratory fitness (American College of Sports Medicine, 2006; Garber et al., 2011).

1.5.2 Evidence of the benefits of physical activity and exercise after stroke

Systematic reviews and meta-analyses have demonstrated that participation in physical activity and exercise interventions after stroke can improve cardiorespiratory fitness (Marsden et al., 2013; Pang et al., 2006), balance, mobility, and physical function (An & Shaughnessy, 2011; Mehrholz et al., 2013; Mehrholz et al., 2011; Pang et al., 2006; Pollock et al., 2014; Rensink et al., 2009; Saunders et al., 2013; States et al., 2009; van de Port et al., 2007; Veerbeek et al.,
2011; Wevers et al., 2009), cognitive function (Cumming et al., 2012), depressive symptoms (Adamson et al., 2015; Eng & Reime, 2014), mood (McDonnell et al., 2014), and quality of life or independence (Chen & Rimmer, 2011; Mehrholz et al., 2013; Mehrholz et al., 2011; Rensink et al., 2009; Veerbeek et al., 2011). While the effects of physical activity and exercise on cardiovascular risk factors or function have not been established in stroke, several studies have shown positive influences on vascular risk reduction (e.g. improved blood pressure, lipid profiles, insulin sensitivity, systemic and cerebrovascular hemodynamics, and cardiac function; Billinger et al., 2012b; Ivey et al., 2007; Lennon et al., 2008; Potempa et al., 1995; Rimmer et al., 2009; Tang et al., 2014a; Tang et al., 2014b). Furthermore, there is evidence that aerobic exercise may enhance motor learning and control in stroke, by contributing to a neural environment that supports plasticity (e.g. by upregulating neurotrophins such as brain-derived neurotrophic factor; (Mang et al., 2013).

1.5.3 Early introduction to aerobic exercise post stroke

Studies that examined cardiorespiratory fitness, as discussed in the previous section, have focused mostly on individuals in the chronic period of stroke recovery, i.e. more than 3-months after stroke, who are ambulatory and have mild-to-moderate levels of stroke impairment (Marsden et al., 2013; Smith et al., 2012). In contrast, there is less evidence for physical activity and exercise early after stroke. The early introduction to aerobic exercise may be particularly important to enhance the outcome of rehabilitation and promote physical activity both in hospital and after discharge. This period is critical for regaining neurological function (Duncan et al., 1992; Jorgensen et al., 1995; Wade & Hewer, 1987) and any gains have the potential to augment all aspects of rehabilitation. With respect to the delivery of care, in-patient rehabilitation represents the ideal environment for multi-disciplinary staff to identify and manage pre-existing medical conditions while developing an optimal aerobic exercise prescription at an appropriate time. For example, evidence has shown that people with stroke have greater recovery in functional ambulation when adapted aerobic and resistance training is started earlier in rehabilitation (Marzolini et al., 2014). Furthermore, people with stroke are faced with a sudden onset of disability that disrupts the continuity of their life experience and may have a heightened appreciation for the need to change their behaviours (Cott et al., 2007). Accordingly, the early introduction to aerobic exercise may provide an opportunity to foster positive beliefs, change patient perspectives that may enhance the outcome of rehabilitation and reduce long-term
sedentary behaviours which are prevalent after discharge. Still, the early introduction to aerobic exercise should be presented to patients as one part of a lifestyle intervention that is supported through a continuum of care from the hospital to home, since evidence has shown that exposure to aerobic exercise during in-patient rehabilitation alone is not sufficient to increase or maintain participation after discharge (Brown et al. 2014).

Evidence has demonstrated that aerobic exercise is feasible early after stroke, including exercise testing and aerobic training with various modalities (e.g. seated recumbent stepping machines, cycle ergometers, and treadmills) by people with mild-to-severe stroke impairment (Billinger et al., 2012b; Duncan et al., 2011; Katz-Leurer et al., 2003b; MacKay-Lyons et al., 2013; Rose et al., 2011; Tang et al., 2009b; Wang et al., 2014). In a systematic review by Stoller et al. (2012) aerobic exercise interventions early after stroke were shown to improve cardiorespiratory capacity and walking endurance. In addition, individual studies in the subacute period of stroke recovery, i.e. within 3-months after stroke, have shown that aerobic exercise interventions can improve cardiorespiratory fitness (MacKay-Lyons et al., 2013; Mattlage et al., 2013; Murakami et al., 2002; Okada, 2005; Tanne et al., 2008), balance, mobility, and physical function (Billinger et al., 2012b; Duncan et al., 2011; Katz-Leurer et al., 2006; Kuys et al., 2011; Langhammer et al., 2007; MacKay-Lyons et al., 2013; Murakami et al., 2002; Nadeau et al., 2013; Rose et al., 2011; Rose et al., 2013; Tanne et al., 2008), patients’ perceptions of physical health (Faulkner et al., 2014), quality of life or independence (Duncan et al., 2011; Langhammer et al., 2007; Langhammer et al., 2008), and health status (including vascular risk and function; Billinger et al., 2012b; Kono et al., 2013).

1.6 Aerobic exercise as part of stroke recovery

Aerobic exercise may be delivered to individuals with stroke by incorporating adapted training in conventional rehabilitation or community programs. Three forms of rehabilitation in which this could occur are during in-patient or outpatient stroke rehabilitation, through out-patient cardiac rehabilitation, or in community-based programs.

1.6.1 Stroke rehabilitation

Aerobic exercise is recognized as an important part of comprehensive stroke rehabilitation in best-practice guidelines (Lindsay et al., 2010). Comprehensive stroke rehabilitation aims to: 1)
reverse the deficits caused by the stroke and minimize their impact; 2) prevent, recognize, and manage secondary medical conditions, including recurrent stroke; 3) maximize independence in the ability to perform activities of daily living; 4) facilitate psychological and social adaptation and coping by the patient and family; 5) optimize the resumption of prior life roles and reintegration into the community; and 6) enhance quality of life (Roth and Harvey 2000 as cited by Billinger et al. 2014).

Clinical guidelines recommend that once a person with stroke is medically stable, they should participate in a structured aerobic exercise program that: 1) is supervised by trained personnel; 2) is a routine part of standard rehabilitation; 3) includes graded exercise testing as part of a medical evaluation to screen for contraindications to exercise and inform exercise prescription; 4) involves the quantitative monitoring of exercise intensity to ensure the planned intensity is met and to safeguard against adverse events; and 5) is progressed according to the individual (Billinger et al., 2014; MacKay-Lyons et al., 2012). The American Heart Association/American Stroke Association recommends that aerobic exercise prescriptions include activities 3 to 5 days per week, at an intensity of 40 to 70% of oxygen consumption reserve or heart rate reserve (or 55 to 80% of heart rate maximum; or rating of perceived exertion of 11 to 16 on a 6 to 20 scale), for 20 to 60 minutes per session or multiple 10 minute sessions (Billinger et al., 2014). Evidence from research suggests that the clinical application of these recommendations may vary widely, according to observation and reasoning to tailor programs to the individual and practice environment (Ammann et al., 2014; Billinger et al., 2014; MacKay-Lyons et al., 2012; MacKay-Lyons et al., 2011; Marsden et al., 2013).

While therapeutic interventions can improve balance, endurance, and mobility post-stroke (Duncan et al., 2003), standard in-patient stroke rehabilitation is often not of sufficient intensity to provide an aerobic training benefit (Kuys et al., 2006; MacKay-Lyons & Makrides, 2002a). For example, MacKay-Lyons and Makrides (2002a) have shown that patients spend less than 3 minutes in a heart rate zone of 40 to 85% of heart rate reserve during an average physiotherapy session, and less than 1 minute in this range during an average occupational therapy session. Instead, rehabilitation programs are often focused on recovery associated with stroke-related functional impairments and mobility outcomes (Ivey et al., 2005).
As indicated in Section 1.4.3, evidence has shown that aerobic exercise is feasible and effective in the subacute period of stroke recovery. In light of this evidence, stroke guidelines state that the benefits of aerobic exercise far outweigh the potential risks that may be encountered even by those individuals with complex health needs, when conducted in a manner that is consistent with recommendations (Billinger et al., 2014; MacKay-Lyons et al., 2012). For example, exercise testing is a core component that is well established as an important part of clinical assessment for high risk individuals, such as those with stroke or potential asymptomatic coronary artery disease (American College of Sports Medicine, 2010). In the literature, few adverse events have been reported during exercise testing and training early after stroke (among 423 people trained in 11 studies only 16 adverse events were reported within 4 studies; Stoller et al., 2012) and within in-patient stroke rehabilitation (among 598 people trained in 13 studies only 13 adverse events reported across 3 studies; Billinger et al., 2012b; Eich et al., 2004; Katz-Leurer et al., 2003a; Katz-Leurer et al., 2006; Katz-Leurer et al., 2003b; Kuys et al., 2011; Letombe et al., 2010; MacKay-Lyons et al., 2013; Murakami et al., 2002; Okada, 2005; Outermans et al., 2010; Rose et al., 2011; Tang et al., 2009b). Example of adverse effects included myocardial infarction, recurrent stroke, abnormal blood pressure responses, and abnormal electrocardiogram.

1.6.2 Cardiac rehabilitation

Structured aerobic exercise programs are an important part of comprehensive cardiac rehabilitation and have been shown to positively impact cardiovascular risk factors, enhance quality of life, reduce depressive symptoms, and reduce morbidity and mortality (Heran et al., 2011; Lawler et al., 2011). Since there are several parallels that exist between stroke and heart disease (i.e. etiology, comorbidities, and cardiovascular risk factors), protocols have been developed to guide the inclusion of people with stroke in cardiac rehabilitation (Lennon et al., 2008; MacKay-Lyons et al., 2010).

Adapted cardiac rehabilitation programs for people with stroke have been shown to be feasible and effective over multiple domains of recovery (Kirk et al., 2014; Marzolini et al., 2013; Marzolini et al., 2014; Prior et al., 2011; Tang et al., 2010). When given the opportunity to participate in adapted cardiac rehabilitation programs, stroke patients can complete exercise testing, attain recommended aerobic exercise levels, and achieve training-related improvements in exercise capacity comparable to people with a diagnosis of coronary heart disease (Marzolini
et al., 2012a; Marzolini et al., 2012b; Tang et al., 2009a). Furthermore, adapted cardiac rehabilitation provides a model for stroke rehabilitation that offers several advantages, including access to existing infrastructure, expertise with cardiovascular disease management, and the ability to engage participants with well-established education and exercise procedures that extend beyond the borders of the facility.

Despite the evidence and guidelines, there are few opportunities for people with stroke to participate in secondary prevention programs that are structured in a similar way to cardiac rehabilitation. In Ontario, and likely elsewhere, cardiac rehabilitation is relatively unavailable to people with stroke; stroke patients can be included in 60% of cardiac rehabilitation programs in Ontario, yet, these individuals represent less than 5% of total enrollment (Tang et al., 2009a).

From the available literature, this limitation does not appear to be due to adverse events that occur during exercise testing or training (420 people in 7 studies; 11 adverse events reported across 4 studies; Kirk et al., 2014; Marzolini et al., 2012a; Marzolini et al., 2012b, 2013; Marzolini et al., 2014; Prior et al., 2011; Tang et al., 2010). Instead, Tang et al. (2009a) suggest reasons that limit inclusion in cardiac rehabilitation are the lack of a program mandate to include people with stroke; the presence of neurological deficits post-stroke; healthcare professional perceptions of post-stroke disability; and the lack of awareness among healthcare professionals of the benefits of cardiac rehabilitation after stroke.

1.6.3 Community-based programs

Structured aerobic exercise in community-based programs has the potential to promote consistent participation in aerobic exercise early after stroke. Evidence from randomized and non-randomized controlled trials has shown that aerobic exercise in community programs is feasible and improves cardiorespiratory fitness, physical and cognitive function, depressive symptoms, and social participation (Moore et al., 2014; Pang et al., 2005; Stuart et al., 2009). When included as part of complex lifestyle interventions, aerobic exercise also contributes to improving vascular risk factors and reducing the incidence of new vascular events (Kono et al., 2013; Mayo et al., 2015).

While information has been provided in clinical practice guidelines (Billinger et al., 2014) and a systematic review (Poltawski et al., 2013) to guide the development and/or implementation of community-based exercise programs post-stroke, it is unclear whether the need for stroke-
specific programs is warranted or justified. Certainly, the American College of Sports Medicine have highlighted important factors to consider regarding exercise testing and training for individuals with chronic disease (American College of Sports Medicine, 2006, 2010). In addition, one systematic review has shown that programs designed for one chronic disease population may be applied to other populations with minimal changes to account for disease-specific factors (Desveaux et al., 2014). Furthermore, exercise programs that include people with stroke among those with different neurological disabilities (Ploughman et al., 2014; Salbach et al., 2014) or partner individuals with stroke and their caregivers (Huijbregts et al., 2008) are feasible and effective.

Despite the evidence and guidelines, there are few opportunities for people with stroke to participate in physical activity in the community. In a study by Fullerton et al. (2008), 213 fitness facilities in the Greater Toronto Area provided information on the facility, available programs, as well as barriers and the willingness to provide stroke-specific programs. Although many respondents reported they were interested in providing fitness programs specific to stroke, only 12% of fitness facilities offered fitness programs to people with stroke. It is likely that the opportunity for participation in stroke-specific programs, or those that accommodate multiple types of disability, would be lower in smaller urban or rural settings. From the available literature on physical activity and exercise in the chronic period of stroke recovery, there does not appear to be evidence that the safety of community-based exercise should preclude participation (Saunders et al., 2013).

1.7 The determinants of participation in aerobic exercise after stroke

The lack of participation in aerobic exercise may reflect limited opportunities to participate in structured aerobic exercise programs (Fullerton et al., 2008; Tang et al., 2009a). It has been shown that levels of physical activity during hospitalization are typically low (Janssen et al., 2014; Moore et al., 2013; Prajapati et al., 2013; West & Bernhardt, 2012). In addition, even when structured aerobic exercise programs are included as part of in-patient stroke rehabilitation, low rates of participation remain (Biasin et al., 2014). Participation in aerobic exercise after stroke may be influenced by a complex interplay of factors that may be actual or perceived, involving the people with stroke, healthcare providers, and practice environment. Identifying the
factors that influence participation in aerobic exercise during in-patient stroke rehabilitation is an important foundation to inform knowledge translation and execute effective intervention strategies (Graham et al., 2006).

One approach to understanding the factors that may influence participation in aerobic exercise early after stroke is to consider a framework for an individual’s health behaviours. Bandura’s Social Cognitive Theory describes the interaction of cognitive constructs and environmental factors that may be perceived as barriers or facilitators in the regulation of motivation, action, and well-being (Bandura, 1971, 1998). In this model, perceptions of self-efficacy (i.e. beliefs in the capability to organize and execute an action), outcome expectations (i.e. beliefs that an action will lead to an outcome), and the perceived competence to exercise control over actions are particularly important components that affect personal change. Inherently, these beliefs will be based, in part, on patients’ self-perceptions. Still, Bandura’s model recognizes that cognitive constructs do not operate in isolation from social constructs, such as learning from the observation of others or interactions that influence behaviours through persuasion. This social support may be provided by family, friends, health professionals or other people with stroke; however, each may have one or more unique roles that could influence exercise behaviour.

The following paragraphs provide evidence of behavioural, social, and environmental factors that may be perceived as barriers or facilitators by people with stroke to participation in physical activity and aerobic exercise according to Bandura’s model. Similarly, this model will be used to organize evidence regarding factors that may influence physiotherapist decisions to prescribe or implement aerobic exercise after stroke. The role of physiotherapists in providing aerobic exercise as part of stroke rehabilitation is particularly important, since their interactions may be highly influential in enhancing recovery and preparing an individual for resuming previously valued activities. Given that information on physiotherapists’ perspectives on aerobic exercise is limited, factors that have been demonstrated to influence the implementation and use of stroke rehabilitation recommendations will also be presented.

1.7.1 People with stroke

The belief that a person can overcome challenges and perform physical activity or exercise (i.e. self-efficacy) influences exercise participation as well as physical functioning, depression, activities of daily living, and quality of life or perceived health status after stroke (Jones & Riazi,
Both the belief in the benefits of exercise and perceived ability to overcome challenges can predict the uptake and maintenance of exercise behaviours in stroke (Kinne et al., 1999; Shaughnessy et al., 2006). Low levels of self-efficacy and outcome expectations are barriers to exercise (Nicholson et al., 2013a; Nicholson et al., 2013b; Poltawski et al., 2014; Simpson et al., 2011) and may be affected, or the effect of, negative patient perceptions related to their health problems, stroke-related impairments, embarrassment, fear of recurrent stroke or falling, lack of control, and lack of motivation (Jurkiewicz et al., 2011; Lennon et al., 2013; Nicholson et al., 2013a; Nicholson et al., 2013b; Reed et al., 2010).

Friends and family are important members of the post-stroke social support network, helping to facilitate exercise (Galvin et al., 2009) and providing encouragement that motivates participation and sustains commitment (Nicholson et al., 2013b; Poltawski et al., 2014; Resnick et al., 2008). These people are also important to help manage conflict and advocate for better services (Reed et al., 2010). In addition, people with stroke perceive professionals, particularly physiotherapists, as important sources of guidance and emotional support (Morris et al., 2012; Nicholson et al., 2013a; Simpson et al., 2011). Professional support and recommendations can influence levels of engagement, while a lack of professional support on discharge from the hospital and lack of follow-up are barriers to physical activity after stroke (Nicholson et al., 2013b). Other people with stroke can act as a source of comparison for motivation, encouragement through competition, support through the exchange of information and advice, and connections which can reduce social isolation (Carin-Levy et al., 2009; Damush et al., 2007; Graham et al., 2008; Lennon et al., 2013; Nicholson et al., 2013a; Poltawski et al., 2014; Reed et al., 2010).

People with stroke have identified several environmental factors that may influence participation in physical activity and exercise, including the access, transport, and cost of structured classes or interventions as well as lack of information on how to exercise (Lennon et al., 2013; Nicholson et al., 2013a; Nicholson et al., 2013b). In addition, these individuals perceive a need for external support, services that align better with their needs, and more information on stroke recovery (Reed et al., 2010).

Bandura’s Social Cognitive Theory may well provide a way to frame factors that influence an individual’s willingness to participate in aerobic exercise early after stroke. However, individuals recovering from stroke may not be given the opportunity to express their willingness or decision
to participate. As has been highlighted in Section 1.3, individuals recovering from stroke commonly have pre-stroke medical conditions (e.g. unstable or acute cardiovascular concerns) and residual post-stroke impairments that may require aerobic exercise programs to be adapted. Specifically, these characteristics may impact the safety of performing exercise testing or engaging in exercise that meets the intensity suggestions of stroke recommendations. For example, beta-blocking medications blunt the cardiovascular response to exercise and there is, to-date, no recommended adjustment to age-predicted maximum heart rate calculations to compensate (Garber et al., 2011; Pang et al., 2006). Similarly, cognitive impairments may interfere with an individual’s ability to report distress, while physical impairments may limit a person’s ability to engage in activities or achieve beneficial training intensities (Doyle & MacKay-Lyons, 2013).

Still, the aforementioned barriers and facilitators to participation in physical activity and aerobic exercise have predominantly focused on ambulatory individuals in community settings once in-patient rehabilitation is complete (Morris et al., 2012; Nicholson et al., 2013a). While this body of literature forms an important foundation, it is important that stroke rehabilitation recommendations and guidelines are based on an understanding of contextually appropriate determinants. For example, patients are becoming accustomed to the sudden onset of disability within in-patient rehabilitation and have yet to encounter the barriers or facilitators related to their home environment.

