Moving Towards Reducing Prolonged Sedentary Behaviour After Stroke

by

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ABSTRACT

Background: Stroke is a leading cause of adult disability globally. In Canada, about 405,000 individuals are living with the effects of stroke and this number is projected to rise by over 60% in the next two decades. People with stroke are often physically inactive and sedentary which may increase their risk of having secondary health conditions. Due to the mobility deficits associated with stroke, moving fast enough to attain moderate-to-vigorous intensity physical activity targets may be challenging for many people with stroke. Targeting prolonged sedentary behaviour by frequently standing and taking steps throughout waking hours, using the whole-day activity approach, might be feasible and sustainable in improving activity behaviour and mitigating the risks associated with prolonged sedentary behaviours after stroke.

Objective: To explore the perspectives of people with stroke about sedentary behaviour, and to develop and test a theory- and home-based sedentary behaviour change intervention for people with stroke.

Methods: The Intervention Mapping framework guided the development of a novel sedentary behaviour change intervention for people with stroke. The first step using this framework requires a needs assessment. A qualitative exploratory study (Study I) was conducted with 13 people with stroke on their perspectives about sedentary behaviour and how they can make changes in their day-to-day lives to sit less and move more. The systematic approach to the process of intervention development, including the theoretical basis, content, implementation and evaluation planning, were described in Study II. At the outset of implementing the developed intervention, a cross-sectional study (Study III) using 7-day accelerometry data at baseline was conducted to quantify the volume and pattern of usual activity behaviours. Participants were within 2-4 weeks of discharge from inpatient stroke rehabilitation. Testing of the intervention program was done over an 8-week period in Study IV.

Results: The qualitative study showed that there was limited awareness of the health risks of prolonged sedentary behaviour among people with stroke. Misperceptions do exist, as some individuals will rather sit at home if they were not "exercising" while one participant thought that lying was healthier than sitting. Some strategies for behaviour change were identified. It was possible to use the Intervention Mapping framework to systematically develop a **ST**and **U**p **F**requently **F**rom **S**troke *(STUFFS)* program focused on frequently breaking up prolonged sedentary behaviour as well as reducing overall sedentary time after stroke. The *STUFFS* program includes a self-monitoring component that empowered people with stroke to self-manage and reduce their sedentary behaviours. The results from the cross-sectional study showed that in addition to the 75% of waking hours (11.2 hours) spent in sedentary behaviour, people with stroke spent an average of 9 hours per day in bed, with 50% spending longer than 9 hours per day in bed. After 8 weeks of the *STUFFS* intervention, the sedentary time reduced by 54 minutes (P<0.05) and 27 minutes (P=0.05) at post-intervention and follow-up time points, respectively. The health, function, and patient-reported quality of life outcomes were improved across both time points (P<0.05). However, compared to baseline, participants spent significantly more time in bed after the intervention, but not at follow-up. The improvements in upright behaviours (standing and stepping) were not significant over time.

Conclusions: Prolonged sedentary behaviour is a problem after stroke. People with stroke living in the community require support to reduce sedentary behaviour after inpatient stroke rehabilitation. This work provides a foundation on which further sedentary behaviour research can build upon to support people with stroke.

PREFACE

This thesis is an original work by Victor Ezeugwu. The research project, of which this thesis is a part, received ethics approval from the University of Alberta Health Research Ethics Board in two phases:

Phase 1: Project Name "A qualitative exploratory study on sedentary behaviour in people with stroke: what is it and how might you change it?" No. Pro00047950, May 20, 2014.

Phase 2: Project Name "The feasibility of a home-based transition intervention to reduce sedentary behaviour and improve function within the first 6 months after stroke," No. Pro00053129, November 27, 2014.

Some of the findings from this doctoral research have been published in two peer-reviewed journals.

Chapter 3 of this thesis has been published as Ezeugwu V.E., Garga N., Manns P.J. "Reducing sedentary behaviour after stroke: perspectives of ambulatory individuals with stroke," *Disabil Rehabil*. 2017;39:2551-2558. I was responsible for concept formation, ethics application, data collection, data analysis, and manuscript writing. Ms. Neera Garga helped with recruitment and revised the manuscript from the perspective of a clinician involved in stroke rehabilitation. Dr. Manns is the supervisory author and was involved in concept formation, data analysis, and manuscript edits.

Chapter 5 of this thesis has been published as Ezeugwu V.E., Manns P.J. "Sleep duration, sedentary behaviour, physical activity, and quality of life after stroke rehabilitation," *J Stroke Cerebrovasc Dis*. 2017;26:2004-2012. I was responsible for concept formation, data collection, data processing and analysis, manuscript writing and revision. Dr. Manns is the supervisory author and was involved in concept formation and manuscript edits.

DEDICATION

To my late dad, Ben – you were my first teacher. You gave me your blessings at the beginning of this journey, but you did not stay until the end.

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The Igbos' of South-Eastern Nigeria believe that it takes a community to raise a child. So it is with completing a PhD. I am immensely grateful to my supervisor, Dr. Patricia (Trish) Manns, who provided superb mentorship, support, and guidance throughout this doctoral program. I have greatly benefited and continue to receive support from Trish's several research and clinical networks and collaborators.

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CHAPTER 1

INTRODUCTION AND OVERVIEW OF THE PROJECT

1.1 Introduction

Stroke is traditionally defined as "a rapidly developing clinical sign of focal (or global) disturbance of cerebral function with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than that of vascular origin."[1] In 2013, the American Heart Association/American Stroke Association recommended that stroke should broadly include central nervous system infarction, ischaemic and haemorrhagic strokes, as well as subarachnoid haemorrhage, cerebral venous thrombosis, silent strokes, and stroke not otherwise specified.[2] But the two main types of stroke remain ischaemic and haemorrhagic strokes.[2] Ischaemic stroke is an episode of neurological deficit due to central nervous system infarction while haemorrhagic stroke is attributable to a focal collection of blood within the brain parenchyma or ventricular system that is not caused by trauma.[2] The signs and symptoms of stroke vary depending on the site(s) affected and may include weakness on one side of the body, sudden loss of vision, difficulty with communication, problems with balance or coordination and reduced mobility.

On a global scale, mortality rates are high from stroke. An estimated 5.7 million deaths were caused by stroke in 2005; if interventions are not instituted, this number is projected to rise to 7.8 million by 2030.[3] Among Canadians, about fifty thousand new strokes occur each year, with an estimated 405,000 individuals living with the effects of stroke, and this number is also projected to rise to somewhere between 654,000 and 726,000 by 2038.[4, 5] Stroke is the leading cause of adult disability among Canadians.[6] Recurrence after a primary stroke is high, such that about a third of people with stroke may have another stroke within 5 years.[7] These recurrent strokes tend to occur more in individuals with risk factors such as high blood pressure and unhealthy glucose levels.[8, 9] These risk factors are more prevalent in people with stroke compared to age-matched healthy adults.[10, 11] Not only is stroke recurrence detrimental to health, it imposes considerable burden on the health care system.[12] The yearly cost of stroke in Canada is estimated at 3·6 billion dollars[13] and this takes into account the costs associated with health-care as well as the economic cost associated with lost output as a result of stroke.

Identifying potential ways to improve the health of persons after stroke is critically important to decrease the risk of another stroke, to minimize disability, and ultimately to reduce health care costs. There is evidence that increasing the frequency of rehabilitation in the first year after stroke is associated with a lower incidence of recurrent stroke and all-cause mortality.[14] Canadian Stroke Best Practice Recommendations[15, 16] emphasize the need for secondary prevention of stroke at all levels of care during the recovery phase, from the emergency room, through inpatient and outpatient rehabilitation, to community reintegration. Care immediately after a stroke is usually comprehensive and diverse. People with stroke are seen by a variety of health care professionals as either inpatients or outpatients, or as both. Those admitted to a stroke unit or rehabilitation hospital receive intense therapy.[17] Once discharged from the hospital, the services that people with stroke access to help them maintain health and function are less organized and available.[18] The intensity of practice of functional skills, as well as general activity, may decrease substantially during that time.[19]

Improving physical activity is an important goal in the stroke recovery process and provides benefits in the primary and secondary prevention of stroke.[20] Due to the challenges faced by people with stroke in meeting public health guidelines for physical activity and exercise, an exclusive set of recommendations were developed for people with stroke in 2004.[21] The 2004 recommendations emphasize aerobic physical activity on 3 to 7 days per week for 20-

60 minutes or multiples of 10 minutes sessions; strengthening exercises for 2-3 days per week; and stretching and balance exercises for 2-3 days every week.[21] Despite the recommendations, studies with people with stroke have shown that activity levels are still low in this population.[22-24] A Canadian survey showed that people with stroke are the least active of all groups with chronic conditions.[25] It is particularly disturbing that many people with stroke who have the capacity to participate in higher levels of activity do not.[19, 24] Decreased physical activity after stroke may lead to cardiovascular deconditioning and other negative health outcomes, especially in this population already at an increased risk of recurrent stroke events.[26] There is evidence that blood pressure regulation is a major concern in people with stroke, even up to 1 year, after stroke.[27] Larger waist circumference is significantly associated with an increased risk of all-cause mortality in people with stroke.[28] Research using risk-modelling have suggested that the risk of recurrent stroke could be reduced by 20% with increased physical activity.[29] In the 2014 updated recommendations for physical activity and exercise for people with stroke, Billinger and colleagues[30] stated that programs to promote physical activity in people with stroke should target secondary prevention of stroke with a focus on low- to moderate-intensity physical activity, muscle-strengthening exercises and, for the first time, reduction of sedentary behaviour. Also, the most recent Canadian Stroke Best Practice Recommendations for secondary prevention of stroke included the reduction of sedentary behaviour under the general exercise guidelines for people with stroke.[16]

Sedentary behaviour is particularly prevalent in the stroke population, with over 80% of the day spent sedentary.[19, 31] Sedentary behaviour is defined as “any waking behaviour characterized by energy expenditure ≤1.5 metabolic equivalents (METs) while in a sitting, reclining, or lying posture.”[32, 33] For instance, in the early post-stroke period, Mattlage et al.[34]

reported that people with stroke in a hospital stroke unit were engaged in sedentary behaviours (including sleep) for 94% of their day. In a longitudinal study, Tieges and colleagues[19] reported that people with stroke spend 83% (median of 19.9 hours) of a 24-hour monitored period in sedentary behaviour at 1-month after stroke and this did not change at 6 and 12 months post stroke. Another observational study with people with stroke showed that prolonged sedentary behaviour persists from hospital discharge to 3 months post-discharge.[35] This is a time period when ideally progress should be at its fastest, yet sedentary time remains the same, even up to six months post-discharge from the hospital.[35] Two studies on sedentary behaviour in chronic stroke (>4 years post stroke) reported that people with stroke spend 85% of the day[31] and 74.8% of waking hours[36] in sedentary behaviours. The volume of sedentary behaviour in people with stroke is higher than the 63.4% of waking hours reported in healthy older adults from a population-representative sample.[37]

Sedentary behaviour has important short- and long-term consequences on health. There is a strong and consistent evidence of the detrimental association between sedentary behaviour and all-cause (including cardiovascular disease) mortality.[38-43] Low to moderate evidence has been reported for associations of sedentary behaviour with type 2 diabetes, metabolic syndrome, larger waist circumference, and obesity.[38, 41, 44] There is a dose-response association between sitting time, all-cause mortality and cardiovascular disease, with an increased risk for those who report sitting for majority of their day compared to those who spend less time sitting, independent of leisure time physical activity.[45] Evidence from a meta-analysis showed that there is a 34% higher risk of mortality for adults sitting for 10 hours per day compared to those sitting for 1 hour, after accounting for physical activity level.[42] Findings from a meta-analysis of 9 cohort studies has suggested that 10 or more hours per day spent in sedentary behaviours may represent the risk threshold for adverse cardiovascular events.[46] Accumulating between 7 to 10 hours per day may also increase the risk of cardiovascular events.[46] On the flip side, compared to lower levels of physical activity, there was a 30% lower relative risk of all-cause mortality in individuals who accumulate higher levels of physical activity (broadly defined to include all physical activity and not only moderate-to-vigorous intensity activity).[43]

Sedentary pursuits displace time that could be spent in healthier activities, including routine light-intensity activities which can make up a large proportion of an individual's daily activities.[47] Reducing time in sedentary behaviour by increasing light-intensity physical activity appears to be a feasible behavioural change approach, as a first step,[48] towards improving activity in people with stroke. This is particularly important as people with stroke find it difficult to attain recommended levels of moderate- to- vigorous intensity physical activity.[24, 49] Moreover, the evidence from the literature has shown that increasing exercise or moderate-to-vigorous intensity physical activity does not decrease sedentary behaviour.[50, 51] Thus, interventions targeted at improving moderate-to-vigorous intensity physical activity do not have the potential to reduce sedentary behaviour. On the other hand, light intensity physical activity is strongly inversely correlated with sedentary behaviour, such that increasing light-intensity activity decreases sedentary behaviour.[52] Research has shown that light-intensity physical activity provides a sufficient stimulus to improve blood lipids and glucose metabolism in older adults.[53] Every 60 minutes per day increase in light-intensity physical activity is associated with a 14% reduced risk of all-cause mortality in people with limited mobility,[54] which provides support for this approach to behaviour change.

Behaviour change interventions that specifically target sedentary behaviour are needed with people with stroke to minimize the risks of prolonged sedentary behaviour, especially in the community after discharge from organized hospital care. However, how to help people with stroke to reduce sedentary behaviour is currently not known. An initial step in any novel intervention is to evaluate the feasibility, acceptability and efficacy of the intervention in the target population.[55] In addition, the potential pathways (i.e. mediators) through which change in the targeted behaviour may occur need to be explored.[56] Only one sedentary behaviour change intervention has been conducted with people with chronic stroke.[36] The participants in the treatment arm in that study did not show superior outcomes relative to the controls (i.e. both groups reduced sedentary time), but it was safe and feasible to reduce prolonged sedentary behaviours.[36] The authors suggested a need for systematic development of a sedentary behaviour change intervention. A recent consensus paper by the Stroke Recovery and Rehabilitation Roundtable also highlighted the gaps in stroke trials with respect to poor description of how interventions are developed or monitored, a lack of theoretical framework, and poor reporting of the components of interventions.[57]

1.2 Thesis Objectives

The main objectives of this project were to: 1) explore the perspectives of people with stroke about sedentary behaviour; 2) develop an intervention targeted at reducing sedentary behaviour in people with stroke; 3) describe objectively-determined whole-day sedentary and non-sedentary behaviours after inpatient stroke rehabilitation; and 4) test the effects of a sedentary behaviour change intervention within the first 6 months after stroke.

1.3 Research Questions

1. What are the perspectives of people with stroke about sedentary behaviour and how can it be changed?

2. Can a theory- and home-based sedentary behaviour change program be designed and developed for people with stroke?
3. How sedentary are people with stroke after inpatient rehabilitation?
4. What is the effect of an 8-week sedentary behaviour change intervention on health, physical function, quality of life and accelerometer-determined outcomes?

1.4 Structure of the Thesis

To answer the research questions, the first step was to explore the perspectives of people with stroke about sedentary behaviour and how it can be changed. This part of the project used qualitative research methods, and informed the development of the sedentary behaviour change intervention. The results of the qualitative study are presented in Chapter 3 in a paper entitled, "Reducing sedentary behaviour after stroke: perspectives of ambulatory individuals with stroke." The design and development of the sedentary behaviour change intervention is reported in Chapter 4 in a paper entitled, "Using Intervention Mapping to design and develop a home-based sedentary behaviour change intervention after stroke: **ST**and **U**p **F**requently **F**rom **S**troke (**STUFFS**)." The intervention development paper describes the systematic and scholarly process followed in the development of the intervention using an Intervention Mapping framework. Chapter 5 is a cross-sectional, cohort study that objectively examined whole-day activity behaviour for 7 consecutive days after discharge from inpatient stroke rehabilitation. This chapter describes sleep duration (defined as time in bed), sedentary behaviour, physical activity and quality of life and how they relate to participants' demographics and clinical attributes. In Chapter 6, the final paper, we report the longitudinal effects of an 8-week sedentary behaviour change intervention on health, physical function, quality of life, and accelerometer-determined outcomes. The goal of reducing sedentary behaviour was targeted through strategies such as taking steps at frequent intervals during waking hours, or doing tasks in standing instead of sitting, where possible.

1.5 Significance of the Thesis

This thesis adds to the literature by evaluating the perspectives of people with stroke about sedentary behaviour, measurement of whole-day activity behaviour immediately after inpatient stroke rehabilitation, and the development and testing of a novel, theory- and home-based sedentary behaviour change intervention for people with stroke. The *STUFFS* program is feasible to deliver in the home environment and was well accepted by people with stroke, with a high retention rate at post-intervention and follow-up time points. The beneficial effects of promoting light-intensity activity such as frequently walking around the house while reducing sitting time is supported by research evidence, including lower mortality risk,[54] and lower incidence of major mobility disability.[58]

CHAPTER 2

LITERATURE REVIEW

This chapter on literature review is presented in sections, mainly around activity behaviour variables, their association with health outcomes, and the theoretical frameworks used in this project. Although the main aim of this thesis is on strategies to change sedentary behaviour after stroke, there is still some confusion in the literature over the definition of sedentary behaviour and how it differs from physical inactivity. The purpose of this section is to present a clear understanding of study variables through a review of the literature.

2.1 Stroke

Stroke refers to the acute onset of focal neurological deficit, which is caused by interruption in blood supply to areas of the brain. It is a heterogeneous condition having multiple subtypes.[2] Stroke can result from either inadequate blood supply due to blockage (ischaemic stroke) or blood leakage into the brain parenchyma or ventricles (intracerebral haemorrhage) or surrounding subarachnoid space (subarachnoid haemorrhage).[2] Stroke is a clinical term used to identify the constellation of signs and symptoms associated with the disease while infarction and haemorrhage are more specifically defined by both clinical and neuroimaging evaluations.[2] Stroke leads to a sudden unilateral weakness or numbness in one region of the body, loss of vision or double vision, difficulty with speaking, and altered gait or poor balance in standing or walking.[59] Also, there may be altered consciousness or confusion.[59] The definition of stroke excludes transient ischaemic attacks (TIAs) defined as "a transient episode of neurological dysfunction caused by focal brain, spinal cord, or retinal ischaemia without acute infarction."[60] But TIA is an important predictor of stroke with 43% of ischaemic strokes occurring within one week of a preceding TIA.[61] Advances in neuroimaging have helped in redefining TIA – such that the time window of 24 hours has been removed,[60] highlighting the variability in the capacity of the brain to survive an insult. The confirmation of stroke diagnosis is also dependent on neuroimaging. Imaging studies help to determine individuals who will benefit from reperfusion therapy which is associated with less disability from stroke. The advances in acute care of stroke have resulted in more people surviving from stroke.

2.1.1 Epidemiology

Over 30 million people worldwide are living with the effects of stroke.[62] The mortality rates from stroke are decreasing due to the improvements in stroke prevention and management, especially in acute stroke care.[62] However, the number of people living with the effects of stroke is increasing due to the overall population growth, people are living longer, and the advances in acute stroke.[5] As at 2013, it was estimated that about 405,000 Canadians are living with stroke, and this included 214,000 females and 191,000 males. Further, 88% (354,000) of those with stroke in Canada were community-dwelling adults.[5] Based on the prevalence rates and the aging population, it is projected that the number of people living with stroke in Canada will rise to between 654,000 and 726,000 by the year 2038.[5] More specifically, it is expected that the Prairie provinces will experience the largest increase.[5] The increasing awareness of the early signs of stroke among the populace may have also contributed to the larger survival rates.

2.1.2 Subtypes of stroke

The two main types of stroke are ischaemic and haemorrhagic strokes. Ischaemic stroke can be classified into subtypes based on the location of the infarct in the brain circulation. These subtypes include strokes in the: anterior cerebral artery, middle cerebral artery, posterior cerebral artery, brain stem, cerebellum, deep small vessel (lacunar) or stroke in more than one vascular territory.[63] Ischaemic strokes have also been classified as syndromes such as total anterior circulation syndrome, partial anterior circulation syndrome, posterior circulation syndrome, and lacunar syndrome.[64] Ischaemia in the brain results from stenosis or occlusion of large or small blood vessels due to thrombosis or emboli from remote vascular regions or it may be a consequence of diminished systemic perfusion.[2] Following a critical reduction of blood flow, brain cells are reversibly or irreversibly injured, depending on the severity and duration of ischaemia.

Haemorrhagic stroke is classified according to the location of the lesion in the brain circulation (anatomical) or by the possible cause (mechanistic).[65] For example, haemorrhagic stroke can be classified anatomically as intracerebral which may be supratentorial or lobar intracerebral haemorrhage. Haemorrhagic stroke can also be classified by causal mechanism such as hypertension, cerebral amyloid angiopathy, anticoagulant use, vascular structural lesions, or undetermined cause.[65]

2.1.3 Risk factors for stroke

A risk factor refers to an individual's attribute which increases their likelihood of developing a disease relative to other people, such that when that factor is absent the risk of disease decreases.[66] Risk factors for stroke can be classified into non-modifiable and modifiable. Factors such as age, sex, birth weight, or ethnicity are non-modifiable. Modifiable risk factors include high blood pressure, cigarette smoking, obesity, diabetes, dyslipidemia, and physical inactivity.[66] In people with stroke, blood pressure reduction strategies are often recommended to prevent stroke recurrence. In addition to the recommended drug regimen, life-style strategies such as reduced salt and alcohol intake, weight loss, diet rich in fruit and vegetables, and regular aerobic physical activity are important in mitigating the risks of stroke recurrence.[66, 67]

Improving levels of physical activity have beneficial effects in the primary and secondary prevention of stroke and may also help to modify other stroke risk factors.[66, 67]

2.2 Moderate-to-vigorous intensity physical activity

The historical approach to physical activity promotion in the general population has focused on attaining a certain threshold of moderate-to-vigorous intensity physical activity. The recommendation is that all healthy adults should engage in moderate-intensity aerobic physical activity for at least 150 minutes per week.[68] For example, it is suggested that an individual can meet this threshold by walking briskly for 2 miles (about 3.2 kilometers) daily.[68] In addition, Haskell and colleagues posited that an individual can also meet the physical activity recommendation by walking briskly for 30 minutes two times a week and also engaging in a jogging program for 20 minutes on two other days.[69] Generally, the benefits of moderate-to-vigorous physical activity include enhanced glucose uptake and insulin sensitivity, improved lipid profile, reduced blood pressure, improved health of blood vessels, and protection against obesity.[70] It is also associated with reduced risk of stroke, ischaemic heart disease, diabetes, cognitive disorders, and total mortality.[66, 71, 72]

Some of the physical activity literature has addressed the question of physical activity, at different intensities, and stroke risk. For example, Lee and Paffenbarger,[73] in a prospective study of 11,130 men in the Harvard University Alumni Health study reported a decreased risk of stroke as physical activity levels increased. A decreased risk of stroke was observed with walking at least 20 kilometers per week at energy expenditures of between 1000 and 3000 kilocalories, but the association showed a U-shaped relationship, and weakened at higher exercise intensities (such as climbing stairs). The reason for the weaker association at higher intensities was unclear, however it suggests that there may be no additional benefit derivable from vigorous physical activity. There was no association between light-intensity activities (operationally defined as <4.5 METs in that study) and stroke risk.[73] Another study[74] investigated 39,315 women in the Women's Health study who were followed up for 11.9 years and found that 579 of the women suffered a stroke. In that study, vigorous-intensity physical activity (defined as activities ≥ 6 metabolic equivalents) was not significantly associated with stroke risk, but moderate-intensity physical activity over two hours a week, walking, and walking intensity were inversely related to stroke risk.[74] Again, the rationale for this observed difference was not clear; however, participation in vigorous activities was far lower than moderate activities, which may have caused a distortion in the observed effect. A third international, multicentre study - the INTERSTROKE trial[75] found that regular physical activity was among the major factors that could substantially reduce the burden of stroke.

2.3 Light-intensity physical activity

Light-intensity physical activity includes things like slow walking, washing dishes and other household tasks which require energy expenditure in the range of 1.6 to 2.9 METs.[76] Light-intensity physical activity is important as it occupies about 39% of waking hours in adults compared to about 3% occupied by moderate-to-vigorous intensity physical activity.[52,77] A large proportion of total daily energy expenditure is achieved through the concept of non-exercise activity thermogenesis (which is the energy expended for everything we do that is not sleeping, eating or structured exercise).[78] Some everyday activities, such as stair climbing, activates muscles substantially,[79] and standing instead of sitting considerably increases daily muscle activity. Repeated sit-to-stand transitions have been shown to increase energy expenditure greatly, especially when done in quick successions.[80] It has been estimated that performing 15 sit-to-stand transitions per minute is equivalent to 4.3 METs.[80]

Using data from a nationally representative sample of Canadian adults in the 1981 Canada Fitness Survey, Katzmarzyk[81] reported that individuals who stood most of the day had a 33% lower risk of all-cause mortality compared to those who reported standing almost none of the time. Previous research has found an inverse relationship between light-intensity physical activity and sedentary behaviour, which suggests that changes to sedentary behaviour can be achieved by increasing light-intensity physical activity.[52] Even in individuals who are able to meet the recommendations for moderate-to-vigorous physical activity, which accounts for only 3% of waking hours in healthy adults,[77] opportunities to increase light-intensity physical activity are still important. Beneficial associations between light-intensity physical activity and health have been reported. Light-intensity physical activity improves glucose uptake,[82, 83] reduces risk of cardiovascular diseases,[84, 85] improves longevity,[86] and lowers risk of all-cause mortality by 14% in people with limited mobility.[54] The associations between light-intensity physical activity, cardiovascular health, and mortality have been investigated in older adults (n= 4,232).[47] In that study, high levels of light-intensity physical activity, regardless of exercise habits, were beneficially associated with waist circumference, triglycerides, insulin sensitivity, glucose levels, and high-density lipoprotein cholesterol.[47] Furthermore, high levels of light-intensity physical activity were associated with lower risks of cardiovascular events and all-cause mortality.[47] The detrimental relationship between sedentary behaviour and health appears to be mediated through displacement of time that could be spent in healthier light-intensity physical activity,[87] since increasing exercise levels does not reduce sedentary behaviour.[50, 51]

2.4 Sedentary behaviour

The health benefits of exercise or moderate-to-vigorous physical activity are well established.[68, 88, 89] However, a rapid emergence of substantial research within the last two decades suggest that sedentary behaviour should be considered as a separate construct, distinct from lack of exercise.[39, 90, 91] The term sedentary behaviour is derived from the Latin word *sedere*, "to sit". Two things define sedentary behaviour, low energy expenditure (≤1.5 metabolic equivalents) and posture (sitting, reclining, or lying).[33]

Prior to the emergence of more intentional sedentary behaviour research, studies often classified those who were not able to attain moderate-to-vigorous intensity physical activity cut-offs as sedentary, and drew conclusions about the health effects of sedentariness.[91] For example, in the Harvard University Alumni study, men who accumulated less than 2000 kilocalories per week through walking, climbing stairs, and playing sports were classified as sedentary,[73] even though sedentary behaviour (as currently defined) was not directly measured. Also, the 1999 Youth Risk Behaviour Survey characterized participants as having a sedentary lifestyle if they did not report participating in sufficient moderate-to-vigorous physical activity.[92] As a result, there is confusion when conclusions are drawn since it becomes unclear whether researchers are concerned with "sedentary behaviour" or "physical inactivity."[93] These inconsistencies led the Sedentary Behaviour Research Network[32] to propose a definition for sedentary behaviour as: "any waking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents, while in a sitting, reclining or lying posture."[32, 33] This definition of sedentary behaviour was an important step in recognizing "sedentary behaviour" as distinct from "physical inactivity." There has been an impressive growth in research within the field of sedentary behaviour, including adoption by countries in recommendations for public health guidelines.[94, 95] However, some researchers appear not to have adopted this definition. Even in the stroke literature, Moore and colleagues[96] classified sedentary time as time spent doing activities where energy expenditure is less than 3 METs, a significant deviation from the accepted energy expenditure range for sedentary behaviour (≤1.5 METs).