1.7.2 Physiotherapists

Prior research has shown that the implementation and use of stroke recommendations can be limited by low self-efficacy for performing evidence-based practice activities and motivation to implement (McCluskey et al., 2013; Salbach et al., 2007), negative beliefs about the capabilities of individual professionals, and negative beliefs about the consequences of implementing stroke recommendations among physiotherapists (McCluskey et al., 2013). These beliefs may be affected by, or the effect of, negative physiotherapist perceptions regarding their training (i.e. the lack of knowledge and skills) and the inability to adequately select and prioritize therapy (Bayley et al., 2012; McCluskey et al., 2013; Pollock et al., 2000; Salbach et al., 2007). Alternately, these beliefs may be related to negative perceptions of patient capabilities (McCluskey et al., 2013).
In addition, physiotherapists have reported several factors related to social support and the environment that may influence their motivation or ability to implement and use evidence-based stroke recommendations. Barriers include inadequate staffing, insufficient interdisciplinary collaboration or communication to prepare and execute coordinated patient care plans, lack of time, and a lack of equipment (Bayley et al., 2012; Pollock et al., 2000).

Doyle and MacKay-Lyons (2013) have examined physiotherapist perceptions on the utilization of aerobic exercise as part of neurological rehabilitation in Canada. This study showed that 88% of physiotherapists agreed that aerobic exercise should be included in their treatment programs and 77% reported that they prescribed aerobic exercise. However, these respondents provided information that suggested their beliefs, knowledge, and practice were inconsistent with stroke guidelines. For example, only 3% reported that exercise testing is an essential part of the clinical screening process, 36% estimated baseline aerobic capacity based on the participants’ maximal heart rate, and 43% or less monitored the heart rate manually or with a heart rate monitor or oximeter. The most commonly perceived barriers were related to patient safety (cardiac concerns), the patient’s ability to participate in aerobic exercise (cognitive/perceptual deficits, physical inability to perform at a training level, and fatigue) and the practice environment (lack of staff to supervise, time, and screening tools to ensure patient safety).

However, only one study has focused on structured aerobic exercise and the in-patient rehabilitation setting. Specifically, Biasin et al. (2014) determined the feasibility of integrating a structured aerobic exercise program within in-patient stroke rehabilitation. These authors found that 40% of people with stroke completed the structured program (exercise testing and aerobic training), 63% achieved 20 minutes of exercise (at least once during training) and spent, on average, 10.7 minutes at intensity greater than 50% of age-predicted maximum heart rate. Patient safety (cardiac concerns) was a barrier to referral to the training program, while the patients’ ability to perform exercise (fatigue) and the practice environment (scheduling conflicts) limited program attendance.

There is a need to provide more information on physiotherapist perceptions that influence the decision to prescribe and implement aerobic exercise early after stroke and whether these perceptions differ among rehabilitation centers. The in-patient stroke rehabilitation environment may offer interdisciplinary cooperation, context specific experience, and infrastructure to
manage patients with complex healthcare needs that may not be available elsewhere (e.g. community-based programs).
2 Patient characteristics that influence enrollment and attendance in aerobic exercise early after stroke

2.1 Abstract

**Purpose:** To identify patient characteristics that influence physiotherapist decisions regarding enrollment and attendance in a structured aerobic exercise program early after stroke.

**Methods:** A retrospective chart review was conducted with a consecutive sample of 345 people admitted to in-patient stroke rehabilitation over a 2 year period. The main outcome measures were patient demographics, pre-existing medical conditions, and post-stroke outcome variables (neurological deficit, physical impairment, balance control, and functional mobility and independence) were compared between individuals enrolled and not enrolled in a structured aerobic exercise program. The rate of attendance was calculated for the enrolled group.

**Results:** One hundred and twenty nine patients (38%) were enrolled in the structured aerobic exercise program. Patients who were older (p=0.0093) and had cardiac disease (p=0.012), cardioembolic sources (p=0.0094), and arthritis (p=0.031) were less likely to be enrolled in aerobic exercise. Post-stroke outcome variables were not associated with enrollment. Among those enrolled, the rate of attendance was positively correlated with the FIM cognitive rating (r=0.27; p=0.0031).

**Conclusions:** Enrollment in structured aerobic exercise programs during in-patient stroke rehabilitation can be limited by safety concerns related to patients’ cardiovascular and musculoskeletal status. Barriers associated with the perception of cardiovascular risk factors should be confronted since they do not preclude participation in cardiac rehabilitation. In addition, post-stroke deficits do not limit participation in adapted aerobic exercise early after stroke. It is likely that the characteristics of the structured aerobic exercise program were integral to accommodate the breadth of post-stroke deficits encountered in this study. Future research investigating physiotherapist and practice environment factors that influence the decision to prescribe and implement aerobic exercise is warranted.
2.2 Introduction

People recovering from stroke often have reduced cardiorespiratory fitness (Brooks et al., 2008; Kelly et al., 2003) that persists over many years (MacKay-Lyons & Makrides, 2004; Smith et al., 2012) and is negatively reinforced by activity limitations (Kelly-Hayes et al., 2003). Systematic reviews examining aerobic exercise interventions after stroke have shown improvements in aerobic capacity, walking endurance, walking speed, and quality of life (Chen & Rimmer, 2011; Pang et al., 2006; Stoller et al., 2012). Accordingly, aerobic exercise is recognized as part of stroke rehabilitation best-practice guidelines (Lindsay et al., 2010; MacKay-Lyons et al., 2012), is recommended in clinical guidelines (Billinger et al., 2014), and has been advocated for secondary stroke prevention (Kernan et al., 2014). However, participation in aerobic exercise to improve cardiovascular fitness is complicated by the presence of coronary heart disease (in up to 75% of individuals) and numerous comorbid conditions (Chimowitz et al., 1997; Goldstein et al., 2001; Roth, 1993).

Structured aerobic exercise programs are an important part of comprehensive cardiac rehabilitation and have been shown to positively impact cardiovascular risk factors, enhance quality of life, reduce depressive symptoms, and reduce morbidity and mortality (Heran et al., 2011; Lawler et al., 2011). In contrast to cardiac rehabilitation, in-patient stroke rehabilitation programs do not routinely include structured aerobic exercise, despite evidence of the feasibility and effectiveness of symptom-limited exercise testing (MacKay-Lyons & Makrides, 2002b; Tang et al., 2006) and aerobic training early after stroke (Biasin et al., 2014; Billinger et al., 2012b; Duncan et al., 2011; Katz-Leurer et al., 2003b; MacKay-Lyons et al., 2013; Tang et al., 2009b). While therapeutic interventions can improve the balance, endurance, and mobility of patients early after stroke (Duncan et al., 2003), the intensity of these interventions is often not sufficient to induce an aerobic training benefit (Kuys et al., 2006; MacKay-Lyons & Makrides, 2002a). The early introduction to aerobic exercise may be particularly important to enhance the outcome of rehabilitation and promote physical activity both in hospital and after discharge.

The absence of structured aerobic exercise programs during in-patient stroke rehabilitation may reflect barriers that involve the patient, healthcare providers, and practice environment. The patient’s pre-existing medical conditions and post-stroke deficits are important considerations that may influence the safety or ability to participate. Therefore, the present study aimed to
identify patient characteristics that influence physiotherapist decisions regarding enrollment and attendance in a structured aerobic exercise program that is routinely provided as part of standard in-patient stroke rehabilitation. We hypothesized that patients that were enrolled and had high rates of attendance would have a lower prevalence of cardiovascular risk factors as well as lower levels of cognitive and physical impairments.

2.3 Method

Consent was provided and study procedures were approved by the Toronto Rehabilitation Institute (University Health Network; TRI-UHN) research ethics board.

2.3.1 Sample

A retrospective chart review was conducted on individuals diagnosed with stroke and admitted to the TRI-UHN in-patient Stroke Rehabilitation Service over a two-year period. Diagnosis was confirmed by the indication of acute stroke in electronic patient records from diagnostic imaging (i.e. computerized tomography scan, magnetic resonance imaging, carotid ultrasound, cerebral angiogram, and/or echocardiogram). Physiotherapists and trained research personnel extracted de-identified data from charts of all individuals admitted between October 2010 and September 2012. There were no other inclusion/exclusion criteria.

2.3.2 Standard in-patient stroke rehabilitation

Patients received multidisciplinary rehabilitation including physiotherapy, occupational therapy, and speech or language services (as needed) 5 days per week for the duration of their stay. In addition, structured aerobic exercise was routinely scheduled as part of standard care (Biasin et al., 2014). Patients were referred to the aerobic exercise program as soon as they were: (i) medically stable according to American College of Sports Medicine guidelines (American College of Sports Medicine, 2010); (ii) able to understand and follow instructions (e.g. to maintain cadence); and (iii) able to report concerns (e.g. pain or discomfort; supportive strategies were used for patients with aphasia).

Patients performed a graded sub-maximal exercise test using a semi-recumbent stepping machine to screen for contraindications to exercise and to inform the initial aerobic exercise prescription. Exercise testing was terminated when the patient: (1) reached 70% (60% for individuals taking
beta-adrenergic blocking medications (β-blockers) or those who were diabetic with comorbid conditions) of age-predicted maximum heart rate (defined as 208-(0.7 x age; Tanaka et al., 2001); (2) reported a ‘strong’ rating of perceived exertion (5 out of 10, Borg Category-Ratio 10-point scale); (3) was unable to maintain stepping cadence (decrease of 10 steps per minute); or (4) requested the session to end. Heart rate, rating of perceived exertion, stepping rate, workload, and 5-lead electrocardiography output were monitored minute-to-minute.

A physiotherapist and trained assistants supervised aerobic exercise that was delivered in a group format 3 times per week using semi-recumbent stepping machines (two had optional leg stabilizer attachments). In each session, the patient’s heart rate was monitored to ensure the planned intensity was met and to safeguard against adverse events. Details of each aerobic exercise session were recorded in a patient log (e.g. the frequency, intensity, and duration of exercise; heart rate from a heart rate monitor and rating of perceived exertion, at rest and at 5 minute intervals; blood pressure from an automated system at rest, immediately after exercise, and during exercise if recommended by the primary treating physiotherapist).

The aerobic exercise prescription was progressed according to the individual. Across sessions, the target was to increase the duration of aerobic exercise to at least 20 minutes before increasing workload. Typical exercise sessions started with 2-5 minutes ‘warm-up’, up to 30 minutes of aerobic training, and 2 minutes ‘cool-down’ (i.e. low-intensity exercise).

2.3.3 Enrollment and rate of attendance evaluation criteria

For the purposes of this study, patients were considered “enrolled” in the aerobic exercise program if they completed graded sub-maximal exercise testing and attended ≥1 aerobic exercise session. The rate of attendance was used to standardize the frequency that patients attended the aerobic exercise sessions prescribed; rate of attendance = (total number of sessions attended divided by the total number of sessions prescribed) x 100. Enrollment and the rate of attendance were obtained from hospital charts.
2.3.4 Measures

2.3.4.1 Demographic variables

Patients were characterized according to sex, age, body mass index, the type and location of stroke, the affected side, and time post-stroke.

2.3.4.2 Pre-existing medical conditions

Pre-existing medical conditions were separated into 4 domains: cardiovascular factors, musculoskeletal factors, other comorbid conditions, and prescribed medications. Cardiovascular factors included the presence of hypertension, previous transient ischemic attack, previous cerebrovascular accident, cardiac disease (angina, prior myocardial infarction, prior coronary artery bypass graft, prior percutaneous transluminal coronary angioplasty), potential cardioembolic sources (atrial fibrillation, abnormal aortic or mitral valve, cardiomyopathy, patent foramen ovale or shunt, and poor left ventricular function), carotid stenosis and indications of a prothrombotic or hypercoagulable state. Musculoskeletal factors included the presence of osteoporosis, arthritis, pain, joint replacement or fusion, and prosthetics. Other comorbid condition factors included a history of smoking and the presence of diabetes, peripheral vascular disease, peripheral neuropathy, respiratory complications, cancer, cognitive impairment or dementia, head injury, Parkinson’s disease, Multiple sclerosis, Cerebral palsy, epilepsy, and migraines. Prescribed medications included β-blockers and angiotensin-converting enzyme inhibitors.

2.3.4.3 Post-stroke outcome variables

Post-stroke outcome variables were evaluated according to 5 domains at admission to in-patient rehabilitation: neurological deficit, physical impairment, balance control, and functional mobility and independence. The National Institutes of Health Stroke Scale (NIHSS) is a 11-item assessment that was used to assess neurological deficit (Brott et al., 1989). The NIHSS includes details of the severity of motor and sensory impairment, aphasia, apraxia, and neglect, with scores ranging from 0 to 2, 3, or 4 (depending on the item). A score of 0 indicates no neurological deficit for that item. The NIHSS has high inter-rater (ICC=0.95) and intra-rater (ICC=0.93) reliability (Goldstein & Samsa, 1997).
The Chedoke McMaster Stroke Assessment (CMSA) is a physical impairment inventory that was used to indicate an individual’s stage of motor recovery post-stroke (Gowland et al., 1993). The present study used CMSA leg, foot, arm, and hand sub-scales. Scoring ranges from 1-7, with 1 indicating more impairment and 7 indicating full or almost full recovery of function. The CMSA foot and leg scores have good inter-rater (ICCs=0.85-0.96) and intra-rater (ICCs=0.94-0.98) reliability.

The Berg Balance Scale (BBS) is a 14-item rating scale that was used to measure balance control (Berg et al., 1989). Participants are asked to perform each of the 14 tasks and their ability to perform the task is rated on a scale from 0-4. Higher scores indicate improved performance. The BBS shows good internal consistency (Cronbach’s α>0.97) as well as inter-rater (ICC=0.98), intra-rater (ICC=0.97) reliability in the elderly and people with acute stroke (Berg et al., 1995).

The Clinical Outcome Variable Scale (COVS) is a 13-item scale that was used to assess functional mobility status (Seaby & Torrance, 1989). Items assess rolling, lying to sitting, sitting balance, transfers, ambulation, wheelchair mobility and arm function. Performance is rated on a 7-point scale, with a score of 1 indicating full dependence and a score of 7 indicating independence. The COVS shows good internal consistency (Cronbach’s α=0.93) as well as inter-rater (ICC=0.97), intra-rater (agreement on all items >85%) in people with mobility dysfunction.

The Functional Independence Measure (FIM) is a 18-item assessment that rates the level of independence in 6 areas of function: self-care, sphincter control, transfers, locomotion, communication, and social cognition (Keith et al., 1987). The total FIM function score can be divided into FIM motor rating and FIM cognitive rating. Level of independence is rated on a scale from 1-7, with 1 corresponding to full dependence, and 7 corresponding to complete independence. The psychometric properties of the FIM have been established in stroke (Zeltzer, 2011).

### 2.3.4.4 Statistical analysis

Descriptive statistics were calculated for all measures from the patient’s first hospital admission. Data were presented as counts and percentages or means, medians and standard deviations. Chi-square and unpaired t-tests were performed to determine the difference between stroke patients enrolled and not enrolled in the structured aerobic exercise program using the Statistical Analysis
Software 9.2 package. Bonferonni correction was applied, with a criterion significance of p<0.05, divided by the number of pre-existing medical condition and post-stroke outcome variable domains, to adjust the level of significance for multiple comparisons. Four pre-existing medical condition domains (adjusted p<0.0125) and five post-stroke outcome variable domains (adjusted p<0.01) were considered. Spearman correlations were performed to evaluate relationships between continuous variables and the rate of attendance. Unpaired t-tests were used to compare rates of attendance for binomial variables.

A stepwise multivariate logistic regression was performed on enrollment status with patient characteristics, pre-existing medical conditions, and post-stroke outcome variables that were significant at p<0.20 in bivariate analyses. Multicollinearity was assessed using Spearman’s rank correlation coefficient and variance inflation factor >5.

2.4 Results

2.4.1 Patient characteristics

Of the 345 patients in the sample population, data from 7 were excluded (Figure 2-1). Reasons for exclusion were: no confirmation of acute stroke in diagnostic imaging (n=5) and patients declined diagnostic imaging (n=2). Characteristics of the remaining sample population (n=338) are presented in Table 2-1.
Figure 2-1 - Study flow chart (October 2010 to September 2012).
Table 2-1 - Patient characteristics at admission by enrollment status.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Total (N=338)</th>
<th>Enrolled (n=129)</th>
<th>Not enrolled (n=209)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%) or Mean ± SD</td>
<td>No. (%) or Mean ± SD</td>
<td>No. (%) or Mean ± SD</td>
</tr>
<tr>
<td>Males</td>
<td>189 (55.9)</td>
<td>85 (65.9)</td>
<td>104 (49.8)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>69.1 ± 13.0</td>
<td>65.5 ± 13.7</td>
<td>71.2 ± 12.0</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.2 ± 7.2</td>
<td>26.3 ± 5.1</td>
<td>26.2 ± 8.2</td>
</tr>
<tr>
<td>Time post-stroke (days)</td>
<td>20.4 ± 27.5</td>
<td>23.9 ± 38.6</td>
<td>18.2 ± 17.2</td>
</tr>
<tr>
<td>Length of stay (days)</td>
<td>38.9 ± 26.0</td>
<td>39.3 ± 21.7</td>
<td>38.6 ± 28.4</td>
</tr>
<tr>
<td>Right handed</td>
<td>290 (85.8)</td>
<td>116 (89.9)</td>
<td>174 (83.3)</td>
</tr>
<tr>
<td>Stroke type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ischemic</td>
<td>255 (75.4)</td>
<td>89 (69.0)</td>
<td>166 (79.4)</td>
</tr>
<tr>
<td>Hemorrhagic</td>
<td>46 (13.6)</td>
<td>23 (17.8)</td>
<td>23 (11.0)</td>
</tr>
<tr>
<td>Transforming to hemorrhagic</td>
<td>21 (6.2)</td>
<td>10 (7.8)</td>
<td>11 (5.3)</td>
</tr>
<tr>
<td>Unclear in medical records</td>
<td>5 (1.5)</td>
<td>3 (2.3)</td>
<td>2 (1.0)</td>
</tr>
<tr>
<td>Affected Hemisphere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>131 (38.8)</td>
<td>43 (33.3)</td>
<td>88 (42.1)</td>
</tr>
<tr>
<td>Left</td>
<td>161 (47.6)</td>
<td>66 (51.2)</td>
<td>95 (45.5)</td>
</tr>
<tr>
<td>Both</td>
<td>40 (11.8)</td>
<td>19 (14.7)</td>
<td>21 (10.1)</td>
</tr>
<tr>
<td>Unclear in medical records</td>
<td>5 (1.5)</td>
<td>1 (0.8)</td>
<td>4 (1.9)</td>
</tr>
<tr>
<td>Affected Side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>166 (49.1)</td>
<td>66 (51.2)</td>
<td>100 (47.9)</td>
</tr>
<tr>
<td>Left</td>
<td>140 (41.4)</td>
<td>53 (41.1)</td>
<td>87 (41.6)</td>
</tr>
<tr>
<td>Both</td>
<td>11 (3.3)</td>
<td>5 (3.9)</td>
<td>6 (2.9)</td>
</tr>
<tr>
<td>No paresis</td>
<td>16 (4.7)</td>
<td>5 (3.9)</td>
<td>11 (5.3)</td>
</tr>
</tbody>
</table>

Percentages take into account missing data for some variables.
No., number; %, percentage; SD, standard deviation.
There were no significant differences between patients who were and were not enrolled, except for sex (p=0.0047) and age (p<0.0001).

2.4.2 Enrollment

One hundred and forty four (144/338; 42.6%; Figure 2-1) patients were referred to graded sub-maximal exercise testing an average of 36.1 (±39.3) days post-stroke (Table 2-2). Four patients were withdrawn after exercise testing and eleven patients did not attend at least one aerobic exercise session. The remaining one hundred and twenty nine patients (129/338; 38.2%) were considered enrolled in the aerobic exercise program. No patients were enrolled if their length of stay was <12 days; however, few patients in the not enrolled group had a length of stay <12 days (13/209; 6.2%).
Table 2-2 - Structured aerobic exercise program details.