From a physiological viewpoint, using animal model, Hamilton and colleagues[97] reported that prolonged sedentary behaviour results in sustained periods of unloading of muscles which leads to suppression of skeletal muscle lipoprotein lipase activity and decreased glucose uptake by the muscles. Lipoprotein lipase is a key enzyme that facilitates triglyceride uptake into muscle tissue and is involved in production of high density lipoprotein cholesterol.[98, 99] Low levels of lipoprotein lipase are associated with increased level of serum triglycerides and reduced level of high density lipoprotein cholesterol.[98, 100] Sedentary behaviour and structured exercise affect lipoprotein lipase activity differently in muscle fibre types, with a 10-20 fold decrease in lipoprotein lipase activity reported in red oxidative muscle with sedentary behaviour, but a 2-3 fold increase in white glycolytic muscles with exercise.[97] Tremblay et al.,[101] introduced the term "sedentary physiology" to conceptualize the unique nature of sedentary behaviour and the associated physiological implications as an extension to the "inactivity physiology" construct originally described by Hamilton and colleagues.[97]

2.5 Too much sitting is different from too little exercise

There has been some debate in the literature about whether sedentary behaviour is just physical inactivity by another name.[93] This notion was first challenged by Owen and colleagues,[102] when they suggested that sedentary behaviour (i.e. too much sitting) might have independent and qualitatively different effects on metabolism and health outcomes compared to insufficient moderate intensity activity (i.e. too little exercise), and that each should be addressed as distinct research and public health issues. For example, an individual may meet the daily moderate intensity activity target (i.e. 30 minutes per day) and yet engage in a high level of sedentary behaviour during the remaining 15.5 hours of non-sleep time (assuming a sleep time of 8 hours per day). This is illustrated in an infographic published by the Australian Heart Foundation (see Figure 2.1). Besides strength training, brisk walk, and time in bed, all the other behaviours shown in the infographic are sedentary. It is also possible for an individual to be inactive and non-sedentary for the most part of the day. For example, if someone is employed as a sales associate in a retail outlet, that person may be standing and walking around for 7-8 hours of their working day and will hardly ever sit. Such persons are not sedentary, but they have not engaged in physical activity at the moderate-to-vigorous intensity level. The approach to using only moderate intensity activity cut-offs to quantify physical activity levels neglects the substantial contributions of non-exercise physical activity (i.e. light intensity, 1.6 - 2.9 METs) to daily energy expenditure, which is often displaced by time in sedentary behaviours.[47, 103, 104] Sedentary behaviours occupy between 55-60% of waking hours in the general population.[77, 105]

2.6. Measurement of Sedentary Behaviour

Diverse activities in different domains make up sedentary behaviour and could pose a challenge in measurement of sedentary time.[106] According to Healy et al.,[107] measurement of sedentary time in the general population can be achieved through subjective measurement (categorization into specific behaviours such as TV viewing time or specific domains like work, domestic or transport) or objective measurement (examining the overall sedentary time across the day). In addition to the measurement of total sedentary time per day, it is also important to quantify the pattern - the way in which activity behaviour is accumulated - either as long, uninterrupted or short, interrupted bouts (see Figure 2.2). Uninterrupted and prolonged sedentary bouts are particularly harmful to health.[103, 108-110] The operational definitions for the activity behaviour variables used in this project are provided in Table 2.1.

Figure 2.1. Whole-day activity behaviour

(From: https://www.heartfoundation.org.au/images/uploads/main/Active_living/Sit_less__move_more.jpg)

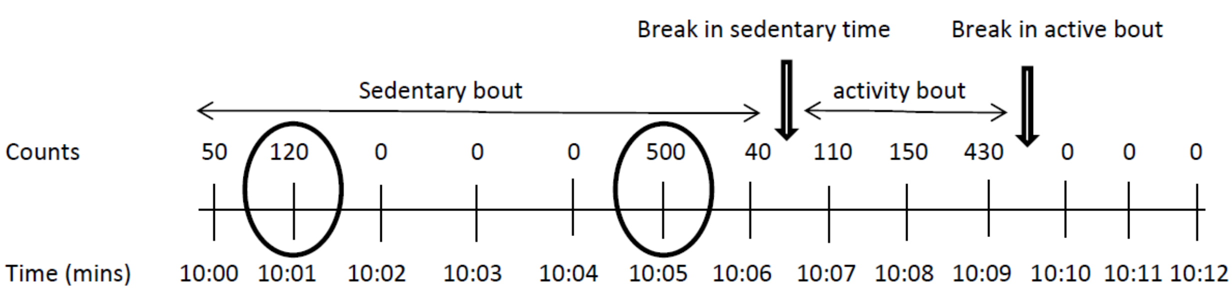

Figure 2.2. Sedentary bout, activity bout, and breaks using Actigraph.[111]

Table 2.1. Operational definitions of activity behaviour terms used in this thesis

Term	Definition
Sedentary behaviour	Activities done in sitting, reclining, or lying that do not increase energy expenditure substantially above the resting level (1.0-1.5 METs).[33]
Sedentary bout	A minimum uninterrupted period of sitting, reclining, or lying and low energy expenditure (1.0-1.5 METs).[112]
Break in sedentary time	A defined point in time where there is a change from sedentary behaviour to non-sedentary behaviour.[113]
Light-intensity physical activity	Activities that involve energy expenditure within the range of 1.6-2.9 METs.
Moderate-to-vigorous physical activity (MVPA)	Activities that involve moving fast enough to work up the heart rate and 'break a sweat', with energy expenditure ≥ 3.0 METs.

2.6.1 Subjective measurement

The common subjective measurement options include questionnaires (self-administered or interviewer-administered), activity diaries and recall of activity within the week.[107] The International Physical Activity Questionnaire (IPAQ) which was developed as a surveillance measure of physical activity also includes specific items to assess sedentary behaviour.[114] Other measurement tools to assess sedentary behaviours in multiple domains have been developed. An example is the Sedentary Behaviour Questionnaire (SBQ)[115] which assesses time spent in 9 sedentary behaviours on weekdays and weekends. The sedentary behaviours assessed by SBQ include sitting/lying while: watching TV, playing video games, listening to music, talking on the phone, doing paperwork or work on the computer, reading, playing musical instrument, doing crafts and, traveling. While the SBQ showed good reliability for assessment of sedentary behaviour, it performed poorly compared to objective data from activity monitors.[115] There is also the Bouchard Activity Record (BAR) which assesses activities across the energy spectrum from sitting or lying to higher levels of activity.[116] A study that compared the validity of the BAR against objective measurement from activity monitors showed that the BAR underestimated sedentary time.[116] Subjective measurements are attractive because they are inexpensive and result in data that are relatively simple to analyze, while providing information that is domain-specific with regards to activity.[117] However, they are limited by high levels of error and recall bias.[118] In addition, for people with chronic diseases they may be influenced by fluctuations in health status, changes in mood, depression, anxiety, and problems with memory and cognition.[117] A significant limitation of subjective measurements is that they provide only estimates of activity behaviour.[119] Subjective measures do not appropriately capture how long an individual spends in a bout of physical activity or sedentary behaviour.[120] Moreover, daily physical activity in people with impaired mobility is mostly performed as part of activities of daily living (e.g. standing up from a chair, getting into and out of a car, or walking to the washroom).[121] Such activities are difficult to recall and cannot easily be captured using subjective measures or questionnaires. Subjective measurement of sedentary time is often reported in proportions. An example is the percentage of people within an estimated category of sedentary time, as shown in Table 2.2. To provide more robust and valid measures of activity behaviours, objective measures were developed.

2.6.2 Objective measurement

Advances in technology have made it possible to measure sedentary time through the use of accelerometers. Accelerometers are small electronic devices that provide objective measures of volume and intensity of human movement.[122] Objective measurement of sedentary behaviour using these miniature electronic devices is gaining ground in the literature and has led to significant population-based physical activity research. The most commonly available device is the pedometer which quantifies the number of steps taken per day, with less than 5000 steps/day considered as the "sedentary life index."[123] However, pedometers do not actually measure sedentary time (i.e. sitting, reclining or lying) and the accuracy of pedometers is compromised at slow walking speeds (≤ 3.2 kilometre per hour).[124] Accelerometers are the preferred activity monitors for measurement of physical activity and sedentary behaviour.[124-126]

Accelerometers can be broadly classified into two families, energy expenditure (e.g. Actigraph LCC, Pensacola, FL) and postural classification devices (e.g. activPAL, PAL Technologies Ltd., Glasgow, UK).[113] There are several types of accelerometers, but two of the most commonly used and valid ones - Actigraph and activPAL, will be discussed.

Actigraph: The triaxial Actigraph is a small (5.1 x 4.1 x 1.5 cm), light (27g) instrument that detects acceleration in selected planes and converts the data into "counts," which are then reported in specific time intervals or epochs, usually 1-minute epochs. The activity count is the net external force generated during bodily movement associated with physical activity behaviour and directly reflects the energy cost of physical activity.[105] The more activity a person does, the greater the number of counts recorded by the Actigraph.[127] Activity counts per minute are stored in the Actigraph's random access memory and the data can be downloaded and processed using ActiLife software. These counts per minute are classified using cut-points (i.e. thresholds) into sedentary, light or moderate-to-vigorous physical activity levels, with sedentary behaviour being <100 counts per minute. For example, using data from the Actigraph, studies have shown that healthy adults in Australia[52] and United States[105] spend 57% and 55% of their monitored time, respectively in sedentary behaviours (see Table 2.2).

The Actigraph is worn on the hip attached by an elastic belt during waking hours and is a valid and reliable tool for measurement of physical activity.[128] In people with limited mobility such as multiple sclerosis, the Actigraph was shown to demonstrate good reliability of 0.80 and 0.93 over 3 and 7 days of activity monitoring, respectively.[129] There is a limitation with using the Actigraph to measure sedentary behaviour, as this device does not distinguish postures (i.e. sitting versus standing) and if there is a lack of movement, such as in quiet standing (a stationary, non-sedentary behaviour)[33] counts may go below 100 counts per minute resulting in misclassification of behaviour.[130] An illustration of how the Actigraph determines bouts of sedentary behaviour or physical activity as well as interruptions (i.e. breaks) was shown earlier in Figure 2.2. Counts above 100 sustained for at least 2 minutes represents a break in sedentary time. The way the ActiLife software detects a break can also be configured differently. Some researchers have used a threshold of any counts above 100 counts per minute to represent a break, but that may also pick up some "noise" as a break, when in fact there was no change in behaviour.

ActivPAL: Unlike the energy expenditure classification devices that require cut-points of activity counts to classify activities, postural classification devices such as the activPAL determine absolute body positions and transitions between postures (i.e. lying/sitting, standing, and taking steps) within time intervals.[126, 131] Postural classification devices provide robust measurement of sedentary time as currently defined, by classifying daily activities into sitting, lying, or reclining (sedentary behaviour), or upright activities such as standing or taking steps (non-sedentary behaviour).

The activPAL3 micro is a single thigh mounted device that weighs only 9g and is usually affixed with a transparent waterproof dressing on the thigh to allow for continuous wear for a period of time, usually 7 days, and is able to capture all the activities of daily living.[121, 132] The activPAL has been validated in people with stroke and provides highly accurate measurement of sedentary behaviour and detection of transitions from non-upright to upright positions or vice-versa.[121] The activPAL has also been successfully used in other studies with people with stroke to measure sedentary time and overall daily activities.[19, 35, 36] Due to the high accuracy and reliability of the activPAL in classifying sedentary (i.e. sitting/lying) from non-sedentary behaviour (i.e. upright), it has been suggested that the activPAL should be used as the gold standard for measuring sedentary behaviour.[116, 130] Overall, studies with people with stroke have shown that accelerometers are generally user-friendly and can be used at various stages of stroke recovery to provide accurate and reliable measures of day-to-day activity behaviour.[24, 133]

An advantage of objective measurement using accelerometers is that minute by minute data allows determination of the pattern of activity throughout the day, including breaks in sedentary time, and duration of active and sedentary bouts.[103] Generally, the challenge with the use of accelerometers is compliance with wearing the device and appropriate documentation of non-wear time. Although studies have stated that a minimum of 10 hours/day of accelerometer wear is needed to produce a valid day,[105, 122] other researchers have suggested that a wear time of at least 13 hours/day may be preferred.[134] Thus, strategies to ensure compliance are important. Using water-resistant straps to secure accelerometers (e.g. the activPAL on the thigh) encourages non-removal and allows for continuous wear for an extended period of time, usually 7 days.

A study that compared the activPAL with Actigraph (both devices were worn on the thigh), reported that both devices correctly classified standing 100% of the time in healthy adults, sitting >95% of the time and interestingly, activPAL classified cycling as stepping 93% of the time, compared to Actigraph <1% of the time.[135] This suggests that the placement position may affect the accuracy of the device, and that the activPAL may also be useful in monitoring performance during cycling tasks in individuals who are not ambulatory but can ride a stationary bike.

Table 2.2. Measurement of sedentary time in healthy adults

Study Description	Population	Method of Assessment	% Sedentary	Reference
Subjective				
Nord-Trondelag Health Survey (HUNT) 2006-2008 (Norway)	≥60 years (n=13,433)	Self-reported daily sitting	89.8 (≥4h/d) 55.6 (7-10h/d)	Chau et al.[136]
Objective				
AusDiab (Australia)	Middle-aged adults, healthy (n=169)	Actigraph	57	Healy et al.[52]
Canadian Health Measures Survey 2007-2009 (Canada)	Representative Canadian sample, 20-79 years (n=2,832)	Actical	69	Colley et al.[137]
NHANES 2003-2004, 2005-2006 (USA)	Representative US sample, aged 6 years and older (n=6329)	Actigraph	55	Matthews et al.[105]
Scottish Older Adults (UK)	≥ 60 years, 24 hour monitoring (n=22)	activPAL	75 (at baseline)	Fitzsimons et al.[138]

2.7 Sedentary behaviour and stroke

To date, a few studies have examined the extent of sedentary behaviour in people with stroke during the acute, subacute, and chronic phases of recovery.[19, 31, 34, 35, 139] Overall, the available evidence indicates that sedentary behaviour is highly prevalent in people with stroke from the early stages of stroke to over 4 years after stroke.[19, 34, 139] In a multi-national, population-based study, the odds of engaging in high levels of sedentary behaviour (≥ 8 hours per day) was highest in people with visual impairment, followed by people with stroke, among 11 chronic conditions studied.[140] A systematic review and quantitative synthesis of activity behaviour after stroke reported that in the acute and subacute periods, studies that used behavioural mapping (direct observation of an individual's activity behaviour) showed that sitting time was similar in both periods (37.6 vs. 32.6%). However, time spent in bed was longer during the acute phase compared to the subacute period (45.1 vs. 23.8%).

Using objective measures of sedentary time in the early period after stroke (acute), two studies reported that people with stroke engage in sedentary behaviours for about 95% of a 24-hour monitored period.[34, 141] In the subacute period (between 1 and 6 months post stroke), studies have shown that people with stroke spend between 80% and 83% of a 24-hour monitored period in sedentary behaviour and the level of sedentariness remains high even at 1 year after stroke.[19, 35] In the chronic phase of stroke recovery, sedentary behaviour levels range from 80% to 85% of a 24-hour monitored period,[19, 31, 35] or 75% of waking hours (i.e. when sleep time was removed).[139]

Table 2.3 shows the percentage of the day spent in sedentary behaviours by people with stroke in the acute, subacute, and chronic phases of recovery measured by Actigraph or activPAL activity monitors.

Table 2.3. Objective measurement of sedentary time in people with stroke

Study Description	Population	Monitoring Device	Sedentary Time (%)*	Reference
Acute stroke (USA)	Inpatients (n=32); aged 29-80 years; time since stroke, < 1 week.	Actigraph on hemiparetic ankle	94	Mattlage et al.[34]
Acute/subacute stroke (UK)	Inpatients (n=41); mean age 69±11 years; time since stroke, < 2 months	ActivPAL on nonparetic thigh	96	Kerr et al.[141]
Longitudinal, acute stroke followed for 1 year (UK)	Inpatients and outpatients (n=96); aged 38 – 90 years; time since stroke at baseline, < 1 month.	ActivPAL on nonparetic thigh	83 at 1 month post stroke 80 at 6 months post stroke 80 at 1 year post stroke	Tieges et al.[19]
Longitudinal, subacute stroke followed for 6 months (Australia)	Community-dwelling (n=36); mean age 71±14 years; time since stroke at baseline, <4 months	ActivPAL on nonparetic thigh	83 at 1 month post discharge 82 at 3 months post discharge 83 at 6 months post discharge	Mahendran et al.[35]
Chronic stroke (Australia)	Community-dwelling (n=40); mean age 67±11 years; time since stroke, 4.4 ±10.0 years	ActivPAL on nonparetic thigh	75 (waking hours)	English et al.[139]
Chronic stroke (UK)	Community-dwelling (n=22); mean age 56±10 years; time since stroke 4.2±4.0 years	ActivPAL on nonparetic thigh	85	Paul et al.[31]

* Sedentary time is reported as percentage of 24-hour monitoring (including sleep) except indicated as otherwise.

2.8 Association of sedentary behaviour with health outcomes

Sitting is not a disease per se, but high volumes of sitting, and particularly prolonged bouts of sitting are risk factors for disease.[142] Evidence for the detrimental relationship between sedentary behaviour and health is not entirely new. In the early 1700's, Bernardino Ramazzini in his work 'Morbis Artificum Diatriba' (Diseases of Workers) reported on the negative effects of work environments where sitting were predominant (termed 'chair workers').[143] Ramazzini stated that the workers suffered ill-health as a result of their sedentary lifestyle and suggested walking and exercising for the 'chair workers' to mitigate some of the negative effects in some way.[143] Also, a study of London bus drivers in the 1950's, even though a physical activity study at the time, showed a significant association between risk of myocardial infarction and prolonged sitting among bus drivers compared to bus conductors who stood and climbed stairs during their working day.[144] Despite these early reports, there has been an exponential growth of more intentional sedentary behaviour research in the last two decades.[33, 82, 104, 145]

2.8.1 Sedentary behaviour and cardio-metabolic risk

Studies in healthy individuals have shown that prolonged sedentary behaviour is linked to cardiometabolic markers (e.g. obesity, high cholesterol levels, diabetes and insulin resistance),[77, 146, 147] and cardiovascular disease,[148] independent of levels of moderate-intensity physical activity. A meta-analysis of 9 cohort studies reported that accumulating 10 or more hours per day in sedentary behaviours represent the "danger zone" threshold for increased cardiovascular events, after adjusting for physical activity and other potential confounders.[46] In people with limited mobility, it has been suggested that every increase of 25 to 30 minutes in sedentary time per day is associated with a 1% increase in hard coronary heart disease risk.[149] Notwithstanding the negative health consequences of sedentary behaviour, there is evidence that interruptions in sedentary time, even just standing up and walking around regularly, is beneficially associated with health outcomes, after controlling for total sedentary time and moderate intensity activity levels.[82, 103, 150] More specifically, breaking up sedentary time is associated with lower waist circumference, triglycerides, and 2-hour post-prandial plasma glucose level.[47, 83, 103] In people with and without limited mobility, there is a beneficial association between breaks in sedentary time and waist circumference.[37]

2.8.2 Sedentary behaviour and vascular health

There is a link between sedentary behaviour and vascular function. Hamburg and colleagues[151] investigated changes in vascular function following 5 days of bed rest (the most extreme example of sedentary behaviour) in 20 healthy subjects. The results of the study revealed that reactive hyperemia (a measure of peripheral vascular function) was reduced by about 20% in the legs and 30% in the arms following the prolonged bed rest. The participants also experienced a substantial increase in blood pressure and significant decrease in brachial artery diameter with bed rest. There is evidence that 5 hours of uninterrupted sitting is associated with reduced plasma volume and increased fibrinogen (factors that influence blood viscosity).[110, 152] Higher blood viscosity associated with these findings may lead to an increased risk of thrombus formation and possibly a greater risk of having ischaemic stroke in sedentary individuals.

2.8.3 Sedentary behaviour and mortality

Systematic reviews have been consistent in reporting evidence of the detrimental associations between sedentary behaviour and all-cause mortality.[38-43, 153] Individuals who spend prolonged time in sedentary behaviours are at a higher risk of premature mortality.[45] There is a dose-response association between sitting time and all-cause mortality, with the greatest risk for those who report sitting for about 75% of the day, independent of leisure time physical activity.[45] Van der Ploeg et al.,[145] reported similar associations between sedentary behaviour and all-cause mortality with hazard ratios (i.e. a measure of how often an event happens in one group compared to a referent group) being 1.02 (95% CI, 0.95-1.09), 1.15 (1.06-1.25), and 1.40 (1.27-1.55) for 4-8, 8-11 and >11 hours per day of sitting, respectively, compared with <4 hours per day of sitting, independent of physical activity. Furthermore, Diaz and colleagues recently corroborated those findings.[153] In the Cancer Prevention Study II-Nutrition Cohort, which included 69,776 women and 53,440 men that were followed for 14 years, detrimental associations were found between siting time and all-cause mortality, regardless of physical activity levels.[154] In contrast, Ekelund and colleagues recently reported that the higher risk of mortality attributed to sedentary time, appears to be eliminated by high levels of moderate-intensity physical activity (about 60-75 minutes per day).[155] However, it is important to note that the level of moderate-intensity activity that is required to mitigate the higher mortality risk associated with prolonged sedentary behaviour is about 2.0 to 2.5 times higher than the current recommendations for physical activity.

For people with limited mobility, who have difficulty with meeting current physical activity recommendations and are already on the lower end of the activity continuum, prolonged sedentary time may constitute a double-fold increased risk of poor health and mortality. In adults with limited mobility, Manns and colleagues,[48] posited that the onset of disability is a shift from being active to, in some cases, completely being sedentary. The authors reported that sedentary behaviour in people with limited mobility and the associated co-morbidities could result in sharp increases in mortality and that reducing sedentary behaviour and increasing total physical activity may result in lower rates of mortality.[48] There is evidence that for every increase in total physical activity of 60 minutes per day, people with stroke have a 28% lower risk of all-cause mortality.[156] When considering only light-intensity physical activity, there is a reduced risk of all-cause mortality by 14% with every increase of 60 minutes per day in light-intensity physical activity among adults with limited mobility.[54]

2.9 Interventions to reduce sedentary behaviour

There is mounting evidence across different populations, including people with limited mobility, that it is feasible to reduce sedentary behaviour.[36, 50, 51, 157] For example, an intervention study was conducted with older adults - Stand Up for Your Health,[158] a one-week program designed to encourage older adults to stand up and move after 30 minutes of uninterrupted sitting. That study involved 59 participants aged 60 years and above (mean, 74.3 years); the intervention was based on social cognitive and behavioural choice theories. The specific constructs used to develop the intervention from the behaviour change theories were self-efficacy, goal setting, self-monitoring, outcome expectancies (i.e. barriers and benefits), reinforcement through rewarding behaviour change, and identifying enjoyable non-sedentary behaviours. Following a one-day intervention and monitoring at 6 days post-intervention, there was a reduction in sedentary time of 3.2% (CI: -4.18, -2.14) and increase in light-intensity physical activity of 2.2% (CI: 1.40, 2.99). There were individual variations in change in sedentary time, ranging from a reduction of 13.6% in some older adults to an increase of 8% in others. The limitations of this study were that 1) the intervention was for a single day and even though the intervention was based on theories (social cognitive and behavioural choice), it failed to explore the sociocognitive factors that may have influenced change in sedentary behaviour (i.e. why did some achieve over 13% reduction whereas others increased sedentary time), and 2) measurement of sedentary behaviour was done using Actigraph which does not specifically measure sedentary behaviour. In addition, we do not know if there was maintenance of the behaviour change, since a main purpose of behaviour change interventions is to sustain change even after the intervention has ceased.

Three studies with adults in the free-living environment have also reported changes in sedentary time following interventions. Using a personal activity monitor (Gruve™) as an intervention tool to motivate adults aged 20 to 36 years (n=18) to reduce sedentary behaviour and increase physical activity, one study reported a significant reduction in sedentary behaviour of 33% (3.1 hours/day) from baseline (9.4 hours) after a 4-week intervention (6.3 hours).[159] In addition, there was a 45% increase in light intensity activity (8.4 vs. 5.8 hours/day), 33% increase in moderate intensity activity (1.0 vs. 0.75 hour/day), and 38% increase in vigorous intensity activity (0.61 vs. 0.44 hour/day). The participants in that study wore the Gruve monitor every day to increase their motivation to improve physical activity for the 4-week intervention period, except during sleep, bathing or swimming. The daily goal was to reach a green bar on the device (i.e. the monitor's halo light bars displays different colours beginning with red until a physical activity target of green is achieved).

In another four-arm quasi-experimental study, Kozey-Keadle and colleagues[160] reported reduction in free-living sedentary time of 4.8% compared to controls whose sedentary time increased by 4.3%. That study had 4 groups (n=57) and participants were aged 20 to 60 years. One group was involved only in traditional structured 12-weeks supervised aerobic exercise training at a frequency of 5-days per week. A second group received an intervention to reduce sedentary behaviour and increase physical activity (e.g. standing during television commercials or taking 5-minute breaks every hour at work) and wore a pedometer for self-monitoring. A third group participated in exercise training but also received an intervention to reduce sedentary behaviour and increase non-exercise physical activity, while the fourth group served as controls and were asked to maintain habitual behaviour. Sedentary time was measured using activPAL and results showed that for group 1 (exercise only), sedentary time did not change from baseline to 12-week period. For group 2 (sedentary and light-intensity physical activity intervention), there was reduction in sedentary time by 4.8% at 12-weeks compared to baseline. Group 3 (sedentary and light-intensity physical activity intervention plus exercise) reduced sedentary time by 5.1% at 12-weeks, while the controls increased sedentary time by 4.3% compared to baseline.[160]

A third study with older adults aged 60 years and above (n=24) employed individualized consultations and feedback from activPAL output and reported a reduction in sedentary time of 24 minutes per day (2.2%) and increase in total time spent stepping by 13 min/day over a 2-week period.[138] That study used behaviour change techniques based on ecological model to influence change in sedentary behaviour. Baseline (i.e. pre-intervention) activPAL monitoring provided graphical output that was used to highlight areas of prolonged sedentary behaviours throughout the day during the individualized consultations with the participants. Specific action plans were developed on how to effect behaviour change. Examples of action plans used in the study included: going to the kitchen every hour to drink a glass of water or cup of tea; reduction of time spent watching TV after work on weekdays or manually changing channels on the TV.