<table>
<thead>
<tr>
<th>Structured aerobic exercise program details</th>
<th>Enrollment status: Enrolled (N=129)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Time from stroke to sub-maximal exercise testing (days)</td>
<td>36.1 ± 39.3</td>
</tr>
<tr>
<td>Duration of aerobic exercise program (days)^</td>
<td>17.6 ± 13.4</td>
</tr>
<tr>
<td>Time from end of aerobic exercise program to discharge (days)^</td>
<td>3.6 ± 7.8</td>
</tr>
<tr>
<td>Total aerobic exercise sessions prescribed (number)</td>
<td>9.0 ± 5.6</td>
</tr>
<tr>
<td>Total aerobic exercise sessions attended (number)</td>
<td>7.0 ± 5.1</td>
</tr>
<tr>
<td>Ratio of total prescribed sessions to program duration (number per days)^</td>
<td>0.5 ± 0.1</td>
</tr>
<tr>
<td>Ratio of total attended sessions to program duration (number per days)^</td>
<td>0.4 ± 0.2</td>
</tr>
<tr>
<td>Rate of attendance (%)</td>
<td>77.0 ± 22.0</td>
</tr>
</tbody>
</table>

^N=128, as the last exercise session date was not recorded in the medical record of one participant. SD, standard deviation; %, percentage.
Rate of attendance = (total sessions attended divided by total sessions prescribed) x 100.
Duration of the aerobic exercise program excludes weekends and statutory holidays.

Table 2-1 summarizes the characteristics of patients who were enrolled compared to those who were not enrolled. Bivariate analyses indicated more men were enrolled in the aerobic exercise program than not enrolled (p=0.0047). In addition, enrolled patients were younger than patients who were not enrolled (p<0.0001).

Table 2-3 summarizes the pre-existing medical conditions for patients who were enrolled compared to those who were not enrolled. Bivariate analyses indicated cardiovascular risk factors were less prevalent in patients who were enrolled in aerobic exercise when compared with patients who were not enrolled. Fewer patients in the enrolled group had a diagnosis of cardiac disease (p<0.0005), potential cardioembolic sources (p<0.0001), and were prescribed β-blocker medications (p=0.011). In addition, fewer patients with arthritis were enrolled (p=0.0084), while more patients with cognitive impairment or dementia were enrolled (p=0.0029).
Table 2-3 - Pre-existing medical conditions by enrollment status.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Total (N=338)</th>
<th>Enrolled (n=129)</th>
<th>Not enrolled (n=209)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Yes (%)</td>
<td>No.</td>
<td>Yes (%)</td>
</tr>
<tr>
<td><strong>Cardiovascular factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>257</td>
<td>(76.0)</td>
<td>92</td>
<td>(71.3)</td>
</tr>
<tr>
<td>Previous TIA</td>
<td>29</td>
<td>(8.6)</td>
<td>11</td>
<td>(8.5)</td>
</tr>
<tr>
<td>Previous CVA</td>
<td>88</td>
<td>(26.0)</td>
<td>25</td>
<td>(19.4)</td>
</tr>
<tr>
<td>Cardiac disease</td>
<td>106</td>
<td>(31.4)</td>
<td>26</td>
<td>(20.2)</td>
</tr>
<tr>
<td><strong>Potential cardioembolic sources</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiostenosis</td>
<td>125</td>
<td>(37.0)</td>
<td>30</td>
<td>(23.3)</td>
</tr>
<tr>
<td><strong>Musculoskeletal factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>38</td>
<td>(11.2)</td>
<td>13</td>
<td>(10.1)</td>
</tr>
<tr>
<td>Arthritis</td>
<td>61</td>
<td>(18.1)</td>
<td>14</td>
<td>(10.9)</td>
</tr>
<tr>
<td>Pain</td>
<td>57</td>
<td>(16.9)</td>
<td>26</td>
<td>(20.2)</td>
</tr>
<tr>
<td>Joint replacement or fusion</td>
<td>24</td>
<td>(7.1)</td>
<td>7</td>
<td>(5.4)</td>
</tr>
<tr>
<td><strong>Other comorbid conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past/current smoker</td>
<td>153</td>
<td>(45.3)</td>
<td>61</td>
<td>(47.3)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>96</td>
<td>(28.4)</td>
<td>30</td>
<td>(23.3)</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>28</td>
<td>(8.3)</td>
<td>6</td>
<td>(4.7)</td>
</tr>
<tr>
<td>Respiratory complications</td>
<td>27</td>
<td>(8.0)</td>
<td>10</td>
<td>(7.8)</td>
</tr>
<tr>
<td>Cancer</td>
<td>51</td>
<td>(15.1)</td>
<td>15</td>
<td>(11.6)</td>
</tr>
<tr>
<td>Cognitive impairment or dementia</td>
<td>66</td>
<td>(19.5)</td>
<td>36</td>
<td>(27.9)</td>
</tr>
<tr>
<td><strong>Prescribed medications</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β – blockers</td>
<td>129</td>
<td>(38.2)</td>
<td>38</td>
<td>(29.5)</td>
</tr>
<tr>
<td>ACE inhibitors</td>
<td>182</td>
<td>(53.9)</td>
<td>71</td>
<td>(55.0)</td>
</tr>
</tbody>
</table>

Percentages take into account missing data for some variables.
No., number; %, percentage.
TIA, transient ischemic attack; CVA, cerebrovascular accident; β, beta-adrenergic; ACE, angiotensin-converting enzyme.
The p-values are for the comparison of differences between patients who were and were not enrolled using chi-square tests. *Indicates variables that differed between groups after Bonferroni correction (adjusted for 4 domains; p<0.0125).

Table 2-4 summarizes the post-stroke outcome variables for patients who were enrolled compared to those who were not enrolled. No significant differences were found for any of the factors in bivariate analyses.
Table 2-4 - Post-stroke outcome variables at admission by enrollment status.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Total (N=338)</th>
<th>Enrollment status</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Score ± SD</td>
<td>Enrolled (n=129)</td>
<td>Not enrolled (n=209)</td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>National Institutes of Health Stroke Scale</td>
<td>132</td>
<td>3.7 ± 2.7</td>
<td>64</td>
<td>4.1 ± 2.5</td>
<td>68</td>
<td>3.4 ± 2.9</td>
</tr>
<tr>
<td>Chedoke-McMaster Stroke Assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg (paretic)</td>
<td>298</td>
<td>4.1 ± 1.2</td>
<td>113</td>
<td>4.0 ± 1.3</td>
<td>185</td>
<td>4.2 ± 1.2</td>
</tr>
<tr>
<td>Foot (paretic)</td>
<td>295</td>
<td>3.8 ± 1.4</td>
<td>112</td>
<td>3.5 ± 1.6</td>
<td>185</td>
<td>3.9 ± 1.3</td>
</tr>
<tr>
<td>Arm (paretic)</td>
<td>255</td>
<td>3.7 ± 1.5</td>
<td>102</td>
<td>3.6 ± 1.5</td>
<td>153</td>
<td>3.7 ± 1.5</td>
</tr>
<tr>
<td>Hand (paretic)</td>
<td>254</td>
<td>3.8 ± 1.6</td>
<td>101</td>
<td>3.6 ± 1.7</td>
<td>153</td>
<td>4.0 ± 1.5</td>
</tr>
<tr>
<td>Berg Balance Scale</td>
<td>331</td>
<td>27.0 ± 18.1</td>
<td>127</td>
<td>26.2 ± 18.7</td>
<td>204</td>
<td>27.4 ± 17.7</td>
</tr>
<tr>
<td>Clinical Outcome Variables Scale</td>
<td>333</td>
<td>57.4 ± 17.8</td>
<td>129</td>
<td>56.3 ± 17.7</td>
<td>204</td>
<td>58.1 ± 17.8</td>
</tr>
<tr>
<td>Functional Independence Measure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total function score</td>
<td>283</td>
<td>79.1 ± 21.5</td>
<td>115</td>
<td>76.9 ± 20.2</td>
<td>168</td>
<td>80.6 ± 22.3</td>
</tr>
<tr>
<td>Cognitive rating</td>
<td>283</td>
<td>24.3 ± 5.7</td>
<td>115</td>
<td>23.9 ± 5.7</td>
<td>168</td>
<td>24.5 ± 5.8</td>
</tr>
<tr>
<td>Motor rating</td>
<td>283</td>
<td>54.8 ± 19.2</td>
<td>115</td>
<td>53.0 ± 18.7</td>
<td>168</td>
<td>56.0 ± 19.5</td>
</tr>
</tbody>
</table>

No., number; SD, standard deviation.
The p-values are for the comparison of differences between patients who were and were not enrolled using t-tests. No variables were significantly different between groups using Bonferroni correction (adjusted for 5 domains; p<0.01).

Table 2-5 summarizes the multivariate logistic regression analyses that predicted enrollment in aerobic exercise. Stroke patients who were older (p=0.0093) and had cardiac disease (p=0.012), cardioembolic sources (p=0.0094), and arthritis (p=0.031) were less likely to be enrolled.

Table 2-5 - Multivariate logistic regression model predicting enrollment in a structured aerobic exercise program early after stroke.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Enrollment: Yes</th>
<th>OR</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td>0.973</td>
<td>0.953–0.993</td>
<td>0.0093</td>
</tr>
<tr>
<td>No cardiac disease</td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac disease</td>
<td></td>
<td>0.466</td>
<td>0.257–0.844</td>
<td>0.0117</td>
</tr>
<tr>
<td>No potential cardioembolic sources</td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential cardioembolic sources</td>
<td></td>
<td>0.473</td>
<td>0.268–0.832</td>
<td>0.0094</td>
</tr>
<tr>
<td>No arthritis</td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arthritis</td>
<td></td>
<td>0.431</td>
<td>0.201–0.924</td>
<td>0.0305</td>
</tr>
</tbody>
</table>

OR, odds ratio; CI, confidence interval.
2.4.3 Rate of attendance

The 129 patients who were enrolled were prescribed 9.0 (±5.6) exercise sessions over an average of 17.6 (±13.4) days in the aerobic exercise program. Patients attended 7.0 (±5.1) exercise sessions on average; the rate of attendance was 77.0% (±22.0; Table 2-2). Final aerobic exercise sessions were completed 3.6 (±7.8) days before discharge from in-patient rehabilitation. In bivariate analyses, there were no differences in rate of attendance between those with and without cardiovascular factors, musculoskeletal factors, other comorbid conditions, and prescribed medications. There was a weak, positive correlation between the rate of attendance and the FIM cognitive rating (r=0.27; p=0.0031).

2.5 Discussion and conclusions

2.5.1 Discussion

Over a third of stroke patients admitted to in-patient rehabilitation were enrolled in a structured aerobic exercise program. Multivariate logistic regression revealed that older age and the presence of cardiac disease, cardioembolic sources, and arthritis decreased the odds of being enrolled. However, post-stroke outcome variables (e.g. Chedoke McMaster Stroke Assessment) were not associated with enrollment. Except for a weak correlation between the rate of attendance and the FIM cognitive rating, no other factors were found to impact attendance.

This study suggests that cardiovascular risk factors can be a barrier to enrollment in a structured aerobic exercise program during in-patient stroke rehabilitation. Certainly, the careful consideration of patient safety is warranted. However, it may be concerning that similar cardiovascular risk factor profiles do not preclude participation in cardiac rehabilitation among people with coronary artery disease (Marzolini et al., 2012b). In fact, adapted cardiac rehabilitation models are feasible and effective for individuals with stroke living in the community (Prior et al., 2011; Tang et al., 2009a). When given the opportunity to participate, stroke patients can complete exercise testing, attain recommended aerobic exercise levels, and achieve training-related improvements in exercise capacity comparable to people with a diagnosis of coronary heart disease only (Marzolini et al., 2012a; Marzolini et al., 2012b; Tang et al., 2010).
The presence of arthritis decreased the odds of enrollment in the structured aerobic exercise program by 57%. These findings indicate that musculoskeletal complications can be a barrier to participation in aerobic exercise early after stroke. This barrier may be due to perceptions held by people with arthritis that are related to symptoms, fear of pain, fatigue, and impaired mobility (Wilcox et al., 2006). Conversely, the barrier may be related to physiotherapist perceptions regarding the patient’s ability to perform aerobic exercise. It is important to provide individuals with arthritis with strong recommendations to participate in physical activity regardless of the challenges (Austin et al., 2013; Baillet et al., 2010).

Post-stroke deficits did not limit a person’s ability to perform sub-maximal exercise testing or participate in a structured aerobic exercise program with adapted equipment. These findings differ from a survey of physiotherapists providing neurological rehabilitation across Canada (Doyle & MacKay-Lyons, 2013), in which many reported the impact of stroke-related disability (i.e. physical inability to perform at a training level) as a barrier to aerobic exercise. Features of the structured aerobic exercise program were integral to accommodate the breadth of post-stroke deficits encountered in this study. Since many individuals early post-stroke are non-ambulatory (Wade et al., 1987), this program involved semi-recumbent stepping machines for sub-maximal exercise testing and aerobic training. This mode can accommodate individuals with low levels of physical functioning, without limiting patients with higher functional capacities from reaching intensities required to induce an aerobic training benefit (Billinger et al., 2012b; Billinger et al., 2008; Mattlage et al., 2013). In addition, the use of semi-recumbent stepping machines may make higher client-to-staff ratios (i.e. group therapy) more manageable for supervising personnel.

Although aerobic exercise recommendations suggest individuals with cognitive impairment should not be denied the opportunity to participate in aerobic exercise (Billinger et al., 2014; MacKay-Lyons et al., 2012), physiotherapists practicing neurological rehabilitation commonly report cognitive or perceptual deficits as limiting an individual’s ability to perform aerobic exercise (Doyle & MacKay-Lyons, 2013). In the present study, bivariate analyses showed that the enrolled group had more stroke patients with cognitive impairment or dementia when compared to the not enrolled group. Yet, cognitive impairment or dementia was not associated with enrollment after controlling for confounding factors. Some individuals were not enrolled because they were not able to follow instructions or report concerns due to severe impairment
(i.e. part of referral criteria). However, whether a patient is able to follow instructions or report concerns depends, in part, on perceptions held by healthcare providers and their knowledge of communication-related impairments, including the awareness of patient impairments and strategies to facilitate more effective communication (O’Halloran et al., 2011). Future research is warranted to elaborate on adaptive equipment or procedures that may promote further inclusion within aerobic exercise programs, considering evidence of exercise-related improvements in cognitive function post-stroke (Marzolini et al., 2013; Quaney et al., 2009; Rand et al., 2010). It remains unclear whether the positive relationship between the FIM cognitive rating and the rate of attendance in the present study reflected safety or ability related concerns from physiotherapists or patients.

The criteria for referral to the aerobic exercise program were selected in accordance with American College of Sports Medicine (American College of Sports Medicine, 2010) and post-stroke aerobic exercise recommendations (Billinger et al., 2014). However, whether a patient is medically stable, able to follow instructions, or can report concerns is open to interpretation by healthcare providers within the context of their practice environment. By examining healthcare provider decisions, this study has provided a better understanding of evidence-practice gaps in relation to stroke best-practice guidelines and standards of care offered to populations with similar comorbid conditions (i.e. cardiac rehabilitation).

2.5.2 Limitations

Participation in aerobic exercise results from a complex interplay between the patient, healthcare providers, and the practice environment. The findings in this study may not be generalizable to other stroke rehabilitation centers. The healthcare team-system and structured aerobic exercise program may offer interdisciplinary cooperation, experience, and infrastructure to manage patients with complex healthcare needs that may not be available at other facilities. Since this study was a retrospective review, the authors were unable to consider the severity of cardiovascular and musculoskeletal conditions (i.e. controlled/uncontrolled), nor the timeline associated with the patients’ medical history (i.e. chronicity of conditions). No information was collected on the patients’ pre-stroke exercise behaviour, which limited discussion on how levels of prior experience or fatigue may impact enrollment and the rate of attendance early after
stroke. It is unknown which, if any, of the examined factors were the actual reason for non-enrollment.

2.5.3 Conclusions

This study identified patient characteristics that influence physiotherapist decisions regarding enrollment and attendance in a structured aerobic exercise program early after stroke. Patients who were older and had cardiovascular and musculoskeletal complications were less likely to be enrolled in aerobic exercise. However, post-stroke outcome variables were not associated with enrollment. In addition, the rate of attendance was only associated with one factor, the FIM cognitive rating. Future research should investigate physiotherapist and practice environment factors that may influence the decision to prescribe and implement aerobic exercise early after stroke.
Patients’ perspectives on aerobic exercise early after stroke

3.1 Abstract

**Purpose:** To identify patient perspectives on aerobic exercise during in-patient stroke rehabilitation, including their self-efficacy and beliefs towards exercise, as well as their perceptions of barriers.

**Methods:** A survey was conducted at three Canadian rehabilitation centres to evaluate individuals’ (N=33) self-efficacy and outcome expectations for exercise. In addition, patient perceptions of other people recovering from stroke, social support, and aerobic exercise as part of rehabilitation were assessed.

**Results:** Thirty two people completed the survey. Of these, 97% were willing to participate in aerobic exercise 5.9 ± 8.8 days after admission to in-patient rehabilitation. While outcome expectations for exercise were high, participants reported lower self-efficacy for exercise. Patients reported barriers related to the ability to perform exercise (other health problems (i.e. arthritis), not being able to follow instructions, and physical impairments) more often than safety concerns (fear of falling). The lack of support from a spouse and family were commonly identified, as was a lack of information on how to perform aerobic exercise.

**Conclusions:** Patients with stroke are willing to participate in aerobic exercise within a week after admission to in-patient rehabilitation. However, they perceive a lack of ability to perform aerobic exercise, social support from family, and information as barriers.
3.2 Introduction

Cardiorespiratory deconditioning (Brooks et al., 2008; MacKay-Lyons & Makrides, 2002b; Smith et al., 2012), residual deficits, and high energy costs of movement (Danielsson et al., 2007) compromise the ability to fully participate in activities of daily living after stroke (Glymour et al., 2007; Ivey et al., 2005; Mayo et al., 2002; Shephard, 2009). In addition, people recovering from stroke commonly have cardiovascular comorbidities (Chimowitz et al., 1997; Roth, 1993) which predispose them to recurrent stroke and increased risk of mortality (Hackam & Spence, 2007; Kernan et al., 2014; Meschia et al., 2014).

Physical inactivity is common post-stroke, contributes to the deconditioned state during hospitalization (Janssen et al., 2014; Moore et al., 2013; Prajapati et al., 2013; West & Bernhardt, 2012), and shares an inverse relationship with cardiovascular health (Physical Activity Guidelines Advisory Committee, 2008). While therapeutic interventions can improve balance, endurance, and mobility post-stroke (Duncan et al., 2003), standard rehabilitation lacks the aerobic intensity required to elicit an aerobic training benefit (Kuys et al., 2006; MacKay-Lyons & Makrides, 2002a). Although rehabilitation guidelines recognize the importance of aerobic exercise as part of a comprehensive stroke rehabilitation program (Billinger et al., 2014; MacKay-Lyons et al., 2012), the evidence and guidelines have not been fully translated into practice.