Work-place interventions aimed at reducing sedentary behaviour have also shown promise in reducing sedentary behaviour and there are beneficial associations with health outcomes. One workplace intervention targeted reducing sedentary behaviour during working hours using standing desks, with continuous monitoring of capillary blood glucose in 10 office workers, aged 21 to 61 years.[161] Postprandial blood glucose levels were significantly reduced by

43% compared with levels during seated deskwork.[161] Energy expenditure was significantly higher in standing work by 174 kilocalories (487 kcal) versus seated work (313 kcal) during the 3.5 hours monitored period. The accelerometer movement counts between days of the intervention and other seated days did not differ (i.e. movements away from the desk were not different), suggesting that the better glycaemic regulation was mainly due to a shift from sitting to standing.[161] Another randomized crossover trial investigated sit-stand workstation intervention to reduce sedentary time (n= 28). The goal of the intervention was to reduce work-time sitting by 50% and email reminders were sent at the beginning of each week. The controls were asked to maintain usual work habits. Sedentary behaviour and physical activities were measured using Modular Signal Recorder and Gruve™ accelerometers. After the 4-week intervention period, sedentary time was reduced by 21%, which translates to a reduction of 3.2 hours over a 40 hour work-week.[162] A non-randomized controlled study (n=43) investigated the efficacy of a multicomponent 4-week intervention to reduce office worker's sitting time and reported that relative to controls, intervention group participants achieved a reduction of 125 minutes in sitting time over an 8-hour work period.[163] The participants in that study were aged 26 to 62 years and had standing workstations installed in the workplace which encouraged participants to substitute standing for sitting every 30 minutes. The key intervention messages were "Stand Up, Sit Less, Move More". The control group carried out usual work practices.[163]

English and colleagues conducted the first sedentary behaviour change intervention with people with stroke.[36] Nineteen participants with a mean age of 65.4 ±12.3 years, 2.8 years post-stroke, received 4 sedentary behaviour change motivational counselling sessions over 7 weeks. A control arm of people with stroke (n=14), mean age 67.8 ± 13.8 years, 4.1 years post-stroke, received 4 education sessions on increasing calcium for bone health. In the unadjusted results, both groups reduced their sedentary time, the intervention arm by 36.1 minutes, while the control arm reduced by 43.9 minutes. The results showed that it was safe and feasible to reduce sedentary time in both groups, but the intervention group did not show superior outcomes relative to the controls.[36]

In a study with persons with multiple sclerosis, Klaren et al.,[164] reported a 99 minutes reduction in sedentary time following a social cognitive theory-based internet intervention. The intervention was delivered via a website which provided content related to strategies on reducing sedentary behaviour. Examples of ways used to improve activity behaviour included standing up while watching TV, or reading a newspaper or while using the telephone. The intervention lasted for a total of 6 months and involved introducing new content materials on the website seven times in the first 2-months, four times in the second 2-months and two times in the third 2-months. There was an additional weekly one-on-one behavioural coaching using Skype™. The main limitations of that study were 1) it used self-reports to assess sedentary time, and 2) the study was a secondary analysis and was not primarily designed to investigate sedentary behaviour in people with multiple sclerosis.

Although measurable gains have been associated with interventions aimed at reducing sedentary behaviour in healthy adults and people with limited mobility, effective ways to reduce sedentary behaviour after stroke are still lacking. Encouraging people with stroke to reduce sedentary time could be a first step to increase their daily energy expenditure. An intervention program developed without understanding the unique characteristics of the targeted population may not be effective in successfully changing behaviour. It is also important to situate the behaviour change process within a theoretical framework. Knowing which variables predict change in behaviour is essential in design of targeted interventions to reduce sedentary behaviour and increase physical activity.

2.10 Theoretical framework for behaviour change

The alarming proportion of over 80% of the day spent in sedentary behaviours by people with stroke[19, 31] makes them a priority group for behaviour change interventions. The role of sociocognitive factors in promoting activity behaviour has been highlighted in the neurorehabilitation literature.[165] Understanding these factors may help to clarify why people with stroke, even those with mild impairments, engage in prolonged sedentary behaviours.[166] Knowledge of the important social cognitive factors will also help in developing effective and targeted interventions. The ultimate goal of health promotion interventions is to teach the skills that are necessary to sustain behaviour change in the longer-term even after the intervention has been withdrawn.[165]

Physical activity and sedentary behaviour are affected by diverse factors, therefore behaviour change theories and models are important in understanding and influencing change in these behaviours. A few studies have investigated the social cognitive correlates of physical activity behaviour among people with stroke.[167-170] Perceived self-efficacy, outcome expectancies, pre-stroke exercise behaviour, and recommendation by a clinician to exercise are suggested factors that may influence physical activity behaviour in people with stroke.[167, 168] Researchers have often employed social cognitive theory as a basis for interventions to promote physical activity in the general population,[171] among older adults,[158] in people with chronic diseases,[44] and those with mobility disability.[164] The social cognitive determinants of sedentary behaviour are unknown in people with stroke.

However, social cognitive theory[172, 173] provides a theoretical framework for behaviour change that may be applicable to individuals with stroke to achieve reductions in sedentary behaviour. There are multiple bi-directional interactions between the behaviour of interest, the environment and personal attributes.[173] A change in one component has an effect on others, but these components are not necessarily of equal strength nor does all the influence take place simultaneously. For example, sedentary behaviour may interact with environmental factors (such as the home or family support), and personal factors (such as the individual's beliefs or expectations about sedentary behaviour). This triadic relationship between the person, the behaviour and the environment is known as reciprocal determinism.[172]

2.10.1 Key behaviour change targets in social cognitive theory

Social cognitive theory is particularly useful in promoting behaviour change as it offers some key constructs as targets for change. According to Bandura,[173] the key targets include knowledge of associated health risks of the behaviour, perceived self-efficacy or task-specific confidence that one can exercise control over one's health habits (which plays a major role in behaviour change). Other targets include outcome expectancies about the expected costs and benefits of changing the behaviour, the goals people set for themselves, concrete plans and strategies for realizing the goals (which provides incentive for action), as well as the perceived facilitators and impediments (barriers) to the change people seek.[172-174] Social cognitive theory provides a guide about how to change these constructs. Each of the key behaviour change targets will be discussed below.

2.10.1.1 Knowledge of health risks: Knowing the risks associated with a particular behaviour, or the benefits to changing it, is an important first step in health promotion. If people with stroke do not know how sedentary behaviour affects their health, they have little or no reason to attempt to change their prolonged sedentary behaviours. However, it is not enough to know about the risks of sedentary behaviour or the benefits of changing it,[175] there are other factors that are necessary to achieve a change in behaviour including a strong belief in ones capability to effect a change or self-efficacy.

2.10.1.2 Self-efficacy: Self-efficacy is the central active “ingredient” in social cognitive theory and has been consistently associated with improvements in physical activity behaviour.[171, 176, 177] Self-efficacy refers to a person’s belief in their capability to organise and execute courses of action required to achieve the desired outcome.[172] Self-efficacy is a key construct in social cognitive theory as it affects health behaviour both directly and by its influence on other determinants (such as outcome expectancies, perceived barriers, and goals). The association between self-efficacy and goal setting is such that the stronger the perceived self-efficacy, the higher the goals people set for themselves and the stronger their commitment to achieving those goals.[173] People with high self-efficacy view barriers as conquerable by persisting. On the contrary, people of low self-efficacy, set lower goals and give up easily when faced with even minor challenges.[173] Self-efficacy is not so much about the skills one possesses, but what one can do with them in challenging circumstances.[174] Self-efficacy can explain up to 53% of variance in physical activity behaviours.[178] Theoretically, we expect that self-efficacy will influence the activities that people with stroke choose to pursue, the degree of commitment in achieving the goals, as well as the ability to persist in the face of challenges. These factors (i.e. choice of activities, commitment and persistence) are related to the initiation and maintenance of physical activity and exercise habits.[176]

Three types of self-efficacy (i.e. task, coping and scheduling) have been conceptualized that affect behaviour change at various stages.[177, 179] Task self-efficacy refers to the confidence for performing basic aspects of a behaviour and is related to initiation of behaviour change. For someone who has survived a stroke, the confidence to stand up and walk around for 5 minutes is task self-efficacy. Coping self-efficacy is the confidence for overcoming challenges associated with performance of the behaviour and is related to maintenance of change. For example, if a stroke survivor usually depends on a family member for getting up and moving around, the confidence to stand and walk for 3 to 5 minutes within a safe zone, even when a family member is not available is coping self-efficacy. Scheduling self-efficacy is one's confidence for managing time demands and inclusion of the behaviour change into one's schedule. Scheduling self-efficacy is the strongest predictor of persistence in a behaviour change intervention.[177, 179] An example of scheduling self-efficacy would be a stroke survivor's confidence to stand up and walk around every 30 minutes, and the confidence to keep that schedule.

Ways to increase self-efficacy: In the general population, there is substantial evidence on the mediating role of self-efficacy in the relationship between physical activity interventions and health outcomes.[176, 180-182] For example, physical activity counselling is associated with self-efficacy which in turn is related to level of physical activity.[183] Among older adults with osteoarthritis of the knee, self-efficacy mediated the effect of an exercise intervention on stair climbing.[184] When self-efficacy is increased, the other correlates (i.e. outcome expectancies, perceived barriers, and goals) are also influenced.[173] Potential ways to increase self-efficacy for sedentary behaviour change in people with stroke are discussed below:

Mastery experience involves mastering behaviour in small steps to build confidence and is a powerful source of self-efficacy. For example, rather than setting a target for people with stroke to reduce sedentary behaviour by 2 hours over an 8-week period, one can aim at a reduction of 15 minutes each week (through activities like standing up and walking around at frequent intervals throughout the day). Successful attainment of the 15 minutes per week goal can boost self-efficacy by enhancing performance accomplishment.[173, 176] Previous mastery experience with other behaviours can also be harnessed. The idea that ‘‘if I've done it before, I can do it again’’ is a powerful thought process that might be employed by individuals to boost self-efficacy.

Vicarious experience or social modeling refers to learning by watching similar others (i.e. other people with stroke) performing the same activity.[173, 176] This is one way that group physical activity or social networking may be beneficial. People with stroke can learn from the experience of others, gain confidence and improve their own performance. Having people with stroke engage with others with similar conditions and share their experiences often motivates people to behaviour change and provides a boost in self-efficacy through the comparative viewpoint that "if they can do it, then I can do it too."[169, 176]

Social persuasion means providing encouragement for people with stroke as they make effort towards behaviour change. This is often the most commonly implemented strategy in neurorehabilitation practice for enhancing self-efficacy. In social persuasion, the therapist or physical activity specialist will talk people with stroke into believing that they possess the capability to effect the behaviour change. Also, "buddies" (i.e. other people with stroke) can also provide persuasion by encouraging similar others.[169, 175, 176]

Physiological or emotional arousal relates to the appropriate interpretation of somatic symptoms.[173] For example, complaints of pain and aches with sitting less and moving more may diminish self-efficacy. People with stroke need to be informed that minor pains and aches with increased activity is the body's normal response to higher physiological demand. This can enhance self-efficacy by helping people with stroke to interpret these feelings in a positive way.

2.10.1.3 Outcome expectancies: Another core construct of social cognitive theory is outcome expectancies (perception of possible benefits of change in behaviour).[173, 174] Outcome expectancy is associated with physical activity, though less consistently than self-efficacy.[185] Outcome expectancies come in three main forms, which can be classified as either positive or negative: 1) physical effects that accompany the behaviour (e.g. pleasant or aversive physical experiences that may result from reducing sedentary behaviour), 2) social effects (i.e. approval or disapproval from others), and 3) self-evaluative reactions to one's behaviour (e.g. feelings of self-worth or frustration associated with change in sedentary behaviour). Positive outcome expectation serves as incentives and negative outcomes as impediments (i.e. outcome expectancy value serves as a moderator of health behaviour).

Outcome expectancy plays a larger role in the initiation of behaviours and less of a role in behavioural maintenance. For example, if a stroke survivor expects that changing sedentary behaviour will result in a lower risk of having a subsequent stroke or lead to improvements in function and well-being; this may act as a motivator to reduce sedentary time. However, self-efficacy will still be needed for the individual to keep the new routine.

2.10.1.4 Socio-structural factors (barriers or facilitators): Behaviour change would require zero effort if there were no barriers to overcome.[173] Perceived barriers (such as fatigue, depression, fear of falls, or lack of family support) are also correlates of behaviour change. Finding ways to overcome these perceived barriers may help individuals to experience success with behaviour change. Presence of a spouse or family member, provision of gait aids to reduce fear of falls, and recommendation by a healthcare provider to reduce sedentary behaviour may encourage people with stroke to engage in, and maintain behaviour change. Things that motivate individuals to achieve behaviour change are considered as facilitators.

2.10.1.5 Goal setting: Setting achievable goals is an important incentive to behaviour change.[186] It is important to differentiate distal from proximal goals. Distal goals are long-term goals that are the overall target of the behaviour change program.[173] For example, the distal goal for a sedentary behaviour change program might be to reduce sedentary behaviour by 2 hours after an 8-week program. Proximal goals (i.e. short-term goals) help people to succeed through development of concrete action plans that are achievable, considering the personal factors and environmental situations. A feasible proximal goal might include, standing up and walking around for 2 to 3 minutes every hour, and gradually increasing that to 5 minutes every half-hour.

2.10.1.6 Self-regulation: Self-regulation has also been shown to mediate the relationship between self-efficacy and physical activity.[187] Health behaviours are not just changed by thinking about it, but require self-regulatory skills.[173] Self-regulation refers to an individual's ability to set specific and achievable goals, and includes using effective strategies (such as cues-to-action and social support) to attain the goals.[173] Self-regulation can be achieved through goal setting, self-monitoring, using cues to action and self-rewards.[176] Self-regulation is fundamental to the success of health promotion interventions. Incorporating tools like activity trackers (such as Fitbit devices) may help people with stroke to monitor their activities and be successful and this may also enhance self-efficacy as a facilitator.

In summary, social cognitive theory provides a framework that supports people with stroke to reduce sedentary behaviour. One of the first steps in any novel intervention aimed at behaviour change is to conduct a needs assessment, often done through qualitative research.

Qualitative studies are useful for exploring information about knowledge, beliefs, facilitators and barriers to changing behaviour.

2.11 Theoretical framework for qualitative study

It will be helpful to briefly describe the qualitative paradigm for needs assessment, which is useful in assessing the perspectives of people with stroke about sedentary behaviour. Adopting a particular framework sets the stage for qualitative research; it helps to create boundaries and guides the researcher in the choice of methods and analysis.[188] For example, the interpretive paradigm is based on the premise that the social world is complex and people give meaning to a phenomenon in many different ways.[189] The different accounts from exploring the perspectives of people with stroke about sedentary behaviour and the ways it can be changed informed the development of the sedentary behaviour change intervention. The qualitative research process was guided by Braun & Clarke's thematic analysis.[190] Thematic analysis provides a systematic, and robust framework for analysis of qualitative data and helps in identifying themes (i.e. patterns) across the data.[190] This approach is often reflective and thorough. A theme represents an important construct that is derived from the qualitative data in relation to the research question.[191] With thematic analysis, the approach used can either be inductive (bottom up) or deductive (top down). Inductive analysis is data-driven, and attempts not to map the data unto a pre-existing frame or the research questions.[191] But allows the data to "speak" in deriving the themes. Deductive analysis on the other hand involves mapping the themes unto some specific research questions and is influenced by the researcher's theoretical stance.[191]

CHAPTER 3

REDUCING SEDENTARY BEHAVIOUR AFTER STROKE: PERSPECTIVES OF AMBULATORY INDIVIDUALS WITH STROKE

Abstract

Purpose: Understanding the determinants of sedentary behaviour (sitting or lying with low energy expenditure) in stroke survivors can enhance the development of successful behaviour change strategies. This qualitative study explored the perceptions of stroke survivors about sedentary behaviour and ways in which it can be changed.

Methods: An interpretative qualitative inquiry was used with thematic analysis of interview data. Interviews were conducted using a semi-structured guide with 13 stroke survivors. Interview transcripts were analysed using thematic analysis. Self-reported sedentary time was assessed during interviews.

Results: Four main themes emerged from the data: meaning of sedentary behaviour, reasons for sedentary behaviour, barriers and facilitators to reducing sedentary behaviour, and strategies to sit less and move more. Only 6 participants knew about sedentary behaviour, and 2 were aware of the associated health risks. Participants encountered barriers in their daily lives that affect engagement in activity including motor impairments, fatigue, cognitive problems, and lack of motivation. Using wearable technologies and action planning to reduce sedentary behaviour hold promise as behaviour change strategies.

Conclusions: There is limited awareness of health risks of sedentary behaviour among stroke survivors. Strategies involving self-monitoring and movement throughout the day are potential ways to reduce sedentary behaviour.

Ezeugwu VE, Garga N, Manns PJ. Reducing sedentary behaviour after stroke: perspectives of ambulatory individuals with stroke. *Disabil Rehabil*. 2017;39:2551-2558

3.1 Introduction

On a global scale, mortality rates from stroke are high. An estimated 5.7 million deaths were caused by stroke in 2005 and, if interventions are not instituted, this number is projected to rise to 7.8 million in 2030.[3] Recurrence after a primary stroke is high, such that about a third of stroke survivors may have another stroke within 5 years.[7] Improving daily activity behaviour is an important goal for stroke survivors and provide benefits in the secondary prevention of stroke.[20] The best practice guideline for promotion of activity in stroke survivors recommends attaining a threshold of 30 minutes per day of moderate-intensity physical activity.[67] That intensity of activity might be difficult to achieve for stroke survivors who often have difficulty with walking. It is not surprising that stroke survivors are among the least active of all people with chronic conditions.[25] Besides being insufficiently active, stroke survivors spend over 80% of their day in sedentary behaviours compared with 50-60% in healthy adults.[19, 24, 31, 192] Sedentary behaviour is defined as "any waking activity characterized by energy expenditure ≤1.5 metabolic equivalents while in a sitting or reclining posture,"[32] sitting quietly is equivalent to 1 metabolic equivalent. The short and long-term consequences of sedentary behaviour on health and well-being include cardiometabolic diseases,[52, 82] vascular problems,[152] depression,[193] and premature mortality.[145] There is a 1% increase in cardiovascular disease risk for every increase of 25 to 30 minutes in sedentary behaviour per day among older adults.[149]

Sedentary behaviour typically displaces time that could be spent in healthier light-intensity activities (i.e. activities of daily living done in standing or walking) that can make up a large portion of an individual's daily activities.[47] Research suggests that light-intensity activities may provide a sufficient stimulus to reduce risks associated with stroke (such as improved blood lipid levels and glucose metabolism).[53] There is evidence that breaking up sedentary time with light activity is beneficially associated with health indicators, such as waist circumference, triglyceride levels, and 2-hour post-load plasma glucose, independent of total sedentary time and moderate-to-vigorous physical activity levels.[47, 83, 103] Using data from a nationally representative sample of Canadian adults in the 1981 Canada Fitness Survey, Katzmarzyk reported that individuals who stood most of the day had a 33% lower risk of all-cause mortality compared to those who reported standing almost none of the time (i.e. most sedentary group).[81]

Behaviour change strategies are typically geared towards populations at the greatest risk of an exposure,[194] providing a strong argument for testing a sedentary behaviour intervention with stroke survivors. However, the ways in which to modify sedentary behaviour are largely unknown in this population. Strategies and messages related to interventions in stroke survivors may be different than those that presently exist. For example, workplace interventions aimed at reducing sedentary behaviour have shown promise demonstrating beneficial associations with health outcomes.[161, 162] With most stroke survivors likely requiring intervention in a home environment, it is not known if the successes reported in the workplace would also apply to the home setting. A recent review reported that self-monitoring and environmental (social or physical) restructuring were among strategies that show promise in reducing sedentary behaviour among healthy adults.[157] Only one intervention study aimed at reducing sedentary behaviour among stroke survivors has been reported in the literature.[36] That study showed that it is safe and feasible to reduce sedentary behaviour in stroke survivors, however the intervention participants did not show superior outcomes compared to controls. To improve the outcomes, there is a critical need to qualitatively explore the perspectives of stroke survivors about sedentary behaviour with an aim to reduce these behaviours.

The purpose of this study was to investigate perceptions of ambulatory stroke survivors about sedentary behaviour including: 1) their understanding of the concept of sedentary behaviour, 2) their perspectives on the barriers and facilitators to reducing sedentary behaviour, and 3) their perspectives on ways that sedentary behaviour might be changed within their day-to-day lives.

3.2 Methods

3.2.1 Study design

This study is the first part of a larger project that looks at the feasibility of a theory-based intervention to reduce sedentary behaviour among stroke survivors. Semi-structured interviews were used to assess the participants' perceptions about sedentary behaviour and how it can be changed in their daily lives. The interview data were analysed using thematic analysis.[190, 191]

3.2.2 Participants

We purposively recruited a sample of people with self-reported history of stroke, aged at least 18 years, able to stand and walk at least 5 metres with or without gait aid, and with capacity to give informed consent. Those with aphasia that would make engagement in an interview difficult were excluded. Participants included those in active rehabilitation at a specialized rehabilitation outpatient program (n=4), engaged in community-based programs (n=2), and members of a stroke support group (n=7).

3.2.3 Procedure

Ethical approval for the study was granted by the institutional Health Research Ethics Board, and intent to conduct research was approved by the health authority in the region.

Recruitment posters were mounted at the stroke outpatient unit of a rehabilitation hospital and also via email to mailing list of members of a stroke support group. One physiotherapist working in the rehabilitation hospital identified participants eligible to participate in the study. Interested participants were individually contacted to set up time for the interview. Depending on the preference of the participants, interviews were conducted at the hospital or in the community. At the interview, study procedures were reviewed with each participant and a consent form signed. After consent was obtained, an audio recorder was turned on and the interview began. The interviews lasted for an average of 40 minutes. The interviewer used a semi-structured interview guide (Table 3.1) to direct the discussion. While the guide provided the main structure for the interviews, if a relevant topic arose, the discussion continued until an appropriate time to return to the questions on the semi-structured interview guide.

Table 3.1. Interview Guide

- Have you heard of the term sedentary behaviour or sitting behaviour?
- When you hear sedentary behaviour, what does it mean to you?
- Tell me how you spend your day?
- Why will you choose to sit instead of stand or walk?
- Looking back at your day, in what ways can you make changes to sit less?
- What are the things that might prevent you from making changes to your sitting time?
- In your opinion, what do you think will help you or encourage you to make changes?
- What supports do you think you will need to help you to sit less and move more?

As part of the interview, the Sedentary Behaviour Questionnaire[115] was administered to quantify self-reported time spent sitting in different domains on a typical weekday and weekend. The behaviours assessed by the Sedentary Behaviour Questionnaire include watching television (TV), playing computer or video games, listening to music, doing paperwork or computer work, reading, using the phone, playing musical instrument, doing crafts, and travelling.[115] Although the Sedentary Behaviour Questionnaire has not been validated in stroke survivors, it has moderate to excellent reliability in older adults.[115] Participants' walking abilities were classified into categories using Functional Ambulation Classification.[195]

3.2.4 Data analysis

All interviews were transcribed verbatim and identifying information removed. We followed the process of thematic analysis including reading and rereading of transcripts, initial noting of the transcript, developing emergent themes from initial notes, searching for connections across emerging themes by organising themes in relation to one another, and looking for patterns across all cases.[191] Two researchers (VE, TM) separately read all transcripts and identified units of information from the data.[196] Subsequently, the researchers met to discuss and agree upon themes arising from the data. Any disagreements were resolved by consensus. The third researcher (NG) did a critical reading of the manuscript and provided further interpretation from the perspective of a clinician involved in stroke rehabilitation. Total daily sedentary time was calculated from the Sedentary Behaviour Questionnaire.

3.3 Results

Thirteen stroke survivors (seven males and six females) were interviewed. Participants' characteristics are summarized in Table 3.2.

Table 3.2. Participants' demographics and self-reported daily sedentary time

Participants	Sex	Age (year)	Time since stroke	Type of stroke	Hemiparetic side	FAC[a] level	Sedentary behaviour (h/day)[b]
1	M	51	12 years	Haemorrhagic	Right	4	5
2	F	27	6 years	Ischaemic	Left	4	6.5
3	M	58	4 months	Ischaemic	Right	3	10
4	F	26	3 months	Undetermined	Right	4	7.5
5	M	54	11 months	Ischaemic	Right	3	6
6	F	43	2 years	Ischaemic	Left	4	8
7	F	45	12 years	Haemorrhagic	Right	4	11
8	F	49	10 years	Ischaemic	Left	4	5.5
9	M	64	3 years	Ischaemic	Right	5	10.5
10	M	70	6 months	Ischaemic	Right	3	12.5
11	F	58	10 years	Ischaemic	Right	4	9
12	M	74	16 months	Ischaemic	Left	4	7
13	M	75	14 months	Ischaemic	Right	4	11

[a]Functional Ambulation Classification[195]
3, Ambulator-dependent for supervision; 4, Ambulator-Independent Level Surfaces Only; 5, Ambulator-Independent
[b]Total self-reported daily sedentary time from the Sedentary Behaviour Questionnaire

Mean (SD) age of the participants was 53.38 (15.74) years. Eleven of the participants were aged between 43 and 75 years, and two participants were much younger at ages 26 and 27 years. Time since stroke ranged from 3 months to 12 years, while self-reported daily sedentary time (i.e. excluding sleep time) ranged from 5 to 12.5 hours. Sedentary time did not differ by gender or age of the participants. Nine participants had hemiparesis affecting their right side. All participants were able to walk independently with little or no supervision, Functional Ambulation Classification 3 to 5 (see Table 3.2). Only two of the participants had returned to full time work. Eight had not returned to their usual work after the stroke, and three were already retired at the onset of stroke. Seven participants were married or living with a common-law partner at home.

Four main themes were developed from data analysis: (i) meaning of sedentary behaviour, (ii) reasons for sitting/lying down, (iii) barriers and facilitators to reducing sedentary behaviour, and (iv) strategies to sit less and move more.

3.3.1 Theme 1. Meaning of sedentary behaviour

About half of the participants (n=6) acknowledged that they knew about sedentary behaviour. For example, one participant defined it as:

> "…Watching TV, sitting on the couch watching TV, I guess video games, for my husband, he sits to play video games sometimes…" (Participant 2, female).

Eight of the 13 participants (61.5%) associated sedentary behaviour with sitting and watching TV. Some said that sitting too much was linked to negative physical and emotional health outcomes such as diabetes or depression:

> "My dad got diabetes, he is diabetic, and he sits a lot..." (Participant 1, male).

> "It means sitting and watching TV, or lying down in bed… I think you could get fat, and if you have a stroke, and you are paralyzed, you get more atrophy in your body, and you become weaker. And for me I get depressed, more depressed. Because then you have time to think about everything, then you get depressed." (Participant 8, female).

Only one participant thought that lying down was a healthier alternative to sitting. He also showed surprise when told that lying down during non-sleeping hours was considered sedentary behaviour:

> "…I lie down in my sofa more. I think it is healthier than sitting down." (Participant 12, male).

Despite half of our participants being aware of sedentary behaviour, participants did engage in sedentary behaviour and were able to detail the reasons for these behaviours.

3.3.2 Theme 2: Reasons for sitting or lying down

Activities done in sitting were centered around watching TV, meal times, travelling, social/religious functions, use of technology (computer, phones), crafts, reading, playing games, or just simply lying down and meditating. The reasons for engaging in sedentary behaviours were similar across participants.

The majority of the participants indicated that the main reason they sit down is for relaxation or comfort. Others saw the period after discharge from the hospital as a time to just sit down and recuperate. Sedentary behaviour was perceived as normal and important after stroke. It was viewed by many participants as a way to relax and unwind.

"…Not too much activity, because my mind wasn't working properly… so, I wasn't thinking straight. You can get comfortable sitting in a freaking chair, you know…and watch a movie or something like that…" (Participant 1, male).

"…whether you are a survivor of stroke or just a normal human being who hasn't experienced any kind of medical calamity, you sit because sitting is comfortable and it is relaxing…I would say I do have sedentary behaviour absolutely, because that's how I unwind…" (Participant 2, female).