The lack of participation in aerobic exercise may reflect barriers encountered by individuals recovering from stroke, including factors that are environmental (access, transport, cost) or personal (health problems, stroke-related impairments, embarrassment, and fear of recurrent stroke; Nicholson et al., 2013a). In addition, the individual may choose not to participate due to negative perceptions or psychosocial factors that influence exercise behaviour and motivation. For example, self-efficacy for exercise, physical activity beliefs, and social support have been highlighted as important factors that influence the uptake and maintenance of physical activity after stroke (Morris et al., 2012). Despite these findings, it remains to be shown what aerobic exercise perceptions or barriers influence participation early after stroke, i.e. within 3-months post-stroke. This early period presents unique challenges but also opportunity to foster positive beliefs, change patient perspectives, and reduce long-term sedentary behaviours.
Therefore, the objectives of this study were to: 1) identify patient perspectives, self-efficacy, and beliefs towards aerobic exercise; and 2) identify the barriers to aerobic exercise within in-patient stroke rehabilitation.

### 3.3 Methods

#### 3.3.1 Study design

A cross-sectional survey of individuals recovering from stroke was conducted at three Canadian hospital-based rehabilitation centres. The local research ethic boards at each centre approved the study.

#### 3.3.2 Participants and setting

Individuals admitted for in-patient rehabilitation with a confirmed diagnosis of stroke were invited to participate in the study at each rehabilitation centre between December 2013 and December 2014. Diagnosis was confirmed by the indication of acute stroke in electronic patient records from diagnostic imaging (i.e. computerized tomography scan, magnetic resonance imaging, carotid ultrasound, cerebral angiogram, and/or echocardiogram). Participants were ≤ 3-months post-stroke, able to transfer with one person assist (or less), and had sufficient trunk control to sit independently. Individuals were excluded if they were unable to provide written informed consent or were unable to understand the evaluation procedures.

All participants received standard multidisciplinary rehabilitation that included physical therapy, occupational therapy, and speech or language therapy as needed 5 days per week. In one rehabilitation centre, individuals had the opportunity to participate in a structured group aerobic exercise program (Biasin et al., 2014).

#### 3.3.3 Measures

##### 3.3.3.1 Participant characteristics

Patient demographic information collected included age, sex, body mass index, the type and location of stroke, affected side, and time post-stroke. In addition, each individual’s pre-existing medical conditions, prescribed medications, and pre-stroke exercise behaviour (Schmidt et al., 2006) were collected. Post-stroke outcome variables collected on admission to in-patient rehabilitation evaluated neurological deficit (National Institute of Health Stroke Scale; Brott et
al., 1989; Goldstein & Samsa, 1997), physical impairment (Chedoke McMaster Stroke Assessment; Gowland et al., 1993), balance control (Berg Balance Scale; Berg et al., 1995; Berg et al., 1989), and cognitive impairment (Montreal Cognitive Assessment; Aggarwal & Kean, 2010; Nasreddine et al., 2005). At discharge from in-patient stroke rehabilitation, social support (Enriched Social Support Inventory; Mitchell et al., 2003) and depression or depressive disorder (Center for Epidemiological Studies Depression Scale; Radloff, 1977; Shinar et al., 1986) were evaluated.

3.3.3.2 Perspectives, self-efficacy, and beliefs towards aerobic exercise at discharge

Aerobic exercise was described to participants as “activities that raise your heart rate or increase your breathing rate for 10 minutes or more (continuously)”. Each individual was asked to provide an example of an activity they had done before their stroke that they considered aerobic exercise. The intensity of the activity was discussed with participants to discern whether it met stroke guidelines.

Participants were asked to report the importance of aerobic exercise on a scale from 0 (not important) to 100 (very important). In addition, each individual was asked whether they did or were willing to participate in aerobic exercise during in-patient rehabilitation. When appropriate, they were asked how many days after admission to in-patient rehabilitation they would have been willing to start aerobic exercise.

Self-efficacy and beliefs towards aerobic exercise were evaluated at discharge from in-patient rehabilitation as factors that influence the perception of barriers and the desire to participate. The Short Self-Efficacy for Exercise scale is a 4-item scale used to indicate the individual’s confidence to perform exercise in the face of challenges (Shaughnessy et al., 2004). Participants report their level of agreement with statements with response options ranging from 1 (not confident) to 5 (very confident). The Short Self-Efficacy for Exercise scale shows good internal consistency (Cronbach’s $\alpha = 0.86$), reliability ($R^2 = 0.38$ to 0.70), and construct validity (all $\lambda$ values significant and $> 0.50$) in people recovering from stroke.

The Short Outcome Expectations for Exercise scale is a 5-item scale used to assess the perception of potential benefits of exercise (Shaughnessy et al., 2004). Individuals report their
level of agreement according to a 5–point Likert-type scale from 1 (strongly disagree) to 5 (strongly agree). The Short Outcome Expectations for Exercise scale shows good internal consistency (Cronbach’s $\alpha = 0.90$), reliability ($R^2 = 0.47$ to 0.78), and construct validity ($\lambda$ values significant and $> 0.50$, except one item with a $\lambda = 0.47$) in people recovering from stroke.

3.3.3.3 Barriers to aerobic exercise questionnaire

A questionnaire was developed to identify patients’ perceptions on other individuals recovering from stroke, social support, and aerobic exercise as part of therapy (Appendix A). This survey expanded on preliminary work (Prout et al., 2015) by considering the available literature on potential barriers to physical activity and aerobic exercise among people with stroke (Jurkiewicz et al., 2011; Morris et al., 2012; Nicholson et al., 2013a; Nicholson et al., 2014; Poltawski et al., 2014; Simpson et al., 2011) and mobility impairments (Cowan et al., 2013; Kinne et al., 1999; Rimmer et al., 2004). In addition, we considered surveys that have been previously validated in stroke and populations with similar etiology/comorbidities and mobility impairments, including the: Barriers to Being Active Quiz (Zalewski and Dvorak, 2011); Exercise Benefits and Barriers Scale (Grace et al, 2008; Sechrist, Walker, and Pender, 1987); Barriers to Physical Exercise and Disability instrument (Rimmer, Rubin, and Braddock, 2000); and Barriers to Health Activities among Disabled Persons scale (Becker, Stuifbergen, and Sands, 1991; Kinne, Patrick, and Maher, 1999). Items were compiled and cross-referenced within a framework after considering the work of Conraads et al. (2012) and Flottorp et al (2013); items were revised to address the study objectives, and elaborated on with expert opinions.

Fifteen items evaluated perspectives on the safety, ability, and motivation to participate in aerobic exercise early after stroke. Four items evaluated perspectives on social support provided by family, healthcare providers, and other people recovering from stroke. Eight items evaluated patient perspectives on aerobic exercise given the context of equipment and procedures encountered during in-patient rehabilitation. In addition, three questions evaluated patient perspectives regarding the necessity of aerobic exercise and benefits specific to stroke recovery and cardiovascular health. Patients were asked to report their level of agreement with statements according to a 5-point Likert-type scale with response options: “strongly agree”, “agree”, “neutral”, “disagree”, and “strongly disagree”.
The questionnaire was administered via in-person interview to each individual by a member of the research team, which allowed respondents to elaborate or provide clarification regarding their responses, if required.

### 3.3.4 Data analysis

Data from the three rehabilitation centres were combined. Descriptive statistics were calculated for participant characteristics and perspectives and reported as means and standard deviations or counts and percentages. Individuals’ self-efficacy and beliefs towards aerobic exercise were scored by summing the rating for each response and dividing by the number of responses; means and standard deviations were reported.

Frequencies were calculated based on the total number of responses to each barrier statement and expressed as counts and percentages. Likert-type scale responses were collapsed by combining “strongly agree” and “agree” to form an “agree” category. Similarly, the “strongly disagree” and “disagree” responses were combined to form a “disagree” category.

### 3.4 Results

#### 3.4.1 Participant characteristics

A total of 33 individuals admitted to in-patient stroke rehabilitation were invited to participate; 32 completed the study and one declined to provide information at discharge. Participants were 68.3 ± 11.0 years of age, predominantly male (19/32; 61%), and admitted to in-patient rehabilitation 12.6 ± 21.5 days post-stroke. Characteristics of the participants are presented in Tables 3-1 and 3-2.

#### 3.4.2 Perspectives, self-efficacy, and beliefs towards aerobic exercise at discharge

Participants rated the importance of aerobic exercise before stroke, as 53.9 ± 41.2 on a scale from 0 (not important) to 100 (important). In contrast, the importance of aerobic exercise after stroke was rated as 82.7 ± 23.6. Ninety one percent of participants (29/32) agreed that aerobic exercise is a necessary part of in-patient stroke rehabilitation. Ninety seven percent of individuals (31/32) agreed that aerobic exercise improves stroke recovery as well as improves or maintains
heart health. Nearly all respondents (31/32; 97%) were willing to participate in aerobic exercise 5.9 ± 8.8 days (median: 1.3 days) after admission to in-patient rehabilitation.

With respect to aerobic exercise early after stroke, the average self-efficacy for exercise score was 3.4 ± 0.1 (out of 5) and the average outcome expectations for exercise score was 4.1 ± 0.2 (out of 5).

Table 3-1 - Demographics, pre-existing medical conditions, and pre-stroke exercise behaviours of patients admitted to in-patient stroke rehabilitation.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All participants (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%) or Mean ± SD</td>
</tr>
<tr>
<td>Females</td>
<td>13 (39)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>68.3 ± 11.0</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>28.1 ± 8.3</td>
</tr>
<tr>
<td>Time post-stroke (days)</td>
<td>12.6 ± 21.5</td>
</tr>
<tr>
<td>Stroke type</td>
<td></td>
</tr>
<tr>
<td>Ischemic</td>
<td>28 (88)</td>
</tr>
<tr>
<td>Hemorrhagic</td>
<td>3 (9)</td>
</tr>
<tr>
<td>Affected Hemisphere</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>17 (53)</td>
</tr>
<tr>
<td>Left</td>
<td>12 (38)</td>
</tr>
<tr>
<td>Both</td>
<td>2 (6)</td>
</tr>
<tr>
<td>Affected Side</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>13 (41)</td>
</tr>
<tr>
<td>Left</td>
<td>16 (50)</td>
</tr>
<tr>
<td>Both</td>
<td>3 (9)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>11 (34)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>22 (69)</td>
</tr>
<tr>
<td>Cardiac disease</td>
<td>7 (22)</td>
</tr>
<tr>
<td>Cardioembolic sources</td>
<td>9 (28)</td>
</tr>
<tr>
<td>Medications</td>
<td></td>
</tr>
<tr>
<td>β – blockers</td>
<td>8 (25)</td>
</tr>
<tr>
<td>ACE inhibitors</td>
<td>20 (63)</td>
</tr>
<tr>
<td>Ca²⁺ - channel antagonists</td>
<td>16 (50)</td>
</tr>
<tr>
<td>Statins, lipid lowering agents</td>
<td>31 (97)</td>
</tr>
<tr>
<td>Antidepressants</td>
<td>7 (22)</td>
</tr>
<tr>
<td>Pre-stroke exercise behaviours (age 30 to age at admission)</td>
<td></td>
</tr>
<tr>
<td>Walking and bicycling (hours per 7 day week)</td>
<td>13.0 ± 19.7</td>
</tr>
<tr>
<td>Sedentary activities (hours per 7 day week)</td>
<td>38.5 ± 41.0</td>
</tr>
</tbody>
</table>

Percentages and averages take into account missing data for some variables. No., number; %, percentage; SD, standard deviation.
### Table 3.2 - Post-stroke outcome variables, social support, and depression or depressive disorder evaluated among patients at in-patient stroke rehabilitation centres.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All participants (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
</tr>
<tr>
<td>National Institutes of Health Stroke Scale</td>
<td>32</td>
</tr>
<tr>
<td>Chedoke-McMaster Stroke Assessment</td>
<td></td>
</tr>
<tr>
<td>Leg (paretic)</td>
<td>32</td>
</tr>
<tr>
<td>Foot (paretic)</td>
<td>32</td>
</tr>
<tr>
<td>Arm (paretic)</td>
<td>31</td>
</tr>
<tr>
<td>Hand (paretic)</td>
<td>31</td>
</tr>
<tr>
<td>Berg Balance Scale</td>
<td>30</td>
</tr>
<tr>
<td>Montreal Cognitive Assessment</td>
<td>32</td>
</tr>
<tr>
<td>Enriched Social Support Inventory</td>
<td>31</td>
</tr>
<tr>
<td>Center for Epidemiological Studies Depression Scale</td>
<td>26</td>
</tr>
</tbody>
</table>

No., number; SD, standard deviation.

#### 3.4.3 Barriers to aerobic exercise

Participants reported 1 item out of 7 related to safety concerns as a barrier to participation in aerobic exercise during in-patient rehabilitation; 59% of respondents (19/32) agreed that fear of falling limited participation (Figure 3-1). In addition, individuals indicated that 3 items out of 7 concerning the ability to exercise were barriers to participation early after stroke (Figure 3-1); specifically, other health problems (e.g. arthritis) and not being able to follow instructions (or think properly) were highlighted by 63% of individuals (20/32), while physical impairment (or mobility problems) was identified by 53% (17/32). A lack of motivation early after stroke was seldom reported; only 28% of respondents (9/32) agreed that people are not motivated to participate in aerobic exercise.

Individuals reported 2 items out of 4 social support factors limited participation in aerobic exercise (Figure 3-1). Specifically, 72% of respondents (23/32) reported a lack of encouragement from a spouse, while 59% (19/32) identified a lack of encouragement from other family members.

Only 1 out of 7 factors related to aerobic exercise as part of rehabilitation was reported as a barrier (Figure 3-1); 53% (17/32) agreed that a lack of information on how to perform aerobic exercise limited participation. Group aerobic exercise was considered better than exercising alone by half the participants (16/32; 50%).
Figure 3-1 - Patients’ perspectives on barriers to aerobic exercise as part of in-patient stroke rehabilitation.
3.5 Discussion and conclusions

3.5.1 Discussion

This is the first study to consider the perspectives of people with stroke on aerobic exercise as part of in-patient stroke rehabilitation. Nearly all individuals considered aerobic exercise a necessary part of their rehabilitation and were willing to participate within one week of admission. While participants had high outcome expectations for exercise scores (i.e. believed in the benefits of aerobic exercise), their self-efficacy for exercise scores were lower than outcome expectations. This suggests respondents were less confident in their ability to overcome challenges to exercise. Individuals did not frequently perceive safety concerns as a barrier to aerobic exercise. Rather, other health problems (e.g. arthritis), not being able to follow instructions, and physical impairments limited their ability to participate. In addition, lack of support from a spouse and other family were identified as barriers. The lack of information on how to perform aerobic exercise was commonly highlighted.

Individuals recovering from stroke reported understanding and having an appreciation of the benefits of aerobic exercise in general (i.e. outcome expectations) and specific to improving or managing the effects of stroke and comorbid conditions. In comparison, patients were less confident in their ability to overcome challenges and identified the lack of information on how to perform aerobic exercise limited participation. The lack of information on how to perform exercise has also been reported by people with stroke in the community (Nicholson et al., 2014; Rimmer et al., 2008; Simpson et al., 2011) and emphasizes a need to improve the approach to patient education. However, patient education alone is ineffective (Boysen et al., 2009) and should be complemented with experience in an adapted aerobic exercise program that follows a standardized approach to assessment and prescription. An interesting finding in the present study was that self-efficacy for exercise scores were high, although participants had relatively low levels of pre-stroke exercise behaviour. It is possible that self-efficacy for exercise may have been inflated by a lack of experience with aerobic exercise (Jones et al., 2005; McAuley et al., 2006).

Patient concerns regarding their ability to perform aerobic exercise were more prevalent when compared to safety concerns early after stroke. Specifically, people identified other health concerns (e.g. arthritis), not being able to follow instructions, and physical impairments as
barriers to participation. Since physiotherapists practicing in-patient stroke (Prout et al. submitted for publication) and neurological rehabilitation in Canada (Doyle & MacKay-Lyons, 2013) have reported similar concerns, it may be that physiotherapists’ perceptions negatively influenced patients’ views. Nevertheless, these concerns are inconsistent with evidence and guidelines that recommend adapted aerobic exercise programs to improve or manage comorbidities and physical impairment for life-long recovery (Biasin et al., 2014; Billinger et al., 2014; Billinger et al., 2012b; MacKay-Lyons et al., 2012; MacKay-Lyons et al., 2013; Marzolini et al., 2013; Zedlitz et al., 2012).

Prior evidence has demonstrated that support from family and friends is important to people recovering from stroke (Galvin et al., 2009) and can improve the motivation to engage in physical activity (Poltawski et al., 2014; Resnick et al., 2008). In this study, the lack of encouragement from a spouse and other family members were recognized as barriers during in-patient rehabilitation. For individuals who lack family support (Kelly-Hayes et al., 2003; Petrea et al., 2009), there may be a particular need for additional support both in the hospital rehabilitation setting and on discharge into the community. Participating in group exercise sessions is one way that patients can receive support. When structured appropriately, group exercise can improve motivation and provide experience that may enhance competence, challenge negative perceptions, and improve beliefs (Banks et al., 2012; Reed et al., 2010). Future research may consider evaluating programs that engage caregivers in partnered aerobic exercise programs (Cao et al., 2010) and whether participation may be influenced by sex-specific exercise programming early after stroke (Andraos et al., 2014).

3.5.2 Limitations

Only three Canadian rehabilitation centres were used in this study. The three centres were selected to represent the spectrum of care available within urban hospital-based stroke rehabilitation centres. However, patient perceptions may not be generalizable to other individuals with stroke or healthcare models. Furthermore, the sample size of the present study was small; recruitment at one rehabilitation centre was interrupted because the structured aerobic exercise program was discontinued for a period to address safety concerns, while at another centre there were few patients referred to study researchers by healthcare providers. Future investigations should build on these findings with a larger group of patients across a wider geographical area.
3.5.3 Conclusions

People recovering from stroke consider aerobic exercise a necessary part of in-patient rehabilitation and are willing to begin training within a week after admission. While individuals believe in the benefits of aerobic exercise, they are less confident in their ability to overcome barriers early after stroke. Patients are concerned with their ability to perform aerobic exercise, the risk of falls, and consider the lack of social support from a spouse and family as limiting participation. Although few barriers were reported with respect to aerobic exercise as part of rehabilitation, a lack of information on how to perform aerobic exercise was commonly highlighted. There is a need to ensure patient education on how to perform aerobic exercise early after stroke and to reinforce these messages with experience in a structured aerobic exercise program that is part of routine rehabilitation and is conducted in a manner consistent with stroke guidelines. Future research is required to understand how to better engage family caregivers in aerobic exercise programs early after stroke.
Physiotherapists’ perspectives on aerobic exercise early after stroke

4.1 Abstract

**Purpose:** To identify the perspectives of physiotherapists on aerobic exercise prescription and implementation at in-patient stroke rehabilitation centres with and without a structured aerobic exercise program.

**Methods:** A survey was conducted at three Canadian rehabilitation centres to evaluate physiotherapist perceptions of individuals recovering from stroke, the practice environment, and their training on aerobic exercise in stroke.

**Results:** Physiotherapists at centres without a structured aerobic exercise program (n = 10) reported the lack of necessary resources and therapeutic support staff and the individuals’ physical impairment as the greatest barriers. In contrast, physiotherapists at the centre with a structured aerobic exercise program (n = 6) reported therapy selection (insufficient time in a single physiotherapy session) and concern for the individuals’ cardiovascular risk and cognitive impairment as the greatest barriers. Both groups of physiotherapists indicated that fatigue was a barrier. Only physiotherapists at the centre with a structured aerobic exercise program had received continuing education on aerobic exercise in stroke.