Participants also perceived that a major determinant of sedentary behaviour in the early period after stroke is the "head game." One participant reported that: "one is in a mental state when you are coming out of the hospital that you just want to sit there. So it is overcoming that and starting to get back into the swing of life, I guess you call it" (Participant 10, male). The perception was that as stroke survivors leave the hospital, their mindset is to get home and rest. This is similar to the idea of going home to recuperate that was reported earlier. This participant stated that it is crucial to overcome that mindset and get back to one's feet. He further said that following some example or having someone to intervene might help to redirect a person's thought in this early period after stroke.

The age at which stroke occurred also affected the participants' goals for activity and recovery. Younger participants perceived that their sedentary behaviour was only temporary as a result of their inability to return to work and the absence of their usual work routine. For example, one participant explained:

> "… Well, for one, I am at home all day, every day. Like I can't work right now. I can't take the bus by myself. So I am at home…I do have to sit down a lot throughout the day." (Participant 4, female).

Having so much time in their hands, several participants sat down to watch TV:

> "…after the stroke, I took about a year before I could do anything… I have never watched so much TV in my life." (Participant 9, male).

> "I spend about 4-5 hours watching TV daily…After breakfast, I lie down and watch TV, sometimes have a nap. Then after supper I don't do much. I sit down and watch TV pretty late until around 10 o'clock or something." (Participant 12, male).

One participant who returned to work indicated that sitting in the vehicle took up to three hours for a round trip to work or appointments. In addition, occupational sitting was reported as one reason for sitting:

> "I sit down in the vehicle for 3 hours per day travelling to and from work….I work Saturdays as well. But that is a sitting job too." (Participant 6, female).

While some participants had sedentary employment, others also sat down to play games for leisure:

> "After lunch, I usually go on the computer, which is sitting again…I play games on the computer for probably about 3 hours." (Participant 11, female).

> "I belong to the legion and we play cards on Thursdays. You are sitting down probably for a total of about 4 hours…If I am not playing cards then I watch TV at night" (Participant 13, male).

Overall, the reasons for sitting were related to comfort, watching television, unable to get back to work, sedentary occupation, or playing games. Participants further discussed factors that make it difficult to sit less (barriers) and things that might make it easier for them to sit less and move more (facilitators).

3.3.3 Theme 3: Barriers and facilitators to reducing sedentary behaviour

The participants found the cognitive and physical sequelae of stroke as barriers to reducing sedentary time. Difficulties with remembering things were suggested as factors that might increase engagement in sedentary pursuits:

> “Because we forget…I get engrossed in watching TV or something.” (Participant 8, female).
>
> “That’s another thing that affects my activity. My memory is not as good.” (Participant 9, male).

Motor impairments, difficulty with walking fast, fatigue and other physical complaints were important factors that affected daily activity levels and encouraged sedentary behaviours. Participants reported that it was hard to do things that they were doing before.

> “I don’t exercise like you would exercise - someone that has got four good working limbs…” (Participant 1, male).
>
> “My main impediment to reducing sitting time is the fact that I have a limp as a result of my stroke and my limp gets worse the faster I walk…Also I had been a swimmer before my stroke, I really enjoyed swimming as a form of physical activity and I was quite good at it, and because I was so significantly affected on my left side I was not sure I will be able to swim again.” (Participant 2, female).

> "Ahh…at the beginning it was hard, because I couldn't move, I couldn't move my leg and I couldn't do certain things. But now it is becoming easier." (Participant 4, female).

There were several reports of fatigue after stroke limiting the ability of participants to engage in activities. In some instances, participants expressed that they experienced a lot of fatigue that prevented them from going out.

> "…You know, we really want to do all these things that you guys are saying, but we struggle so badly with the fatigue. I have such huge fatigue and I still struggle so much." (Participant 6, female).

> "Oh yea. I don't go out much on a daily basis…Because I still get tired. Sometimes, I get really to the point that I can't function." (Participant 9, male).

Another barrier to reducing sedentary behaviour was uncertainty about the prospects for recovery. For example, participants expressed that the period after stroke could be quite challenging and might even lead to depression. The motivation to engage in activities appears to be severely hampered in the early period after stroke. Overcoming that initial period of depression is essential to reducing sedentary behaviour and increasing activity levels after stroke.

> "The stroke patient is tired and demoralized…I used the term the other day and I was trying to express this to my wife. I can't see the future. There is an interruption in my career, there is an interruption in my full earning potential, there is all kinds of changes, and there is "unknowns" like my ability, the extent of my recovery, the speed of my recovery, the quality of my recovery, so all of those things are "unknowns" placed in front of me and there are so many of them that my future is obscured. I cannot see

through that. And so sometime, when I get too deep on the dark side, I just go, 'why I am even trying'…" (Participant 3, male).

As expected of participants living in a cold climate, participants reported that they sat more during winter months. However, many said they get more engaged in activities such as walking and gardening when the weather gets nice. As one participant explained:

> "Initially I used to walk all the time and then winter came and I couldn't walk any longer. But I was walking about a mile a day… This winter time has been hardly anything. The sitting down part has been quite a bit." (Participant 13, male).

Many participants perceived that a sedentary behaviour intervention will be particularly beneficial during the winter time when outdoor activities are severely limited.

Support from family, friends or healthcare providers were perceived as both barrier and facilitator to reducing sedentary behaviour. Some participants reported that lack of support from "significant others" helped them to become more independent with activities of daily living and facilitated sitting less.

> "…It has been a battle, and for all stroke patients, it is a battle…and having support at home, I didn't have that. In fact my husband divorced me… And you know, I think that maybe he did me a favour by just ignoring and not wanting to help me, because I am very independent… Yea, because I had to do it, so I did it." (Participant 8, female).

Although being unsupported by family or friends facilitated reducing sedentary behaviour in some individuals, others reported that being alone encouraged sedentary behaviours unless one had a strong drive to break sedentary habits.

> "You know one more thing, I am by myself which makes a hell of a difference. If you are living with a person, they kind of push you a little bit. Living alone is somewhat tough, because there is no motivation, unless you have it…" (Participant 10, male).

Starting therapy early and receiving support from healthcare professionals was seen by some participants as a good foundation for sitting less and moving more. However, some participants said that they were eager to return to pre-stroke activities, but in some cases, physical therapists and other health care providers recommended a slower return to pre-stroke activities.

> "I spent a month at the rehabilitation hospital… you take all of the therapy disciplines, it really sets a solid foundation for getting active when you leave…" (Participant 2, female).

> "After the stroke, I found that I was sleeping a lot. And they told me it was part of the recovery, you know. Take a rest, they said… I wanted to drive, I wanted to work, I was not allowed…" (Participant 9, male).

As evident in previous comments, some stroke patients were keen to return to 'normal' life. Therefore, the individual's motivation and determination facilitated sitting less and moving more. Participants learned to engage in tasks that they could experience success at, which enhanced their self-efficacy:

> "…It just took determination and I chose to do the activities that I would experience success at… And because I experienced success, it was easy to stick to them." (Participant 2, female).

For participants who were very active prior to their stroke, getting back to moving more was an even more important goal:

> "And because I was very active before my stroke, I used to do a lot of running, like long distance running, and races, so when I had my stroke and I couldn't walk, I almost died… And then you try new things, like the cycling and I did a lot of swimming here…" (Participant 7, female).

The barriers to reducing sedentary behaviour reported by participants were related to the effects of stroke, depression, inclement weather, and lack of support from family and friends. Facilitators to sitting less and moving more were perceived as early therapy and support, personal motivation and confidence, and pre-stroke activity level. Participants discussed ways to sit less and move more.

3.3.4 Theme 4: Strategies to sit less and move more

All participants, except one (Participant 4, female) were positive about sitting less and moving more and offered suggestions on how to reduce sedentary behaviour. Participant 4 explained that she was not willing to interrupt her sitting time as it ruins her enjoyment: "If I am watching television or a movie, I will like to watch it to the end, if I get up to move around…em… that ruins the movie" (participant 4, female).

Some participants discussed about using the simple strategy of standing while making or receiving calls as a way to interrupt sitting time.

> "Yea, stand, definitely stand while you are talking with somebody on the phone, don't be sitting. I stand 99% of the time while using the phone" (Participant 1, male).

Another strategy that reduced sitting time was to stand up at every commercial break on television.

> “I stand up during TV advert breaks…so why would you be sitting? I hate the commercials in the first place…” (Participant 1, male).

> “I go over to the kitchen during commercial breaks on the television to either wash something or put something away” (Participant 13, male).

Use of activity monitors as tools for keeping track of daily sedentary and activity behaviours was discussed by participants as strategies that might help them to be aware of how much they were sitting or engaged in activities and can be a great source of motivation:

> “… Actually, before the stroke I wore a recording device to monitor my level of activity and my sleeping time…I chart my hours on the treadmill, so I can gauge if there is an improvement….I can do the same to reduce sitting. I was thinking of connecting my TV to the treadmill, so if I am not walking on the treadmill, I cannot watch TV” (Participant 3, male).

Some participants also suggested wearing a headphone that is wirelessly connected to the TV so that they don’t have to sit in front of the TV all the time.

> “I use a wireless headset for my TV and anywhere in my apartment, I can hear it. So I don’t have to be in front of the TV all the time. I can get up and move to the kitchenette, and I can watch TV from there if I want” (Participant 10, male).

Others showed willingness to use novel activity monitors that have the capacity to serve as cues to action by vibrating as a reminder when one is sitting for a long time.

> “I love the activity monitors that have a vibrating alert to remind you to stand up and move” (Participant 3, male).

> “I will be happy to get a device that monitors my sitting time and will remind me to get up. I will sign up for that pretty soon…” (Participant 8, female).

Participants discussed that planning to regularly interrupt sedentary habits and move more was something they could possibly do. The perception was that only activities that lasted at least 10 minutes were beneficial to health and thus activities less than 10 minutes were considered less necessary. For example, one participant explained:

> “I had thought that it is only when I walk or exercise for 10 minutes or more that I get benefits…I can stand up every half-hour and walk around for 3-5 minutes, that I can do very well” (Participant 10, male).

This participant further explained that there was up to 4 minutes between sets of his favorite shows and he can make a conscious effort to stand up and walk around during the commercials to reduce sitting time.

Participants dealt with increasing activity in different ways. Some were involved in household tasks which involved standing:

> “I came up with an idea for getting little exercise… there are some activities that I do around the house. Like some sweeping and housework while standing.” (Participant 10, male).

> “I spend about an hour to make my supper while standing and spend about 30 minutes to eat sitting down. I wash the dishes too for 15 minutes standing up.” (Participant 12, male).

Participants' perspectives on how to reduce sedentary behaviour were related to standing while using the phone, standing during television commercial breaks, use of wearable technology, planning to regularly stand up and move around, and doing house-hold chores in standing.

3.4 Discussion

This is the first study to capture the views of people who have survived a stroke on the meaning of sedentary behaviour, reasons for sitting/lying, barriers and facilitators to reducing sedentary behaviour, and strategies to change sedentary habits. The findings from this study provide important insights that will be helpful in designing interventions to reduce sedentary behaviour in stroke survivors. About half of the participants had heard of sedentary behaviour, but only 2 knew of the health risks associated with too much sitting. Knowing the risks and benefits associated with a behaviour is an important first step in health promotion. If stroke survivors do not know how sedentary behaviour affects their health, they have little or no motivation to change the detrimental habits that they enjoy or to engage more in activity. However, it is not enough to know about the hazards of sedentary behaviour or the benefits of activity,[175] there are other factors that influence change in behaviour including belief in ones capability to effect a noticeable change in health or self-efficacy.[173] One participant perceived that sitting less and moving more contributed to her ability to engage more in purposeful and satisfying daily activities.

The design and success of intervention programs for reducing sedentary behaviour and increasing activity in stroke survivors depend, in part, on the identification of factors that encourage them to engage in these sedentary pursuits. Apart from sedentary behaviours that involved sitting in a vehicle during travelling, inability to return to work and physical effects of stroke including motor deficits, some of the reasons given for sedentary behaviours or barriers to reducing it are potentially modifiable. The common modifiable reasons for sitting reported in this study were comfort, "head game" to sit down and recover, playing games, watching television, and work policies. The psychosocial factors (difficulty with remembering and depression) and inclement weather are relative barriers that can be overcome through social support and development of a sedentary behaviour intervention suitable to the home environment. If sedentary behaviour interventions are not instituted, the gains made during stroke rehabilitation in organized hospital care in the period immediately following stroke may be lost as stroke survivors spend a lot of time engaging in sedentary behaviours at home. Some of the barriers, such as support and inclement weather are similar to previously reported barriers to increasing physical activity after stroke.[170]

Participants in this study engaged in common behaviours similar to those reported in the general population including napping, watching TV, sitting at the computer, performing seated activities for work or social gatherings, talking on the phone, and seated transport.[107, 115] A previous qualitative investigation with older women found that they viewed sitting as important in their daily lives.[197] The authors reported that watching TV and playing games were common sedentary tasks that older women loved to do. The reasons for sitting among older women were related to pain, fatigue, pleasure and relaxation which were similar to our findings. Peer and societal pressure were considered as strong determinants of sedentary behaviour in older women. In the present study, stroke survivors similarly perceived sedentary habits as normal and necessary. Participants viewed sedentary behaviour as a means of relaxing and unwinding. There were contrasting responses on the influence of family members or significant others. Some reported beneficial effects of having someone to encourage them to reduce sitting time, but others did not. The mindset of the individual, especially in the early post-stroke period, is a factor that might lead to more sitting. During this early period most participants prefer to sit at home and recover. This might be a critical period to intervene to reduce sedentary behaviour.

Only one feasibility intervention study aimed at reducing sedentary behaviour has been conducted with stroke survivors.[36] Although that study showed that all participants (both intervention and control groups) achieved reductions in sedentary time, the failure of the intervention group to achieve superior effects might be related to the content and delivery of the intervention. Motivational interviewing (a talk-based approach to improve motivation) was employed in the study and participants were seen face-to-face initially followed by 3 telephone counselling sessions. The problem with this mode of intervention is that it is difficult to monitor adherence to the program. In addition, the authors reported that participants did not receive any real-time feedback from the activity monitors that they wore which ordinarily should have provided some incentive to sit less and move more. In the present study, participants expressed that remembering to do tasks can sometimes be challenging for stroke survivors. Providing participants with self-monitoring tools that will give real-time feedback and cues to action such as vibrating alerts or reminders might be helpful. Furthermore, motivational interviewing focuses mainly on a person's motivation to change, interpersonal factors including presence of family and friends as well as professional support for stroke survivors might be beneficial in reducing sedentary behaviour.