**Conclusions:** The lack of resources at rehabilitation centres without a structured aerobic exercise program needs to be addressed. There remains a need for continuing education on aerobic training in stroke, specifically on assessment and prescription using a standardized approach.
4.2 Introduction

Early after stroke, an individual’s cardiorespiratory fitness can be 50-60% lower than values for sedentary age- and sex-matched (MacKay-Lyons & Makrides, 2002b, 2004) and healthy age-matched adults (Brooks et al., 2008; Kelly et al., 2003). This limited cardiorespiratory fitness can persist for many years (Smith et al., 2012) and compromise the ability to perform activities of daily living (Glymour et al., 2007; Ivey et al., 2005) and function independently (Shephard, 2009). Moreover, stroke recovery is often complicated by pre-existing medical conditions (Chimowitz et al., 1997; Kernan et al., 2014; Roth, 1993), residual post-stroke impairments, and increased energy costs of movement (Danielsson et al., 2007).

Aerobic exercise positively impacts post-stroke recovery (Chen & Rimmer, 2011; Pang et al., 2006; Stoller et al., 2012) and is recognized as part of comprehensive stroke rehabilitation in best-practice and clinical guidelines (Billinger et al., 2014; Lindsay et al., 2010; MacKay-Lyons et al., 2012). However, many individuals remain physically inactive during their hospitalization (Janssen et al., 2014; Moore et al., 2013; Prajapati et al., 2013; West & Bernhardt, 2012) and do not engage in rehabilitation that is of sufficient intensity to provide an aerobic training benefit (Kuys et al., 2006; MacKay-Lyons & Makrides, 2002a). This prolonged physical inactivity may reflect limited opportunities to participate in structured aerobic exercise programs (Fullerton et al., 2008; Tang et al., 2009a) and is exacerbated by low rates of participation when structured programs are available (Biasin et al., 2014). Aerobic exercise may be particularly important in the sub-acute period of stroke recovery, i.e. within 3-months post-stroke, given that greater recovery in functional ambulation occurs when adapted aerobic and resistance training is started earlier after stroke (Marzolini et al., 2014). Furthermore, in-patient rehabilitation represents the ideal environment for multi-disciplinary staff to identify and manage pre-existing medical conditions while developing an optimal aerobic exercise prescription at an appropriate time.

To date, stroke rehabilitation literature has primarily focused on barriers and facilitators to physical activity and exercise among ambulatory individuals in the community (Jurkiewicz et al., 2011; Morris et al., 2012; Nicholson et al., 2013a; Simpson et al., 2011). However, there is limited information on physiotherapists’ perspectives regarding the barriers encountered early after stroke and whether perceptions differ among rehabilitation centres. Therefore, this study aimed to identify physiotherapists’ perspectives on aerobic exercise prescription and
implementation at in-patient stroke rehabilitation centres with and without a structured aerobic exercise program.

4.3 Methods

4.3.1 Study design

A prospective cross-sectional study of physiotherapists was conducted between January and July 2014 at three Canadian hospital-based rehabilitation centres that represent institutions that do and do not include a structured aerobic exercise program as part of in-patient stroke rehabilitation. Structured aerobic exercise programs: (i) are supervised by trained personnel, (ii) are a routine part of standard rehabilitation, (iii) include symptom-limited exercise testing to screen for contraindications to exercise and inform exercise prescription, (iv) require the intensity of exercise to be monitored quantitatively to ensure the planned intensity is met and to safeguard against adverse events, and (v) are progressed according to the individual. Ethics approval was obtained from the three participating rehabilitation centres. Table 4-1 provides a description of the characteristics of each rehabilitation centre.

Table 4-1 - Characteristics of rehabilitation centres with (site A) and without (sites B and C) a structured aerobic exercise program.

<table>
<thead>
<tr>
<th>Site</th>
<th>Type</th>
<th>Structured aerobic exercise program</th>
<th>Academic affiliation</th>
<th>Total unit beds (No.)</th>
<th>Average length of stay (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rehabilitation hospital</td>
<td>Yes</td>
<td>Yes</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>Rehabilitation hospital</td>
<td>No</td>
<td>Yes</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>C</td>
<td>Rehabilitation hospital</td>
<td>No</td>
<td>No</td>
<td>33</td>
<td>23</td>
</tr>
</tbody>
</table>

No., number.

4.3.2 Participants

Physiotherapists were included if they were actively practicing in-patient rehabilitation with adults (i.e. ≥18 years of age) recovering from stroke at one of the three participating rehabilitation centres. Each participant provided written informed consent prior to completing the questionnaire.
4.3.3 Barriers to aerobic exercise questionnaire

A questionnaire was developed to identify physiotherapist perceptions on individuals with stroke, the practice environment, and their training on aerobic exercise in stroke (Appendix B). We conducted a literature review on potential barriers to physical activity and aerobic exercise for healthcare providers and individuals with stroke (Doyle and MacKay-Lyons, 2013; Morris, Oliver, Kroll, and Macgillivray, 2012; Nicholson et al, 2013) as well as on healthcare provider and practice environment barriers to the implementation and use of evidence-based stroke rehabilitation recommendations (Bayley et al, 2012; McCluskey, Vratsistas-Curto, and Schurr, 2013; Pollock, Legg, Langhorne, and Sellars, 2000; Salbach et al, 2007). In addition, we considered surveys that have been previously validated in stroke and populations with similar etiology/comorbidities and mobility impairments, including the: Barriers to Being Active Quiz (Zalewski and Dvorak, 2011); Exercise Benefits and Barriers Scale (Grace et al, 2008; Sechrist, Walker, and Pender, 1987); Barriers to Physical Exercise and Disability instrument (Rimmer, Rubin, and Braddock, 2000); and Barriers to Health Activities among Disabled Persons scale (Becker, Stuifbergen, and Sands, 1991; Kinne, Patrick, and Maher, 1999). Items were compiled and cross-referenced within the Flottorp et al. (2013) framework, revised to address the study objectives, and elaborated on with expert opinions.

Physiotherapists reported their level of agreement with statements according to a 5-point Likert-type scale with response options: “strongly agree”, “agree”, “neutral”, “disagree”, and “strongly disagree”. In addition, respondents were asked to rank the three greatest barriers to aerobic exercise for two components: the individuals with stroke and practice environment. The importance of aerobic exercise was reported according to a scale from 0 (not important) to 100 (very important). Details of the approach to patient screening as well as prescribing and implementing aerobic exercise were collected. Each respondent provided demographic and practice information. Each centre provided an inventory of resources available for in-patient stroke rehabilitation.

The questionnaire was administered via in-person interview to each physiotherapist by a member of the research team, which allowed respondents to elaborate or provide clarification regarding their responses, if required.
4.3.4 Data analysis

Data from one rehabilitation centre with a structured aerobic exercise program (site A) was compared to the combined data from the two centres without a structured aerobic exercise program (sites B and C). Descriptive statistics were calculated for physiotherapist demographic and practice information.

The barriers to aerobic exercise were identified in two ways. First, the items ranked as the three greatest barriers, related to individuals with stroke and the practice environment, were standardized by group size; ranked percentage = (the number of times each item was selected divided by the number of respondents) x 100 at site A (6 respondents) and sites B and C (10 respondents). Items that differed by 30% or more were considered different between rehabilitation centres. Second, a barrier score was calculated for each questionnaire item by assigning 5-point Likert-type scale responses to numbers from 1 (not a barrier or a small barrier) to 5 (a common or large barrier). Items that differed by a barrier score of one or more were considered different between rehabilitation centres.

4.4 Results

4.4.1 Participants

A total of 17 physiotherapists were eligible to participate; 16 completed the questionnaire and one declined to participate. Physiotherapist demographic and practice information is provided in Table 4-2.

4.4.2 Perceived importance of aerobic exercise, exercise testing, and prescription

Physiotherapists rated the importance of aerobic exercise as part of physiotherapy practice as 88 ± 12 on a scale from 0 (not important) to 100 (very important). The importance of aerobic exercise as part of in-patient stroke rehabilitation was 90 ± 9 at site A and 78 ± 27 at sites B and C.

Almost all physiotherapists (15/16; 94%) reported that they screened individuals with stroke for safety and indications to participate in aerobic exercise. Symptom-limited exercise testing was
conducted by all respondents (6/6; 100%) at site A and half the respondents (5/10; 50%) at sites B and C.

Ninety-four percent (15/16) of physiotherapists reported that they prescribed and implemented aerobic exercise during in-patient stroke rehabilitation. A quantitative measure of the individuals’ cardiorespiratory response to exercise was used to prescribe and monitor exercise intensity by all respondents (6/6; 100%) at site A and over half the respondents (6/10; 60%) at sites B and C.

**Table 4-2** - Physiotherapist demographic and practice information at rehabilitation centres with (site A) and without (sites B and C) a structured aerobic exercise program.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Rehabilitation centres</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (N = 16)</td>
<td>With SAEP</td>
<td>Without SAEP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. (%)</td>
<td>Site A (n = 6)</td>
<td>Sites B and C (n = 10)</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>13 (81.3)</td>
<td>4 (66.7)</td>
<td>9 (90.0)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 30</td>
<td>2 (12.5)</td>
<td>1 (16.7)</td>
<td>1 (10.0)</td>
<td></td>
</tr>
<tr>
<td>31-40</td>
<td>5 (31.3)</td>
<td>0 (0.0)</td>
<td>5 (50.0)</td>
<td></td>
</tr>
<tr>
<td>41-50</td>
<td>3 (18.8)</td>
<td>2 (33.3)</td>
<td>1 (10.0)</td>
<td></td>
</tr>
<tr>
<td>&gt; 50</td>
<td>6 (37.5)</td>
<td>3 (50.0)</td>
<td>3 (30.0)</td>
<td></td>
</tr>
<tr>
<td>Entry level degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certificate</td>
<td>1 (6.3)</td>
<td>0 (0.0)</td>
<td>1 (10.0)</td>
<td></td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>11 (68.8)</td>
<td>5 (83.3)</td>
<td>6 (60.0)</td>
<td></td>
</tr>
<tr>
<td>Entry-level Master’s</td>
<td>4 (25.0)</td>
<td>1 (16.7)</td>
<td>3 (30.0)</td>
<td></td>
</tr>
<tr>
<td>Highest degree obtained</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor’s</td>
<td>9 (56.3)</td>
<td>3 (50.0)</td>
<td>6 (60.0)</td>
<td></td>
</tr>
<tr>
<td>Entry-level Master’s</td>
<td>4 (25.0)</td>
<td>1 (16.7)</td>
<td>3 (30.0)</td>
<td></td>
</tr>
<tr>
<td>Applied or research Master’s</td>
<td>3 (18.8)</td>
<td>2 (33.3)</td>
<td>1 (10.0)</td>
<td></td>
</tr>
<tr>
<td>Years practicing physiotherapy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤10</td>
<td>4 (25.0)</td>
<td>1 (16.7)</td>
<td>3 (30.0)</td>
<td></td>
</tr>
<tr>
<td>11-20</td>
<td>4 (25.0)</td>
<td>1 (16.7)</td>
<td>3 (30.0)</td>
<td></td>
</tr>
<tr>
<td>21-30</td>
<td>4 (25.0)</td>
<td>2 (33.3)</td>
<td>2 (20.0)</td>
<td></td>
</tr>
<tr>
<td>&gt; 30</td>
<td>4 (25.0)</td>
<td>2 (33.3)</td>
<td>2 (20.0)</td>
<td></td>
</tr>
<tr>
<td>Years practicing with individuals with stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤10</td>
<td>6 (37.5)</td>
<td>1 (16.7)</td>
<td>5 (50.0)</td>
<td></td>
</tr>
<tr>
<td>11-20</td>
<td>3 (18.8)</td>
<td>1 (16.7)</td>
<td>2 (20.0)</td>
<td></td>
</tr>
<tr>
<td>21-30</td>
<td>5 (31.3)</td>
<td>4 (66.7)</td>
<td>1 (10.0)</td>
<td></td>
</tr>
<tr>
<td>&gt; 30</td>
<td>2 (12.5)</td>
<td>0 (0.0)</td>
<td>2 (20.0)</td>
<td></td>
</tr>
</tbody>
</table>

No., number; %, percentage; SAEP, structured aerobic exercise program.
4.4.3 Education and training

Forty-four percent (7/16) of all physiotherapists agreed or strongly agreed that they had received training on aerobic exercise in stroke during their academic preparation (i.e. entry-level degree). Fifty-six percent (9/16) of respondents agreed or strongly agreed that they received training on aerobic exercise in stroke from continuing education (e.g. workshops). All respondents at site A had received training in continuing education on aerobic exercise after stroke, while few respondents at sites B and C were trained in continuing education (Figure 4-1). Ninety four percent (15/16) of physiotherapists agreed or strongly agreed that aerobic exercise is a necessary part of in-patient stroke rehabilitation. All respondents (16/16; 100%) agreed or strongly agreed that they were interested and willing to learn or improve the skills necessary to incorporate aerobic exercise into routine in-patient stroke rehabilitation.

**Figure 4-1** - Physiotherapist training on aerobic exercise in stroke at rehabilitation centres with (site A; n = 6) and without (sites B and C; n = 10) a structured aerobic exercise program.
4.4.4 Perceived barriers

4.4.4.1 Individuals with stroke

Figure 4-2 presents the greatest barriers ranked by physiotherapists, related to individuals with stroke, at sites with and without a structured aerobic exercise program. Cardiovascular risk and cognitive impairment were reported as barriers more frequently at site A (6/6 and 3/6; 100% and 50%) when compared to sites B and C (3/10 and 2/10; 30% and 20%). Alternatively, physical impairment was reported more frequently at sites B and C (8/10; 80%) when compared to site A (2/6; 33%). Fatigue was identified as a barrier by at least half of respondents at all sites (site A: 3/6; 50%; sites B and C: 6/10; 60%).

Barrier scores calculated from Likert scale responses supported the ranked data (Figure 4-2); physical impairments were reported as a greater barrier at sites B and C (3.1 ± 1.0) when compared to site A (2.0 ± 0.6).
Figure 4-2 - Physiotherapist perceptions of barriers related to the individual recovering from stroke at rehabilitation centres with (site A: black-filled) and without (sites B and C: unfilled) a structured aerobic exercise program. The top barriers ranked by physiotherapists (i) and calculated from barrier scores are presented (ii), with differences between rehabilitation centres indicated (*,†). SD, standard deviation.
4.4.4.2 The practice environment

Figure 4-3 presents the greatest barriers ranked by physiotherapists, as related to the practice environment, at sites with and without a structured aerobic exercise program. Insufficient time in a single physiotherapy session was reported more frequently at site A (5/6; 83%) when compared to sites B and C (2/10; 20%). In contrast, the lack of necessary resources and therapeutic support staff were reported more frequently at sites B and C (3/10 and 3/10; 30% and 30%) when compared to site A (0/6 and 0/6; 0% and 0%).

Barrier scores calculated from Likert scale responses elaborated on ranked data (Figure 4-3); the lack of equipment to screen or monitor the individuals’ safety, appropriate equipment to implement aerobic exercise routinely, therapeutic support staff, available space, and support for continuing education were reported as greater barriers at sites B and C (average score: 3.0 ± 0.1, range: 2.9 to 3.1) when compared to site A (average score: 1.8 ± 0.1, range: 1.7 to 2.0).
Figure 4-3 - Physiotherapist perceptions of barriers related to the practice environment at rehabilitation centres with (site A: black-filled) and without (sites B and C: unfilled) a structured aerobic exercise program. The top barriers ranked by physiotherapists (i) and calculated from barrier scores are presented (ii), with differences between rehabilitation centres indicated (*,†). SD, standard deviation.
4.4.5 In-patient stroke rehabilitation equipment

Table 4-3 summarizes the inventory of equipment for in-patient stroke rehabilitation at each centre. More equipment for exercise testing and training (mode) as well as screening and monitoring was available at site A when compared to sites B and C.

Table 4-3 - Equipment inventory at rehabilitation centres with (site A) and without (sites B and C) a structured aerobic exercise program.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>With SAEP</th>
<th>Without SAEP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Site A</td>
<td>Site B</td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>Exercise testing and training mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recumbent stepping machine</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Leg cycle ergometer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upright</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Recumbent</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Seated elliptical machine</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Treadmill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With body weight support</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Without body weight support</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Exercise screening and monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate (automated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest/wrist monitor</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Blood pressure (automated)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Heart activity (electrocardiogram)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Oxygen saturation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse oximeter</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Oxygen consumption (metabolic cart)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

No., number; SAEP, structured aerobic exercise program.

4.5 Discussion and conclusions

4.5.1 Discussion

The majority of physiotherapists valued the role of aerobic training early after stroke.

Physiotherapists at centres without a structured aerobic exercise program reported the lack of necessary resources, lack of therapeutic support staff, and the patients’ physical impairment as the greatest barriers. In contrast, physiotherapists at the centre with a structured aerobic exercise program identified insufficient time in a single physical therapy session as well as concern for
the patients’ cardiovascular risk and cognitive impairment as the greatest barriers. Both groups of physiotherapists indicated that fatigue was a barrier. Physiotherapists at the centre with a structured aerobic exercise program highlighted continuing education on aerobic training in stroke as an important component in their training; no such training was identified by physiotherapists at centres without a structured aerobic program.

The lack of resources is a core barrier to the implementation and use of best practices in stroke rehabilitation (Bayley et al., 2012; Doyle & MacKay-Lyons, 2013; McCluskey et al., 2013). Physiotherapists practicing neurological rehabilitation have reported that symptom-limited exercise tests are not available in their practice environments and that they seldom measure the individual’s cardiorespiratory response to exercise to quantify aerobic capacity or monitor exercise intensity (Doyle & MacKay-Lyons, 2013). In the present study, the lack of resources was identified more frequently by physiotherapists at rehabilitation centres without a structured aerobic exercise program. In fact, the disparity in the actual resources available at centres with and without a structured aerobic exercise program was striking; centres without a structured aerobic exercise program had inadequate equipment to perform exercise testing in a manner consistent with stroke recommendations (i.e. electrocardiograms and heart rate monitors) (Billinger et al., 2014; MacKay-Lyons et al., 2012). Furthermore, these physiotherapists lacked adapted equipment to implement aerobic exercise routinely for individuals with limited mobility (e.g. recumbent stepping machines or leg cycle ergometers).

The lack of therapeutic support staff and space were also found to be barriers at centres without a structured aerobic exercise program, which aligns with studies on implementing stroke evidence-based recommendations (Bayley et al., 2012; McCluskey et al., 2013). One solution that could address these barriers is to share rehabilitation areas with other programs that offer an aerobic component (e.g. pulmonary and cardiac rehabilitation), if available at that centre. Group exercise, either disease-specific or combined among chronic diseases, may involve varied therapeutic support staff (e.g. registered kinesiologists or physiotherapy assistants) and improve the efficient use of existing spaces.

Instead of resource limitations, physiotherapists at the rehabilitation centre with a structured aerobic exercise program reported barriers related to therapy selection more frequently. Specifically, insufficient time in a single physiotherapy session to implement aerobic exercise
was a barrier. The lack of time has been consistently identified as an important factor influencing the implementation (Bayley et al., 2012; McCluskey et al., 2013) and use of evidence-based recommendations in stroke rehabilitation (Pollock et al., 2000; Salbach et al., 2007). This limitation may reflect an expansion of stroke rehabilitation best-practice guidelines without sufficient increases in the treatment time provided. Alternatively, time limitations may reflect a need to explore opportunities to change the delivery of rehabilitation services (i.e. utilization of other program resources or task shifting to therapeutic support staff).

Evidence and stroke guidelines support the use of adapted exercise testing and aerobic training for all patients after a stroke regardless of the level of disability (Biasin et al., 2014; Billinger et al., 2014; Billinger et al., 2012b; MacKay-Lyons et al., 2012; MacKay-Lyons et al., 2013; Prout et al., 2015). However, Doyle and MacKay-Lyons (2013) have shown that the patients’ inability to perform at a training level is a barrier to the clinical utilization of aerobic exercise in neurological rehabilitation. The present study found that the stroke patients’ physical impairment was the greatest barrier to prescribing or implementing aerobic exercise at centres without a structured aerobic exercise program. In addition, fatigue was identified as an important barrier by physiotherapists at all centres in this study. Considering that aerobic exercise interventions can alleviate fatigue in individuals with stroke (Zedlitz et al., 2012), these findings highlight the need to ensure research is translated into practice.

The patients’ cardiovascular risk was the greatest barrier at the rehabilitation centre with a structured aerobic exercise program, which is in agreement with previous studies (Doyle & MacKay-Lyons, 2013; Prout et al., 2015). However, stroke rehabilitation guidelines suggest that the benefits of structured aerobic exercise, if utilized in a manner consistent with recommendations, outweigh the risks of participation (Billinger et al., 2014; MacKay-Lyons et al., 2012). Specifically, clinical recommendations describe the importance of graded symptom-limited exercise testing to detect clinically relevant abnormalities and screen for contraindications in individuals with and without a history of coronary artery disease. It is noteworthy that barrier scores assigned to cardiovascular risk were similar between rehabilitation centres; cardiovascular risk may not have been ranked among the greatest barriers by physiotherapists at centres without a structured program since they were limited to reporting only the top three barriers.
Cognitive impairment was revealed as a barrier to aerobic exercise by physiotherapists at the centre with a structured aerobic exercise program and has been identified by physiotherapists practicing neurological rehabilitation in Canada as well (Doyle & MacKay-Lyons, 2013). Recent evidence has shown that cognitive impairment does not have to prevent enrollment in adapted aerobic exercise programming early after stroke (Prout et al., 2015) and that cognitive function post-stroke can improve with exercise (Marzolini et al., 2013; Quaney et al., 2009; Rand et al., 2010). This study highlights an opportunity to develop practical strategies that promote the inclusion of stroke patients with cognitive impairment.

Physiotherapists at centres without a structured aerobic program had not received continuing education on aerobic exercise in stroke. In addition, these physiotherapists reported a lack of support for continuing education among the barriers to aerobic exercise prescription and implementation. Ongoing training through different learning approaches (Forsetlund et al., 2009b; Roshanov et al., 2011) and support from management, colleagues, and mentors (internal or external to the practice environment) (Ivers et al., 2012) are important to initiate and maintain strong stroke rehabilitation programs.

4.5.2 Limitations

This study was limited by only capturing the perceptions held by physiotherapists at in-patient rehabilitation centres with and without a structured aerobic exercise program at one point in time. An individual's perceptions are dynamic and the views herein may not represent those of physiotherapists in different practice environments or healthcare models. Three centres were chosen to ensure the quality of data and allow physiotherapists to provide detailed answers during in-person interview; few elaborated on their responses. Future investigations should build on these findings with a larger group of physiotherapists and may consider a mass-mailing approach to physiotherapists across a wider geographical area. In addition, this study should be expanded beyond the perspectives of physiotherapists to better represent the interdisciplinary nature of stroke rehabilitation. The extent to which the characteristics of the practice environment and work culture that led to the implementation of the structured aerobic exercise program at site A influenced physiotherapist perceptions were not investigated.
4.5.3 Conclusions

Physiotherapists at centres without a structured aerobic exercise program reported the lack of resources and the patients’ physical inability to perform exercise as the greatest barriers. In contrast, physiotherapists at the centre with a structured aerobic exercise program identified therapy selection and concern for the patients’ cardiovascular risk and cognitive impairment as the greatest barriers. The lack of resources at rehabilitation centres without a structured aerobic exercise program needs to be addressed. After resource limitations have been met, there remains a need for continuing education and ongoing support to improve and maintain structured aerobic exercise programs early after stroke.
5 Discussion
5.1 Summary of findings

This dissertation aimed to better understand factors that facilitate or prevent participation in aerobic exercise early after stroke. To achieve this, three studies were completed to examine patient and healthcare provider perceptions that influence aerobic exercise participation within in-patient stroke rehabilitation. First, patient characteristics were identified that influence participation in aerobic exercise. Building on these findings, the second study identified patient perceptions that influence the decision to participate. Third, physiotherapist perceptions that influence their decision to prescribe and/or implement aerobic exercise were examined. Since the determinants to participation are specific to the context under investigation, the third study considered the characteristics of practice environments with and without structured aerobic exercise programs.

We found that people with stroke and physiotherapists valued the role of aerobic training early after stroke and considered it a necessary part of in-patient stroke rehabilitation. However, patients and some physiotherapists identified several factors that limited participation. Both patients and some physiotherapists reported that physical impairments were a barrier to participation in study 2 and 3; however, the retrospective review in study 1 showed that physical impairments did not limit participation in adapted aerobic exercise. In addition, patients and some physiotherapists perceived that arthritis, fatigue, and cognitive deficits limited participation; whereas arthritis and cognitive deficits limited participation in a structured aerobic exercise program in study 1. Furthermore, physiotherapist perceptions were different at centres with and without a structured aerobic training program in study 3. Specifically, physiotherapists reported the lack of resources and continuing education as key barriers at centres without a structured program. In contrast, physiotherapists identified concerns for patients’ cardiac and cognitive status as well as insufficient time as key barriers at centres with a structured program.

5.2 The impact of physical impairment, symptoms, and co-morbidities on participation

Consistent with a survey of physiotherapists providing neurological rehabilitation in Canada (Doyle & MacKay-Lyons, 2013), physical impairments were perceived as barriers to aerobic exercise by patients and some physiotherapists in study 2 and 3. In contrast, we found that that physical impairments do not have to limit enrollment or attendance in a structured aerobic
exercise program in study 1. It is likely that physiotherapist perceptions on the patients’ inability to perform exercise were influenced by the lack of resources at rehabilitation centres without a structured aerobic exercise program. Indeed, the resource inventory in study 3 highlighted that centres without a structured aerobic exercise program had inadequate equipment to perform exercise testing and training, for individuals with limited mobility, in a way that is consistent with recommendations (Billinger et al., 2014; MacKay-Lyons et al., 2012). Specifically, these centres lacked adapted equipment to implement aerobic exercise routinely (e.g. recumbent stepping machines), which can accommodate people with low levels of function without limiting people with higher functional capacities from achieving aerobic intensities (Billinger et al., 2012b; Billinger et al., 2008; Mattlage et al., 2013). Availability of adapted equipment could encourage participation and make the delivery of aerobic exercise more manageable. If resources are an issue, sharing space, equipment, and staff with other programs that offer aerobic exercise (e.g. cardiac and pulmonary rehabilitation) is one potential solution. It is possible that physical impairment masked, or confounded, a lack of time available to physiotherapists. For example, the time required to set up and perform aerobic exercise on a treadmill may be perceived as a barrier related to patient ability, as opposed to a barrier related to the availability of adapted equipment.

Although several comorbid conditions were found to limit participation in aerobic exercise, none of those identified are unique to stroke. Arthritis was found to limit enrollment in aerobic exercise in study 1 and patients perceived arthritis as a barrier to participation early after stroke in study 2. Aerobic exercise is recommended for people with arthritis to manage the local and systemic effects of the disease (Baillet et al., 2010) and reduce the risk of adverse cardiovascular events (Stavropoulos-Kalinoglou et al., 2013). However, people with arthritis commonly perceive the symptoms of arthritis, including fear of pain, stiffness, fatigue, and impaired mobility as barriers to physical activity (Wilcox et al., 2006). Education and engagement are key to mitigating these perceptions; people with arthritis who exercise report improvements in their arthritic symptoms, are less likely to restrict exercise due to symptoms, and find ways to modify exercise to accommodate physical deficits (Wilcox et al., 2006).

Fatigue was reported as a barrier to prescribing and/or implementing aerobic exercise by physiotherapists at both rehabilitation centres study 3. However, fatigue was not among the patient characteristics or perceptions that limited participation in studies 1 or 2. Fatigue can be
alleviated by aerobic exercise interventions in people with stroke (Zedlitz et al., 2012). Nevertheless, fatigue due to other reasons (e.g. other therapy and lack of sleep) is a factor that contributes to missed exercise sessions that are scheduled during in-patient stroke rehabilitation (Biasin et al., 2014). Therefore, the management of fatigue needs to be discussed by the healthcare team and patients when developing a coordinated care plan to ensure the impact of this barrier is minimized.

In study 3, some physiotherapists reported cognitive deficits were a barrier to prescribing and/or implementing aerobic exercise. These negative perceptions are consistent with findings from Doyle and MacKay-Lyons (2013), who found that cognitive and perceptual deficits limited the clinical utilization of aerobic exercise by physiotherapists practicing neurological rehabilitation in Canada. However, stroke rehabilitation guidelines do not suggest people with cognitive impairments should be excluded from aerobic exercise programs (Billinger et al., 2014). In fact, there is evidence that cognitive function can improve with exercise after stroke (Kluding et al., 2011; Marzolini et al., 2013; Quaney et al., 2009; Rand et al., 2010). Study 1 findings suggest that people with cognitive deficits may be well able to complete exercise testing and engage in aerobic exercise.

Cardiovascular concerns were shown to limit enrollment in a structured aerobic exercise program in study 1 and were perceived by some physiotherapists as the greatest barrier to the prescription and/or implementation of aerobic exercise in study 3. This concern is consistent with the findings of a previous study that examined the feasibility of implementing aerobic exercise within in-patient stroke rehabilitation (Biasin et al., 2014) and the perceptions of physiotherapists practicing neurological rehabilitation in Canada (Doyle & MacKay-Lyons, 2013). While concerns for the patients cardiac status are warranted, individuals with similar cardiovascular comorbidities are not excluded from cardiac rehabilitation (Marzolini et al., 2012b). Furthermore, people with stroke who are given the opportunity to participate in adapted cardiac rehabilitation programs can complete exercise testing, perform at training levels required for an aerobic benefit, and achieve training outcomes that are comparable to people with coronary artery disease (Marzolini et al., 2012a; Marzolini et al., 2012b; Tang et al., 2009a). These findings may suggest an inherent fear of adverse cardiovascular events among physiotherapists, which may be overcome by providing access to equipment to screen patients (i.e. electrocardiograms) and opportunities for training (i.e. on cardiovascular disease, managing risk,
and how to use monitoring equipment) as well as integrating policies and procedures that are similar to those in cardiac rehabilitation.

5.3 Education and engagement of patients

Nearly all individuals with stroke in study 2 reported that aerobic exercise was a necessary part of in-patient stroke rehabilitation and were willing to participate within one week of admission. In addition, they reported that they had an appreciation for the general benefits of aerobic exercise as well as those specific to improving or managing the effects of stroke and comorbid conditions. However, they were less confident in their ability to overcome challenges to exercise after stroke. Patients held negative perceptions regarding physical deficits, other comorbid conditions (i.e. arthritis), the inability to follow instructions, and the fear of falling. These concerns are important to address, since they undermine the patients perceived ability to exercise control over their behaviours (e.g. participation in aerobic exercise; Bandura, 1971, 1998).

Information may be made available to people with stroke in many formats, such as in-person meetings with healthcare providers and hard-copy handouts. For example, infographics may be particularly well suited to those with cognitive impairments. However, mastery experiences, i.e. having the opportunity to participate in exercise, may have the greatest influence on a person’s self-efficacy for exercise (Bandura, 1971, 1998). In addition, consistent messages that reinforce the importance of the program by the entire healthcare team would likely encourage participation. For example, strong recommendations to exercise from physicians have been shown to influence participation in several disabled populations (e.g. people with cardiac disease and arthritis; Austin et al., 2013; Ghisi et al., 2013). The message to be conveyed is that aerobic exercise is an important part of stroke rehabilitation, not an adjunct to regular therapy.

This positive message could be reinforced by prioritizing a regularly scheduled structured aerobic exercise program within the rehabilitation setting. Planning the patient’s day around an aerobic program would allow for optimizing exercise effects that have the potential to augment other therapies and periods of rest. Placing aerobic exercise at the centre of the post-stroke routine in the rehabilitation setting implies that consistent participation is as important as pharmacological and therapeutic interventions. Furthermore, having the ability to predict events in the day and prepare accordingly may influence the ability for patients to manage expectations.
or goals and their commitment to exercise control in order to achieve these goals (Bandura, 1971, 1998).

The maintenance of exercise is a challenge for healthy individuals and those with chronic diseases. One solution may be to adopt a de-medicalized model of participation that acknowledges personal gains, but, emphasizes a community of care and the development of peer-to-peer relationships. Based on the findings of study 2, patients perceive the encouragement and support of family as being particularly important. However, previous research has shown that caregivers often feel excluded from the formal rehabilitation process (Galvin et al., 2009; Smith et al., 2004). Alternatively, family and caregivers could be included in partnered aerobic exercise programs (Cao et al., 2010; Huijbregts et al., 2008), with potential benefits that include distributing education on lifestyle change (e.g. how to exercise and manage comorbidities) and developing critical skills for sustained engagement through practical experience (e.g. modify activity according to disability) across the immediate circle of care. Another opportunity is to have group exercise programs that are specific to stroke or involve individuals with disability or chronic disease. Group exercise provides the chance to connect socially, which can provide implicit pressure to adhere (Damush et al., 2007; Resnick et al., 2008), may challenge negative perceptions of ability, and allows for the exchange of advice or encouragement when attempting new exercises (Reed et al., 2010). These positive aspects may be particularly important to help establish and cultivate supportive relationships for individuals who lack family support.

Innovative technologies may play an important role in reinforcing behavioural change as well. Wearable technologies such as pedometers or accelerometers offer several benefits related to affordability and accessibility, in terms of simplistic output, low-literacy requirements, and can be immediately understandable by patients (Mansfield et al., 2013; Tudor-Locke & Lutes, 2009). In addition, these tools can help patients link self-monitoring, which can be personalized by healthcare providers, to achieve measureable goals. While evidence indicates that accelerometer-based feedback may not increase the amount of walking in people early after stroke, this feedback has been shown to increase the intensity of activity (i.e. cadence) and translate to greater walking speeds (Mansfield et al., 2015). The example of accelerometers may be useful for ambulatory individuals who want to do more during the in-patient stay and require guidance from healthcare providers on lifestyle change, yet have short lengths of stay and may be discharged directly home without adequate follow-up. However, accelerometers may not be
appropriate for non-ambulatory individuals, in terms of relevance to post-stroke goals or device sensitivity. Furthermore, to provide information on increasing or maintaining aerobic capacity, there is a need to measure the intensity of activity according to the individual’s cardiorespiratory response. While heart rate monitors are options, they may be less accessible.

One way to improve the transfer of information and ensure that the important messages of exercise are more accessible to patients is through developing applications for mobile devices. For example, FitBit® applications provide the opportunity for the general public to self-monitor their steps, linking this outcome to short and long-term goals, as well as offer the ability to stay connected with groups of individuals for competition or support. In stroke, there is potential for these applications to facilitate the transition from supervised exercise to independent participation by allowing tailored programming, engaging patients in self-monitoring, producing a tangible record of progress, and providing a sense of accountability by submitting data (Bravata et al., 2007; Heesch et al., 2005). While application interfaces may allow for automatic messages on goal setting using algorithms (Carr et al., 2008; Richardson et al., 2007), tailored counseling holds an important place in engaging people in physical activity for the long-term (Morris et al., 2014). Accordingly, video-based interactions may be used for follow-up contact to facilitate goal-setting as well as planning relapse prevention.

Whether technologies are incorporated into the education and engagement strategy or not, long-term behavioural change should be promoted as part of a lifestyle intervention that extends from the hospital to the community. This may be accomplished by improving access to established outpatient rehabilitation programs that require minor adaptation (e.g. cardiac rehabilitation) as well as engaging community based centres in the delivery of fitness programs to underserved populations (e.g. Young Men’s Christian Association). While healthcare workers play an important role in helping transition patients to the community, there may be potential for monetary incentive programs that motivate behaviour change and offset economic barriers (Mitchell et al., 2014).

5.4 Education and engagement of physiotherapists

Nearly all physiotherapists agreed or strongly agreed that aerobic exercise is a necessary part of in-patient stroke rehabilitation in study 3. In addition, all respondents were interested and willing to learn or improve the skills necessary to incorporate aerobic exercise into routine in-patient
stroke rehabilitation. However, the lack of resources was a core barrier to the implementation and use of aerobic exercise in a manner that is consistent with stroke best practice guidelines. This finding is consistent with prior evidence showing symptom-limited exercise tests are not available and the individual’s cardiorespiratory response to exercise is seldom quantified by physiotherapists practicing neurological rehabilitation in Canada (Doyle & MacKay-Lyons, 2013). Furthermore, the lack of time is as an important barrier as has been shown previously in studies on the implementation and use of evidence-based recommendations in stroke (Bayley et al., 2012; McCluskey et al., 2013; Pollock et al., 2000; Salbach et al., 2007). One solution may be to share rehabilitation areas and resources with other programs that offer an aerobic component (e.g. pulmonary and cardiac rehabilitation), if available at that centre. Group exercise, either disease-specific or combined among chronic diseases (Salbach et al., 2014), may involve varied therapeutic support staff and improve the efficient use of existing spaces.

Physiotherapists practicing stroke rehabilitation perceive several comorbidities as barriers to prescribing or implementing aerobic exercise. Since none of these comorbid conditions are unique to stroke, there is a need to provide education on how to adapt aerobic exercise programs to accommodate impairments or comorbidities. Some physiotherapists in study 3 indicated that they lacked continuing education on aerobic exercise in stroke. Even those who did receive additional training on aerobic exercise in stroke still reported that patients’ cardiovascular status was a prominent concern when prescribing and/or implementing aerobic exercise. Continuing education programs for physiotherapists on topics such as cardiovascular disease and exercise, how to manage risk, and how to use monitoring equipment is needed. This ongoing training may occur through different learning approaches such as continuing education meetings (e.g. conferences, workshops, or lectures), audit and feedback of clinical performance, outreach visits by health professionals to provide practical skills training, and automated clinical decision support services (Forsetlund et al., 2009a; Jamtvedt et al., 2006; Roshanov et al., 2011; Sahota et al., 2011). In particular, mentorship in clinical practice by healthcare professionals who act as local opinion leaders are important to initiate and maintain strong stroke rehabilitation programs (Bayley et al., 2012; Flodgren et al., 2011; Ivers et al., 2012).
5.5 Summary of recommendations for physiotherapists

The following are recommendations for physiotherapists to improve participation in aerobic exercise early after stroke:

- Provide patient education on comorbid conditions that are not unique to stroke (e.g. arthritis) and how aerobic exercise can improve or manage symptoms;
- Provide experience in structured aerobic exercise programs to reduce negative patient perceptions (e.g. physical impairment) and improve self-efficacy for exercise;
- Emphasise how to perform aerobic exercise through education and engagement; general exercise programming, managing comorbidities, and accommodating post-stroke disability;
- Emphasise a community of care; better engage family or caregivers in education and exercise (e.g. partnered exercise) and facilitate peer-to-peer relationships in group exercise;
- Reinforce the message that aerobic exercise is an important part of rehabilitation, not an adjunct to regular therapy; provide strong recommendations to exercise;
- Present aerobic exercise to patients as part of a long-term lifestyle intervention; refer to community services prior to discharge from the hospital;
- Consider arranging therapy around a regularly scheduled structured aerobic exercise program;
- Consider improving knowledge of cardiovascular disease, managing risk, and how to use monitoring equipment;
- Consider improving knowledge of communication-related impairments, including the awareness of patient impairments and strategies to facilitate more effective communication;
- Consider fatigue in coordinated care planning among the interdisciplinary team (e.g. therapy scheduling or pharmacological interventions) to minimize the impact of this barrier;
- Consider sharing therapeutic support staff (e.g. registered kinesiologists or physiotherapist assistants) with other programs that offer aerobic exercise or task-shifting;
- Consider innovative technologies to augmenting patient education and engagement.
5.6 Summary of recommendations for managers and policy makers

The following are recommendations for managers and policy makers to improve participation in aerobic exercise early after stroke.

5.6.1 Centres with and without a structured aerobic exercise program

The recommendations for managers and policy makers at centres with and without a structured aerobic exercise program are to:

- Consider sharing space, equipment, and therapeutic support staff with other programs that offer aerobic exercise (e.g. cardiac and pulmonary rehabilitation);
- Develop group aerobic exercise programs, either disease-specific or combined among chronic diseases;
- Provide opportunities for training on aerobic exercise in stroke; specifically on how to adapt aerobic exercise to accommodate impairments or comorbidities that are not unique to stroke (i.e. physical impairment, cognitive impairment, arthritis);
- Develop materials and innovative technologies that better engage patients, emphasizing the importance of aerobic exercise and facilitating the transition from hospital to community;
- Consider monetary incentives to motivate behaviour change and attendance in aerobic exercise programs in the hospital and community.

5.6.2 Centres without a structured aerobic exercise program

The recommendations for managers and policy makers at centres without a structured aerobic exercise program are to:

- Provide equipment to conduct exercise testing and training in a manner that is consistent with stroke guidelines, specifically,
  - Adapted exercise equipment (e.g. recumbent stepping machines; optional leg stabilizer attachments) to accommodate people with low levels of functioning and may make higher client-to-staff ratios more manageable;
- Provide equipment to monitor the cardiovascular response to exercise in a manner that is consistent with stroke guidelines, specifically,
  - Electrocardiogram to monitor heart activity during exercise testing to ensure safety;
• Equipment to monitor heart rate and blood pressure during exercise to ensure safety and that the planned exercise intensity is met;

• Provide sufficient equipment to implement aerobic exercise as a routine part of rehabilitation.

5.6.3 Centres with a structured aerobic exercise program

The recommendations for managers and policy makers at centres with a structured aerobic exercise program are to:

• Provide opportunities for training on aerobic exercise in stroke; specifically, on cardiovascular disease, managing risk, and how to use monitoring equipment in a manner similar to that provided to healthcare professionals in cardiac rehabilitation;

• Develop materials and procedures to support task-shifting to therapeutic support staff (e.g. registered kinesiologists or physiotherapist assistants);

• Develop adaptive equipment or procedures for people with cognitive impairment that may promote further inclusion (e.g. infographics).

5.7 Limitations

The findings from the three Canadian rehabilitation centres involved may not be generalizable to other healthcare settings or models of care, within Canada or internationally. The small sample sizes of study 2 and 3 may also compromise generalizability. In addition, study 1 was limited by factors inherent to a retrospective review, for example, information on the severity (i.e. controlled/uncontrolled) or timeline (i.e. chronicity) of pre-stroke medical conditions were not available in the Balance Mobility and Falls Clinic database. The extent to which the characteristics of the practice environment and work culture that led to the implementation of a structured aerobic exercise program influenced physiotherapists’ perceptions in study 3 remains unclear. The questionnaires were comprised of closed-ended questions; however, the use of open-ended questions may have allowed for the identification of new barriers not previously reported in the literature, or contributed to our understanding on the relative importance of barriers early after stroke. In addition, the intention of delivering questionnaires to participants via in-person interview was to provide the opportunity to elaborate on responses or provide clarification, as required. However, the interviewer may have introduced bias when delivering the questionnaire during in-person interviews, since participants may have perceived pressure to report positive aspects of participation or healthcare practice.
In this study, Bandura’s Social Cognitive Theory was used to explore the relationships among cognitive constructs and factors that may be perceived as barriers or facilitators to participation in aerobic exercise early after stroke (Bandura, 1971, 1998). Whether applied to the patient or physiotherapist, this model allows for the understanding of individual self-perceptions within the context of social and environmental constructs in comprehensive detail. For example, the patient related findings herein were distributed among all three domains (behavioural: low self-efficacy; social: lack of encouragement from a spouse and family; and environmental: lack of information on how to perform exercise). Moreover, links were drawn between domains when describing potential solutions (i.e. providing experience in a structured aerobic exercise program (environmental domain) may improve the individuals’ self-efficacy for exercise (behavioural domain). However, it may be that other models may provide a better framework to link the findings from this thesis to changes in practice, with the hope of realizing positive outcomes within in-patient stroke rehabilitation.

Physical activity after stroke has been considered using other models of behaviour change with varying degrees of detail and scope; focusing on components of Bandura’s Social Cognitive Theory (Resnick et al., 2008; Shaughnessy et al., 2012; Shaughnessy & Resnick, 2009; Shaughnessy et al., 2006); the Transtheoretical Model (Garner & Page, 2005; Gillham & Endacott, 2010); and combined Transtheoretical Model and extended Health Belief Model (Gill & Sullivan, 2011). While the Transtheoretical Model considers behaviour change over time and incorporates strategies to assist individuals through sequential stages (Prochaska & DiClemente, 1983), none of the studies in this thesis were longitudinal. Accordingly, the Transtheoretical Model would be better suited to research examining aerobic exercise and patient level outcomes at multiple time-points during phases of rehabilitation or through transitions (i.e. hospital to community).

The updated version of Andersen’s Behavioural Model of Healthcare Service Use may better frame the barriers to participation as well as link potential solutions to patient outcomes (Andersen, 1995). The original Andersen model focused on predisposing, need, and enabling factors associated with overall health care utilization, while updated versions have included constructs that consider whether healthcare access (or interventions or technologies) are equitable, efficient, and effective (Appendix C). Alternatively, the Ottawa Model of Health Care Research Use may better suit researchers, practitioners, or policy makers interested in integrating
evidence or policy in practice (Logan & Graham, 1998). The Ottawa model can account for multiple stakeholders (e.g. several clinical disciplines), the evidence-based innovation, knowledge translation strategies, and allows for outcome evaluation at patient, practitioner, and economic levels (Appendix D). A theoretical model that thoroughly considers constructs that govern patient behavioural change within an interdisciplinary model of research use in health care has yet to be determined.

5.8 Future research

The investigation of physiotherapist perceptions may be expanded by using a mass-mailing approach to recruit more physiotherapists across a wider geographical area. In addition, future investigations should consider better representing the interdisciplinary nature of stroke rehabilitation by including other healthcare professionals. Building on this notion, there is a need to better understand the relationship between people with stroke and their caregivers (family, friends, or personal support workers) and caregiver needs, so that they can be better engaged in the rehabilitation strategy. One logical progression of this research is to examine the implementation of structured aerobic exercise programs within different rehabilitation centres. This approach should include detailed information on the pre-intervention infrastructure, audit and feedback regarding barriers and facilitators throughout the implementation process, as well as post-intervention changes in infrastructure, healthcare provider perceptions, and the plan to sustain the program. Research that has evaluated group aerobic exercise programs for people with multiple types of chronic disease or disability may provide useful information for manager interested in maximizing the use of existing resources. In addition, future research is needed to develop adaptive equipment and evaluate interventions or procedures that meet specific physiotherapist concerns regarding including individuals with cardiac comorbidities and conditions that are not unique to stroke (i.e. arthritis, fatigue, and cognitive impairment). Furthermore, there is a need to develop and implement educational tools for patients and caregivers that better engage them in the self-management of aerobic exercise as well as provide support in the hospital and home.

5.9 Conclusions

This dissertation had the main goal of better understanding factors that facilitate or prevent participation in aerobic exercise early after stroke. Evidence indicates that while comorbid
cardiovascular and musculoskeletal conditions can limit participation in a structured aerobic exercise program, post-stroke deficits (e.g. physical impairment) do not. However, these findings were inconsistent with patient perceptions; they reported an inability to perform exercise as well as the lack of social support from family and information on how to perform exercise. These findings demonstrate the need for patient education and experience in structured aerobic exercise programs that show how to manage disability and complex health needs. In addition, physiotherapists perceived different barriers to prescribing and/or implementing aerobic exercise at rehabilitation centres with and without a structured aerobic exercise program. Physiotherapists at centres without a structured aerobic program lack resources and considered patients’ physical deficits as key barriers. Alternatively, physiotherapists at a centre with a structured program considered patient’s cardiovascular and cognitive status as well as insufficient time as key barriers. Therefore, after resource limitations have been met, there remains a need for continuing education on assessment and aerobic exercise prescription using a standardized approach. Furthermore, ongoing support is required to improve and maintain structured aerobic exercise programs early after stroke.
6 References


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Ottawa, Ontario Canada: Canadian Stroke Strategy Best Practices and Standards Writing Group, Canadian Stroke Network.


stroke survivors' perceived barriers and facilitators to physical activity. *Disabil Rehabil.*


7 Appendices
Appendix A - The determinants to participation in aerobic exercise perceived by people with stroke.

Instructions: Thank you for taking the time to answer the following survey. Since you have taken part in the stroke rehabilitation program at [Rehabilitation center], any feedback you can give will be very useful and will help us to provide the best treatment possible. There are 57 questions on the survey and it will take approximately 30 minutes to complete. You are not obligated to answer any questions. Please stop me and ask questions at any time or if you would like me to repeat a question. In this survey we are interested in understanding your views on aerobic exercise. The goal of aerobic exercise is to improve your level of fitness – by raising your heart rate and by increasing your breathing rate. Also, aerobic exercise involves using large muscle groups for an extended period of time.

Some examples of aerobic exercise include

- Stepping, climbing stairs, walking, running, swimming, or rowing
- Using a stationary bicycle (arm or leg), a seated stepping machine, or a treadmill

Remember, the important parts of aerobic exercise include

- Raising your heart rate or increasing your breathing rate
- Moving for 10 minutes or more (continuously)

This may have been different than what you did in your regular physical therapy during rehabilitation, which may have focused on balance or walking.

Regular physical therapy activities that may be less than 10 minutes in duration (continuous)

- Sitting activities (e.g. balancing while sitting on a bed)
- Standing activities (e.g. moving from sitting to standing, standing still, or reaching while standing)
- Stepping activities (e.g. stepping onto and off blocks)
- Walking activities (e.g. practicing parts of walking, or walking)

Remember, these activities are NOT considered aerobic exercise because they

- Do not raise your heart rate or increase your breathing rate high enough
- Do not involve moving for 10 minutes or more (continuously)

While regular physical therapy can be hard work, we are interested in any activities that you have done that raise your heart rate or increase your breathing rate higher than during regular physical therapy.

1. Can you provide an example of an activity (e.g. exercise or recreational sport) that you have done, before starting stroke rehabilitation, that you consider aerobic exercise?
Instructions: The first section inquires about your personal view of the importance of aerobic exercise. Please indicate the importance of aerobic exercise on a scale from 0 to 100%, where 0% is not important, 50% is moderately important, and 100% is very important.

2. Prior to your stroke, how important was aerobic exercise to you? ______%
3. Since your stroke and your experiences in rehabilitation at [Rehabilitation center], how important is aerobic exercise to you? ______%

Instructions: This next section inquires about your personal view of your participation in aerobic exercise.

4. Which of the following statements best represents your thoughts on your participation in aerobic exercise at [Rehabilitation center]?
   a) I did participate in aerobic exercise as much as I could
   b) I did participate in aerobic exercise, but, I would have participated more (if able/allowed)
   c) I did not participate in aerobic exercise, but, I would have been willing to (if able/allowed)
   d) I did not want to participate in aerobic exercise

Response: a) Continue to Question 5           b) Continue to Question 5
           c) Continue to Question 6           d) Continue to Question 7

5. Please describe the type of activity you participated in. Specifically, (was the/what was the)…
   Format(s):  ☐ Group program  ☐ Individual program  ☐ Group and individual
   Location(s):  ☐ In the same area as your regular physical therapy
                 ☐ In a different area than your regular physical therapy
                 ☐ Inside: A non-specific area (e.g. bedside, hallway)
                   ☐ Inside: An area specific for aerobic exercise
                   ☐ Outside: An area outside the rehabilitation facility
                   ☐ Other, please specify: _________________________________
   Mode(s):  ☐ Overground/box stepping                          ☐ Stair climbing
             ☐ Overground walking                                   ☐ Overground jogging
             ☐ Overground running                                    ☐ Stepping machine
             ☐ Cycling machine (arm/leg ergometer)                   ☐ Elliptical machine
             ☐ Treadmill                                              ☐ Circuit training
             ☐ Other, please specify: _______________________________
             ☐ Other, please specify: _______________________________
             ☐ Other, please specify: _______________________________
6. When (did you or would you have been willing to) start the aerobic training program?
_______ days after admission to stroke rehabilitation

Instructions: This next section inquires about any conversations or contact you may have had with members of the healthcare team (such as physicians or physical therapists) about aerobic exercise.

7. During your stroke rehabilitation, did someone on the healthcare team at [Rehabilitation center] talk to you about aerobic exercise?

☐ Yes Continue to Question 8
☐ No Continue to Question 13
☐ Don’t remember Continue to Question 13

8. Who recommended exercise and what was the strength of the recommendation? Please indicate the strength of the recommendation on a scale from 1 to 5, where 1 a weak recommendation and 5 is a strong recommendation.

9. Did this person (or these people) describe benefits of and barriers to aerobic exercise with you?

<table>
<thead>
<tr>
<th>Question 8 and 9</th>
<th>Weak</th>
<th>Strong</th>
<th>Described benefits and barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Yes = 1; No = 2; Don’t remember = 3)</td>
</tr>
<tr>
<td>Physician</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Physical therapist</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Occupational therapist</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nurse</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Other, specify:</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(or Don’t remember)</td>
</tr>
</tbody>
</table>
10. Were you told to do anything specific regarding aerobic exercise?
   □ Yes  Continue to Question 11
   □ No   Continue to Question 12
   □ Don’t remember  Continue to Question 12

11. What were you told to do regarding aerobic exercise?

_________________________________________________________________________________
_________________________________________________________________________________
_________________________________________________________________________________

12. How was information given to you about aerobic exercise? Specifically, was the format…
   □ Oral  □ Written  □ Both oral and written

Instructions: This next section inquires about your confidence in participating in aerobic exercise.

13. Refer to Question 4  If answered (a) or (b)  Continue to Question 13a
    If answered (c) or (d)  Continue to Question 13b

13a. Collect parts A and B of following table

Instructions: In order to better understand your confidence in participating in aerobic exercise at [Rehabilitation center], we would like to ask you some questions. Please indicate your level of confidence on a scale from 1 to 5, where 1 is no confidence and 5 is very confident.

Part A - For example, how confident are you that you could…. “Perform aerobic exercise through pain”?

Part B – Also, please indicate whether you did … “Perform aerobic exercise through pain” while at [Rehabilitation center]?

13b. Collect part A only of following table

Instructions: Please imagine that you were asked to participate in an aerobic exercise during your stroke rehabilitation at [Rehabilitation center]. In response to the following questions, please indicate your level of confidence on a scale from 1 to 5, where 1 is no confidence and 5 is very confident.

Part A - For example, how confident are you that you could…. “Perform aerobic exercise through pain”? 
**Question:** How confident are you that you could…

<table>
<thead>
<tr>
<th>Item</th>
<th>No confidence</th>
<th>Very confident</th>
<th>Have you?*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participate in aerobic exercise through pain</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Participate in aerobic exercise alone</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Participate in aerobic exercising through fatigue</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Participate in aerobic exercise though depressed</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

*Yes = 1; No = 2

**Instructions:** Please refer to the description of aerobic exercise again (re-iterate the goals and components of aerobic exercise).

The last section includes a number of statements about aerobic exercise for people recovering from stroke, in general, in hospital-based rehabilitation. Please indicate the degree to which you disagree or agree with the statements on a scale from 1 to 5, where 1 strongly disagree, 2 is disagree, 3 is neutral, 4 is agree, and 5 is strongly agree.

For example, a question may ask whether “aerobic exercise is enjoyable”, for the majority of people (other than yourself) who are recovering from stroke in hospital-based rehabilitation.

<table>
<thead>
<tr>
<th>Item</th>
<th>5-point Likert type scale response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Aerobic exercise is enjoyable</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>15. After stroke, people are too tired to participate in aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>16. Participating in aerobic exercise after stroke is embarrassing</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>17. Aerobic exercise improves endurance</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>18. People in exercise clothes look funny</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>19. Aerobic exercise improves and maintains heart health</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>20. Participating in aerobic exercise is not safe after stroke</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>21. Aerobic exercise makes people feel better</td>
<td>Strongly disagree</td>
</tr>
</tbody>
</table>
22. Participating in aerobic exercise increases the risk of injury after stroke | Strongly disagree | Disagree | Neutral | Agree | Strongly agree
23. Participating in aerobic exercise increases the risk of heart attack after stroke | Strongly disagree | Disagree | Neutral | Agree | Strongly agree
24. After stroke, participating in aerobic exercise increases the risk of having another stroke | Strongly disagree | Disagree | Neutral | Agree | Strongly agree
25. Aerobic exercise improves mood | Strongly disagree | Disagree | Neutral | Agree | Strongly agree
26. Aerobic exercise will make the effects of stroke worse | Strongly disagree | Disagree | Neutral | Agree | Strongly agree

You are doing great, you are nearly 1/3 of the way done! Please remember that the statements are asking about aerobic exercise for the majority of people (other than yourself) who are recovering from stroke in hospital-based rehabilitation.

<table>
<thead>
<tr>
<th>Item</th>
<th>5-point Likert type scale response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>27. Cardiovascular (or heart) health problems after stroke limit participation in aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>28. Other health problems (e.g. arthritis, diabetes, or breathing problems) limit participation in aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>29. Physical impairments (or mobility problems) after stroke limit participation in aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>30. Not being able to communicate properly after stroke (e.g. aphasia) limits participation in aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>31. Difficulties with language (e.g. English as a second language) limit participation in aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>32. Not being able to follow instructions (or think properly) after stroke limits participation in aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
</tbody>
</table>
33. Aerobic exercise improves stroke recovery
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
34. Aerobic exercise improves alertness
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
35. Aerobic exercise is boring
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
36. People are not motivated to participate in aerobic exercise after stroke
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
37. A lack of information about how to perform aerobic exercise limits participation after stroke
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
38. The fear of falling limits participation in aerobic exercise
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree
39. The fear of a heart attack, injury, or having another stroke limits participation in aerobic exercise
   Strongly disagree | Disagree | Neutral | Agree | Strongly agree

You are doing great, you are 2/3 of the way done! Please remember that the statements are asking about aerobic exercise for the majority of people (other than yourself) who are recovering from stroke in hospital-based rehabilitation.

<table>
<thead>
<tr>
<th>Item</th>
<th>5-point Likert type scale response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>40. Aerobic exercise costs too much</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>41. A lack of encouragement from a person’s spouse (or significant other) limits participation in aerobic exercise after stroke</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>42. A lack of encouragement from a person’s family members limits participation in aerobic exercise after stroke</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>43. A lack of support from other people recovering from stroke limits participation in aerobic exercise after stroke</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>44. Exercise takes too much time from family relationships</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>Question</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>45. Exercise takes too much time from family responsibilities</td>
<td></td>
</tr>
<tr>
<td>46. Participating in aerobic exercise with others,</td>
<td></td>
</tr>
<tr>
<td>in a group, is better than exercising alone after stroke</td>
<td></td>
</tr>
<tr>
<td>47. Aerobic exercise is a necessary part of stroke rehabilitation</td>
<td></td>
</tr>
<tr>
<td>48. Aerobic exercise is tiring</td>
<td></td>
</tr>
<tr>
<td>49. Aerobic exercise takes too long</td>
<td></td>
</tr>
<tr>
<td>50. There is no time (too busy) during stroke rehabilitation to</td>
<td></td>
</tr>
<tr>
<td>participate in aerobic exercise</td>
<td></td>
</tr>
<tr>
<td>51. Participating in aerobic exercise after stroke interferes with</td>
<td></td>
</tr>
<tr>
<td>other therapy</td>
<td></td>
</tr>
<tr>
<td>52. There are too few places at [Rehabilitation center] to participate</td>
<td></td>
</tr>
<tr>
<td>in aerobic exercise</td>
<td></td>
</tr>
<tr>
<td>53. Places to participate in aerobic exercise at [Rehabilitation</td>
<td></td>
</tr>
<tr>
<td>center] are too far away</td>
<td></td>
</tr>
<tr>
<td>54. [Rehabilitation center] facilities do not have convenient</td>
<td></td>
</tr>
<tr>
<td>schedules</td>
<td></td>
</tr>
<tr>
<td>55. A lack of support from health care professionals limits</td>
<td></td>
</tr>
<tr>
<td>participation in aerobic exercise after stroke</td>
<td></td>
</tr>
<tr>
<td>56. A lack of appropriate equipment limits participation in aerobic</td>
<td></td>
</tr>
<tr>
<td>exercise after stroke</td>
<td></td>
</tr>
<tr>
<td>57. Participating in aerobic exercise can result in earlier</td>
<td></td>
</tr>
<tr>
<td>discharge from in-patient rehabilitation</td>
<td></td>
</tr>
</tbody>
</table>
Appendix B - The determinants to participation in aerobic exercise perceived by physiotherapists.

Instructions: Thank you for taking the time to answer the following survey. Since you have treated in-patient stroke clientele at [Rehabilitation centre], your feedback is very helpful in order to maintain or improve the care of patients. There are 72 questions on the survey and it will take approximately 30 minutes to complete. You are not obligated to answer any questions. Please feel free to ask questions at any time.

The primary goal of aerobic exercise is to improve cardiorespiratory fitness. Aerobic exercise refers to activities that are rhythmic in nature and involve the use of large-muscle groups for extended periods of time. Some examples of aerobic exercise are listed in (A).

(A) Aerobic exercise examples
- Stepping, climbing stairs, walking, jogging, running, circuit training
- Using a bicycle (or cycle ergometer) or stepping machine or elliptical machine or treadmill

The duration and intensity of the activity is particularly important. For this survey, we consider aerobic exercise as any activity – similar to the activities in (A) – that you prescribe and/or implement during in-patient stroke rehabilitation that meets the criteria in (B).

(B) Aerobic exercise criteria
- The activity must induce a high heart and breathing rate for **10 consecutive minutes or more**
- The intensity must be monitored and related to the level of metabolic stress **quantitatively**

<table>
<thead>
<tr>
<th>Quantitative* Measures</th>
<th>Qualitative Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Heart rate</td>
<td>• General response to exercise</td>
</tr>
<tr>
<td>• Blood pressure</td>
<td>• Patient feedback</td>
</tr>
<tr>
<td>• Oxygen saturation</td>
<td>• Rating of perceived exertion</td>
</tr>
<tr>
<td>• Oxygen consumption</td>
<td>• Talk test</td>
</tr>
</tbody>
</table>

Many activities that are prescribed during in-patient stroke rehabilitation may not induce a cardiorespiratory training benefit, despite being focused on improving functional motor performance. For this study, we are interested in activities where the duration and intensity are higher than what stroke clientele may achieve in the activities listed in (C).
(C) In-patient stroke rehabilitation activities that may be less than 10 consecutive minutes in duration

- Sitting activities (e.g. balancing while sitting on a bed)
- Standing activities (e.g. moving from sitting to standing, standing still, or reaching while standing)
- Stepping activities (e.g. stepping onto and off blocks)
- Walking activities (e.g. practicing parts of walking, or walking)

This section inquires about your personal view of the importance of aerobic exercise.

For the following items, please indicate how important you view aerobic exercise by choosing the corresponding number on the following rating scale:

<table>
<thead>
<tr>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
</tr>
<tr>
<td>Important</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Important</td>
</tr>
</tbody>
</table>

1. In general, how important is aerobic exercise as part of physical therapy practice? _____%
2. Given your experience with rehabilitation and a stroke clientele, how important is aerobic exercise as a part of in-patient stroke rehabilitation? _____%

This section inquires whether you currently screen stroke clientele for safety and indications to participate in aerobic exercise during in-patient rehabilitation at [Rehabilitation centre].

For the following items, place a mark in the appropriate box that indicates your response. Please provide a detailed response where indicated.

3. Which of the following statements best represents your position on screening stroke clientele for safety and indications to participate in aerobic exercise?

- [ ] I do screen stroke clientele
- [ ] I do screen stroke clientele, but, I would do more (if able)
- [ ] I do not screen stroke clientele, but, I would (if able)
- [ ] I do not and would not screen stroke clientele
4. Please indicate what information you most commonly use to screen for safety and indications to participate in aerobic exercise. *(Check all that apply)*

- No safety screen
- General patient presentation/symptoms
- Physician consultation
- Health record
- Resting blood pressure
- Blood pressure response to exercise (☐ Sub-maximal or ☐ Maximal exercise)
- Heart rate response to exercise (☐ Sub-maximal or ☐ Maximal exercise)
- Heart activity (i.e. ECG* output) in response to exercise (☐ Sub-maximal or ☐ Maximal exercise)
- American College of Sports Medicine’s contraindications to exercise
- Physical Activity Readiness Questionnaire or Physical Activity Readiness Medical Examination
- Risk stratification categories (American College of Sports Medicine, American Heart Association)
- Symptom-limited exercise test (☐ Sub-maximal or ☐ Maximal)
- Other, please specify: _____________________________________________________________
- Other, please specify: _____________________________________________________________
- Other, please specify: _____________________________________________________________

*ECG, electrocardiogram

5. How many years of clinical experience do you have screening stroke clientele for participation in aerobic exercise during in-patient rehabilitation? ______ years

6. In the last year, how many times have you screened stroke clientele for participation in aerobic exercise during in-patient rehabilitation? ______ times

This section inquires whether you currently prescribe and/or implement aerobic exercise during in-patient rehabilitation at [Rehabilitation centre] for stroke clientele.

For the following items, place a mark in all boxes that apply, circle the most appropriate option, or provide written details to indicate your response.

7. Which of the following statements best represents your position on prescribing and/or implementing aerobic exercise for stroke clientele?
8. Please provide the details of aerobic exercise that you most commonly prescribe. Specifically,

Frequency (days per week):  1  2  3  4  5  6  7
Duration (min/bout):       ≤5  6-10  11-15  16-20  21-25  26-30  31-35  
                                           36-40  41-45  46-50  51-55  56-60  >60

Intensity:

- Signs, symptoms, or parameters monitored
- Average level of intensity
  (e.g. Heart rate)  (e.g. 40% of maximum heart rate)
- Patient feedback
- Talk test
- General response to exercise
- Rating of perceived exertion
- Heart rate (manual measurement)
- Heart rate (automated measurement)
- Heart activity (i.e. Electrocardiogram)
- Blood pressure (manual measurement)
- Blood pressure (automated measurement)
- Oxygen saturation
- Oxygen consumption
- Cadence (or the frequency of movement)
- Work (e.g. work rate or work load)
- Speed (or velocity)
- Inclination (or grade)
- Amount of body weight supported

Format(s):
- Group program
- Individual program
- Both group and individual programs
Mode(s):
- □ Overground/box stepping
- □ Overground walking
- □ Overground running
- □ Cycling machine (arm/leg ergometer)
- □ Treadmill
- □ Other, please specify: ______________________________________
- □ Stair climbing
- □ Overground jogging
- □ Stepping machine
- □ Elliptical machine
- □ Circuit training
- □ Other, please specify: ______________________________________
- □ Other, please specify: ______________________________________
  
Location(s):

<table>
<thead>
<tr>
<th>Physical therapy area</th>
<th>Area dedicated to stroke clientele?</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ The area used for regular care</td>
<td>□ Yes     □ No</td>
</tr>
<tr>
<td>□ A different area than that used for regular care</td>
<td>□ Yes     □ No</td>
</tr>
<tr>
<td>□ Inside: A non-specific area (e.g. bedside, hallway)</td>
<td>□ Yes     □ No</td>
</tr>
<tr>
<td>□ Inside: An area specific for aerobic exercise</td>
<td>□ Yes     □ No</td>
</tr>
<tr>
<td>□ Outside: An area outside the rehabilitation facility</td>
<td>□ Yes     □ No</td>
</tr>
</tbody>
</table>

Additional notes:
_____________________________
_____________________________

9. How many years of clinical experience do you have **prescribing and/or implementing** aerobic exercise during in-patient stroke rehabilitation?
   a. Prescription: ______ years  
   b. Implementation: ______ years

10. In the last year, how many times have you **prescribed and/or implemented** aerobic exercise during in-patient stroke rehabilitation?
    a. Prescription: ______ times  
    b. Implementation: ______ times

11. Do you or your colleagues, or does your department:

   a) … discuss the benefits of aerobic exercise with stroke clientele during in-patient rehabilitation?
      □ Yes     □ No

   b) … discuss the barriers to aerobic exercise with stroke clientele during in-patient rehabilitation?
      □ Yes     □ No
c) … refer stroke clientele to a facility offering aerobic exercise as part of cardiac rehabilitation, for care that is in addition to in-patient rehabilitation at [Rehabilitation centre]?
   ☐ Yes, always ☐ Yes, some of the time ☐ No, none of the time

d) … have and distribute patient education materials for stroke clientele?
   ☐ Yes - Are some materials specific to aerobic exercise: ☐ Yes ☐ No
   ☐ No

This section inquires about your educational preparation and about your personal attitudes toward aerobic exercise early after stroke (i.e. within 3 months after stroke).

For the following items, place a mark in the appropriate box that indicates the degree to which you disagree or agree with each statement.

<table>
<thead>
<tr>
<th>Item</th>
<th>5-point Likert type scale response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. I am interested and willing to learn or improve the skills necessary to incorporate aerobic exercise into routine in-patient stroke care</td>
<td>Strongly disagree 5 Disagree 4 Neutral 3 Agree 2 Strongly agree 1</td>
</tr>
<tr>
<td>13. I learned the foundations in how to prescribe and/or implement aerobic exercise for a stroke clientele as part of my academic preparation (i.e. entry-level degree for physical therapy)</td>
<td>Strongly disagree 5 Disagree 4 Neutral 3 Agree 2 Strongly agree 1</td>
</tr>
<tr>
<td>14. I received formal training (e.g. workshops, courses) in how to prescribe and/or implement aerobic exercise for a stroke clientele</td>
<td>Strongly disagree 5 Disagree 4 Neutral 3 Agree 2 Strongly agree 1</td>
</tr>
<tr>
<td>15. Aerobic exercise is effective (i.e. improves stroke recovery)</td>
<td>Strongly disagree 5 Disagree 4 Neutral 3 Agree 2 Strongly agree 1</td>
</tr>
<tr>
<td>16. Aerobic exercise is a necessary part of physical therapy during in-patient stroke rehabilitation</td>
<td>Strongly disagree 5 Disagree 4 Neutral 3 Agree 2 Strongly agree 1</td>
</tr>
<tr>
<td>17. Aerobic exercise training is feasible</td>
<td>Strongly disagree 5 Disagree 4 Neutral 3 Agree 2 Strongly agree 1</td>
</tr>
<tr>
<td>Item</td>
<td>5-point Likert type scale response options</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>18. I need to include, or increase the use of, aerobic exercise in daily physical therapy practice for stroke clientele</td>
<td>Strongly disagree 5</td>
</tr>
<tr>
<td>19. Physical therapists should be responsible for accessing and evaluating the literature regarding aerobic exercise</td>
<td>Strongly disagree 5</td>
</tr>
<tr>
<td>20. Physical therapists should be responsible for interpreting the literature to inform aerobic exercise prescription and implementation</td>
<td>Strongly disagree 5</td>
</tr>
<tr>
<td>21. Physical therapists should be responsible for accessing and evaluating the screening information (i.e. regarding safety and indications to participate in aerobic exercise) to determine whether aerobic exercise is appropriate</td>
<td>Strongly disagree 5</td>
</tr>
<tr>
<td>22. Physical therapists should be responsible for interpreting the screening information (i.e. regarding safety and indications to participate in aerobic exercise) to inform aerobic exercise prescription and implementation</td>
<td>Strongly disagree 5</td>
</tr>
</tbody>
</table>

This section inquires about your concerns for, and perception of, the majority of stroke clientele within in-patient rehabilitation at [Rehabilitation centre].

For the following items, place a mark in the appropriate box that indicates the degree to which you disagree or agree with each statement.

<table>
<thead>
<tr>
<th>Item</th>
<th>5-point Likert type scale response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>23. My concern for the patient’s cardiovascular status (e.g. potential for heart attack) limits me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree 1</td>
</tr>
<tr>
<td></td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>---</td>
<td>------------------</td>
</tr>
<tr>
<td>24. My concern for a recurrent stroke in patients limits me from prescribing and/or implementing aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>25. My concern for potential injury in patients limits me from prescribing and/or implementing aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>26. My concern for fall risk in patients limits me from prescribing and/or implementing aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>27. Cognitive/perceptual impairments (e.g. inability to follow instruction) limit patients from participating in aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>28. Communication impairments (e.g. aphasia) limit patients from participating in aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>29. Difficulties with language (e.g. English as a second language) limit patients from participating in aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>30. Physical impairments (or mobility restrictions) limit patients from participating in aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>31. Depression after stroke limits patients from participating in aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>32. Non-cardiac comorbidities (e.g. arthritis, diabetes, or respiratory impairment) limit patients from participating in aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>33. Patients are too fatigued early after stroke to participate in aerobic exercise</td>
<td>1</td>
</tr>
<tr>
<td>34. A lack of encouragement from a person’s partner, family, or friends limits patients from participating in aerobic exercise</td>
<td>1</td>
</tr>
</tbody>
</table>
35. Patient motivation to participate in aerobic exercise early after stroke is low

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

36. Aerobic exercise is low on the treatment priority list (or not part of rehabilitation goals) for patients recovering from stroke

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

37. Among Questions 23 to 36, please indicate the **5 greatest barriers** to aerobic exercise for stroke clientele within in-patient rehabilitation at [Rehabilitation centre]. Rank the barriers from greatest (i.e. 1) to least (i.e. 5). *(Indicate the Question number only)*

1) _________ 2) _________ 3) _________ 4) _________ 5) _________

This section inquires about your perception of current in-patient physical therapy practice for stroke clientele at [Rehabilitation centre]. Consider the resources and support that are currently available at [Rehabilitation centre]. Colleagues are professional staff that may include, but are not limited to, physicians, nurses, physical therapists, and occupational therapists.

For the following items, place a mark in the appropriate box that indicates the degree to which you disagree or agree with each statement.

<table>
<thead>
<tr>
<th>Item</th>
<th>5-point Likert type scale response options</th>
</tr>
</thead>
<tbody>
<tr>
<td>38. The adoption of aerobic exercise in routine in-patient care places unreasonable demands on physical therapists</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>39. The time available, in a single physical therapy treatment session, is too short to implement aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>40. The time available, during the entire in-patient length of stay, is too short to provide a meaningful aerobic training benefit to stroke clientele</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>41. Patients who participate in aerobic exercise during in-patient stroke rehabilitation have an increased likelihood of participating in aerobic exercise after discharge</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>42. A patient’s participation in aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>Statement</td>
<td>1</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>----</td>
</tr>
<tr>
<td>interferes with other therapy</td>
<td>disagree</td>
</tr>
<tr>
<td>43. Implementing aerobic exercise, in a group format, is not appropriate for stroke clientele</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>44. The potential (or actual) negative consequences of participation in aerobic exercise outweigh the positive benefits</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>45. Colleagues within my department are skeptical of the feasibility or effectiveness of aerobic exercise early after stroke</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>46. A lack of communication among colleagues regarding the coordination of care (e.g. treatment plans, scheduling, work load distribution, or information exchange) limits me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>47. I receive support from management or colleagues within my department or facility to prescribe and/or implement aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>48. My facility mandates the use of aerobic exercise in practice (mandate is a written requirement)</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>49. My facility supports the use of aerobic exercise in practice</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>50. My facility provides support (e.g. funding and/or time) for continuing education (e.g. to attend training sessions or meetings or conferences)</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>51. Malpractice liability (i.e. the risk of malpractice complaints) limits me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>Exercise</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>52. The necessary resources to develop a prescription and implement aerobic exercise early after stroke are currently available to me</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>53. A lack of equipment, required to screen for (or monitor) patient safety, limits me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>54. A lack of appropriate equipment, required to implement aerobic exercise routinely, limits me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>55. A lack of available and accessible space limits me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>56. A lack of therapeutic support (i.e. full- or part-time physical therapists or trained assistants) limits me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>57. A lack of administrative support or resources (e.g. personnel, documentation, information exchange network) limits me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>58. A lack of interpretive services (e.g. for patients with aphasia or English as a second language) limits me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>59. A lack of information resources or decision aids (e.g. professional journals or guidelines) limit me from prescribing and/or implementing aerobic exercise</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>60. Research findings and current stroke</td>
<td>Strongly</td>
</tr>
</tbody>
</table>
guidelines are not applicable to the patients under my care disagree 1 2 3 4 agree 5

61. Among Questions 38 to 60, please indicate the 5 greatest barriers to aerobic exercise for stroke clientele within in-patient rehabilitation at [Rehabilitation centre]. Rank the barriers from greatest (i.e. 1) to least (i.e. 5). (Indicate the Question number only)

1) _________  2) _________  3) _________  4) _________  5) _________

The last section inquires about personal demographic and practice information.

For the following items, place a mark in the appropriate box, circle the most appropriate option, or provide written details to indicate your response.

62. How old are you? (years)

≤20  21-30  31-40  41-50  51-60  >60

63. What is your gender?  □ Female  □ Male

64. What is your entry-level degree for physical therapy?

□ Certificate  □ Bachelor’s  □ Entry-level Master’s
□ Other, please specify: _____________________________________________________

65. What was the location of the physical therapy school?

□ Ontario  □ Canada  □ International

66. What is your highest degree attained?

□ Diploma  □ Bachelor’s  □ Entry-level Master’s
□ Applied or research Master’s  □ Doctoral
□ Other, please specify: _____________________________________________________

67. Do you belong to one or more professional practice-oriented organizations (e.g. OPA, CPA)?

□ Yes  □ No

68. What position(s) or title(s) do you hold at [Rehabilitation centre]? Some examples may include Physical Therapist, Physical Therapist Practice Leader, Physical Therapist Service Coordinator. Please specify: _____________________________________________________
69. How many years have you been practicing physical therapy? (years)

≤10 11-20 21-30 31-40 >40

70. How many years of clinical experience do you have with a stroke clientele? ______ years

71. Do you supervise physical therapist students at your facility?

☐ Yes ☐ No

72. In a typical week, how many hours do you work?

☐ <20 hours ☐ 20-30 hours ☐ 31-40 hours ☐ >40 hours

73. In a typical day, how many patients do you see?

☐ <5 patients ☐ 5-10 patients ☐ 11-15 patients ☐ >15 patients

74. In a typical day, approximately how many patients with stroke do you see?

☐ <2 patients ☐ 2-5 patients ☐ 6-10 patients ☐ >10 patients

75. What is the typical treatment time available, for a single in-patient physical therapy session, for a stroke client?

_____ hours: _____ minutes

76. Please indicate the percentage of your total work time that you spend in each type of activity during an average month.

a) Patient care _____%

b) Research _____%

c) Teaching _____%

d) Administration _____%

e) Other, please specify: ______________________________ _____%
Appendix C – Andersen’s Behavioural Model of Healthcare Service Use: an emerging model.

Appendix D – The Ottawa Model of Health Care Research Use.