Emerging evidence in other populations (including people with disabilities) provide support that it is possible to reduce sedentary behaviour with associated health benefits.[40, 138, 158, 164] There is evidence from recent systematic reviews that interventions focused on reducing sedentary behaviour results in reduction of sedentary time and the intervention effects are evident even up to 12 months.[50, 51] Previous studies have reported successful sedentary behaviour reduction strategies with older adults, such as standing up while using the phone,[138] and planning regular interruptions to sitting.[103] In the present study, some participants had thought that only activities that were done in bouts of at least 10 minutes resulted in health benefits. The perception was that if activities cannot be sustained, they were needless and participants would sit instead. This is a misconception that should be addressed with patients early on. Regularly interrupting sedentary behaviour has been found to be particularly beneficial in those who are inactive (which many stroke survivors will be).[198] Ways of interrupting prolonged sitting, such as standing up during TV commercials had been previously suggested as a potential strategy to reduce sitting among older adults.[158] Some participants in the present study were already using this approach to reduce and interrupt their sitting time.

The use of technology in a positive way to reduce sitting time is an area of ongoing research. A recently published paper showed significant beneficial effects with the use of an activity monitor as an interventional tool in reducing sedentary behaviour among healthy adults.[159] Some participants in the current study were using activity trackers for monitoring their activity behaviour, even prior to their stroke. The advantage of using monitors to track activity behaviour is that it provides feedback and motivation to do more. Activities in people with impaired mobility are mostly performed as part of activities of daily living (e.g. standing up from a chair, getting into and out of a car, walking to and from the washroom).[121] Such individuals require support to engage in more activity while reducing sitting. Some activity monitors provide cues to action such as visual displays, progress towards daily goal, and vibrations which are incentives to sit less and move more.

Three studies with adults in the home environment have reported positive changes in sedentary behaviour following interventions. Using a personal activity monitor as an intervention tool to motivate healthy adults to reduce sedentary behaviour and increase activity, Barwis et al. reported a significant reduction in sedentary behaviour of 33% (3.1 hours/day) from baseline (9.4 hours) to the end of a 4-week intervention (6.3 hours).[159] Kozey-Keadle and colleagues[160] also reported reduction in sedentary time of 4.8% compared to controls whose sedentary time increased by 4.4%. Another study with older adults employed individualized consultations and feedback from activPAL activity monitor output and reported a reduction in sedentary time of 24 minutes per day (2.2%) and increase in total time spent stepping by 13 min/day over a 2-week period.[138] That study used behavioural change techniques based on ecological model to influence change in sedentary behaviour. Overall, use of wearable technologies might play a significant role in sedentary behaviour change for stroke survivors.

3.5 Strengths and limitations

The strengths of this paper include: 1) this is the first study to explore the knowledge and perspectives of ambulatory stroke survivors about sedentary behaviour and how it might be changed; 2) reducing sedentary behaviour is an emerging research area in stroke survivors and this paper provides important insights that will aid intervention development; 3) using qualitative research to help develop intervention programs is helpful for enhancing patients' compliance and effectiveness of such interventions. Overall, this study offers important insights into how ambulatory stroke survivors can be encouraged to reduce sedentary behaviour.

The limitations of this study were: 1) the thirteen participants were ambulatory, as such our results are only applicable to stroke survivors who are able to stand and take steps; 2) the Sedentary Behaviour Questionnaire used to estimate self-reported sitting time has not been validated in stroke survivors, however it has been used in studies with older adults with good reliability and complemented questions in the semi-structured interview guide related to how participants spend their day; 3) although the self-reported sedentary time did not differ by age of participants or gender, self-report has limitations and the activity goals for younger participants appeared to differ from those of older individuals.

3.6 Conclusion

Sedentary behaviour is prevalent in stroke survivors. Only about half of the participants in this study demonstrated that they were aware of what sedentary behaviour was, and 2 were aware of the health risks associated with it. Misperceptions do exist, as one participant perceived lying (an extreme form of sedentary behaviour) as a healthier alternative to sitting. Participants encountered barriers including physical and psychosocial deficits following stroke. Sedentary behaviour intervention strategies involving movement throughout the whole day, such as standing up every half-hour and doing house-hold tasks in standing are ways to reduce sedentary behaviour acceptable to stroke survivors. Moreover, the immediate post-hospital period appears to be a critical time to intervene to reduce sedentary behaviour, since the mindset of some stroke survivors when leaving the hospital is to go home, rest and recuperate. In designing interventions to reduce sedentary behaviour, using effective cues to action including wearable activity monitors that provide real-time feedback and reminders to stand up and move around frequently might be beneficial.

CHAPTER 4

USING INTERVENTION MAPPING TO DESIGN AND DEVELOP A HOME-BASED SEDENTARY BEHAVIOUR CHANGE INTERVENTION AFTER STROKE: STAND UP FREQUENTLY FROM STROKE (STUFFS)

Abstract

Background: Prolonged sedentary behaviour is a problem immediately following a stroke and it persists from the acute to the chronic phases of recovery. Unfortunately, many people with stroke do not recognize the need to interrupt or reduce prolonged sedentary behaviour and mitigate the associated detrimental health consequences. However, the process of changing behaviour is often complex and multi-faceted, and requires a rational, systematic, and rigorous approach to development of effective interventions.

Objective: To describe the process followed in the systematic design and development of a theory- and home-based sedentary behaviour change intervention for people with stroke.

Methods: The Intervention Mapping protocol was used to design, develop and describe a **ST**and **U**p **F**requently **F**rom **S**troke (***STUFFS***) intervention aimed at reducing prolonged sedentary behaviour after stroke. The intervention was informed by evidence from the literature and a qualitative study with people with stroke.

Results: The *STUFFS* program is an 8-week intervention that incorporates four main components: assessment of usual sedentary and activity behaviours, increase knowledge and awareness of risks of prolonged sedentary behaviour, strategies for behaviour change, and the use of motivational tools to empower people with stroke to reduce sedentary behaviour.

Conclusions: This paper provides information that furthers our knowledge on theory-based strategies to reduce sedentary behaviour in the home environment after stroke and facilitates implementation of this type of intervention.

4.1 Introduction

The majority of people with stroke have low levels of physical activity,[49] and sedentary behaviour, defined as “any waking behaviour characterized by energy expenditure ≤1.5 metabolic equivalents (METs) while in a sitting, reclining, or lying posture,” [32, 33] is highly prevalent.[19, 49] For example, during the acute phase of stroke, individuals spend an average of 94% of the day in sedentary behaviours.[34] A longitudinal study reported that people with stroke spend 83% of 24-hour monitored period in sedentary behaviour in the first month after stroke and this did not change at 6 and 12 months follow-up.[19] More importantly, the gains made during rehabilitation may be lost to a substantial degree after discharge from the hospital to the community.[199] Low activity levels and high sedentary behaviour have negative health consequences, such as increased risk of cardiometabolic diseases and possible stroke recurrence.[46, 96] In addition to the total volume of sedentary time per day, the pattern of accumulation of sedentary behaviour is important, such that frequent interruptions in sedentary behaviour is associated with beneficial cardiometabolic profile.[103, 109] The physical activity and exercise recommendations for people with stroke included, for the first time in 2014, the reduction of sedentary behaviour as part of the statement for healthcare professionals.[30]

Behaviour change is a complex process and for interventions that target behaviour change to be successful, the design and development of the intervention requires a systematic and rigorous process which should be based on a strong theoretical foundation.[173] One of the universally accepted and widely adopted theoretical frameworks for activity behaviour change among the healthy and patient populations is social cognitive theory.[174, 200] Self-efficacy is the active ingredient in social cognitive theory, and through self-monitoring which serves as a facilitator, self-efficacy can be enhanced for behaviour change.[173] Gardner and colleagues[157] in a review of the behaviour change strategies used in interventions that targeted reducing sedentary behaviour among adults reported some promising strategies that were found to be effective in reducing sedentary behaviour.[157] The quite promising or very promising interventions were those that included education, skills training, persuasion, environmental restructuring, problem solving, goal setting, social support, behaviour substitution, feedback on behaviour, and self-monitoring.[157] The use of wearable technology with good self-monitoring attributes (e.g. Fitbit, Fitbit Inc, San Francisco, CA) as facilitators and cues-to-action in reducing sedentary behaviour and increasing activity is becoming popular.[201]

To date, only one sedentary behaviour change intervention study has been conducted with people with stroke.[36] Although intervention participants did not show superior outcomes relative to controls, findings from that study showed that it was safe and feasible to reduce sedentary behaviour in people with stroke. In order to advance research in this area, and in line with recent recommendations for intervention development, monitoring and reporting of stroke trials,[57, 202] we developed ***STUFFS*** (**ST**and **U**p **F**requently **F**rom **S**troke). The *STUFFS* program is aimed at interrupting and reducing prolonged sedentary behaviour after stroke by increasing the frequency of standing and taking steps throughout waking hours. Increasing task repetition in the early period after stroke aligns with the principles that drive plasticity after brain damage.[203] *STUFFS* program was designed to incorporate self-monitoring using consumer-based wearable technology that provide real-time feedback for the user as a source of motivation to sit less and move more.

Without adequately describing the intervention, it is difficult for end-users to implement the behaviour change intervention in clinical practice and it limits the potential for researchers to replicate the study. Further, to adequately develop and describe the intervention, it is important to follow existing frameworks that provide guidance on designing, developing, and reporting of complex health promotion interventions. Such frameworks include Intervention Mapping[204] and

TIDieR (Template for Intervention Description and Replication).[205] The current paper describes the systematic and translatable process followed in the design and development of the *STUFFS* program. This information helps future researchers and practitioners with similar interests to learn from and build on our research.

4.2 Methods

The systematic development of *STUFFS* intervention was guided by the Intervention Mapping framework.[204] Intervention Mapping is a well-known approach that is focused on problem-solving towards developing complex health promotion interventions.[204] The steps in Intervention Mapping are: 1.Logic model of the problem, including needs assessment; 2.Program objectives and expected outcomes; 3.Theory-based change methods and practical applications; 4.Program production; 5.Adoption and implementation plan; and 6.Evaluation plan. Although the steps are linear, the process is iterative, researchers often move back and forth through the stages.

Step 1**: **Logic model, including needs assessment

To assess the need for a sedentary behaviour change intervention after inpatient stroke rehabilitation, a review of the literature was done and a qualitative study conducted with people with stroke.[206] The primary aim of the qualitative study was to explore the level of awareness of people with stroke about sedentary behaviour and the associated health risks, and to determine if changing this behaviour was of interest to people with stroke.[206]

Step 2. Program objectives and expected outcomes

The purpose at this stage was to develop the measurable objectives that we expect to change as a result of the planned intervention. Knowledge of health risks and expectations of benefits associated with reducing sedentary behaviour creates the precondition for change.[173]An important outcome for the *STUFFS* program was to increase knowledge and awareness of the detrimental health effects of prolonged sedentary behaviour. If people with stroke lack knowledge about how prolonged sedentary behaviour might affect their health, they may have little or no incentive to reduce sedentary behaviour. The proximal objectives, the determinants, how to achieve the objectives as well as the behavioural, clinical, and quality of life outcomes that will be targeted, were identified.

Step 3: Theory-based change methods and practical applications

After the change objectives were identified, the appropriate theory-based methods and strategies that will enable achievement of the objectives were determined. Some behaviour change strategies that have shown promise in the general population[157] were included in the *STUFFS* program such as provision of information on harms of prolonged sedentary behaviour, self-monitoring using activity monitors as motivational tools, and social or environmental restructuring.[157]

Step 4: Program production

The details of the intervention, including drafting intervention messages and protocols were developed in Step 4. *STUFFS* sedentary behaviour change intervention was modelled after other sedentary behaviour interventions with older adults[158] and those with diabetes.[44, 207] We identified the measurement tools to use, how to deliver the intervention, and strategies for behaviour change - some of which were suggested by people with stroke during the needs assessement.[206] Further, the ways to support participants to be successful were identified, including the use of self-monitoring tools. The program materials for *STUFFS* intervention were developed such as the data collection tools and a program manual. The program manual received input from expert stroke clinicians in a rehabilitation hospital. The manual was also reviewed by 13 people with stroke and they were asked to comment on the content as well as the ease of understanding of the document. In addition, the Flesch Reading Ease level and the Flesch-Kincaid Reading Grade Level index were used to assess the reading ease of the *STUFFS* program guide. The program manual was refined based on the feedback received from people with stroke. After incorporating the suggestions from people with stroke, another round of refinement was done within the research team, before the final version was adopted.

Step 5: Adoption and implementation plan

A process to implement the program was developed. At the outset of the implementation planning stage for the *STUFFS* intervention, it was decided that it was necessary to establish collaboration with clinicians involved in stroke rehabilitation at a tertiary health institution. A series of stakeholder meetings and information sessions were held to inform staff of the proposed intervention and get their involvement and feedback. This step was important as it helped to set the stage for the program evaluation and testing.

Step 6: Evaluation plan

In the final step of the Intervention Mapping protocol, an evaluation plan was developed to evaluate if the *STUFFS* intervention program will be successful in reaching the goals and objectives of the program. An evaluation plan can include an assessment of the feasibility of the program in the target delivery channel, which in this case was the home environment.

4.3 Results

This section reports on the approaches that we followed in completing the required tasks for each of the 6-step process of Intervention Mapping, from the identification of the problem to the evaluation of the *STUFFS* program. Figure 4.1 is the pictorial representation of the Intervention Mapping steps and practical applications followed during this process.

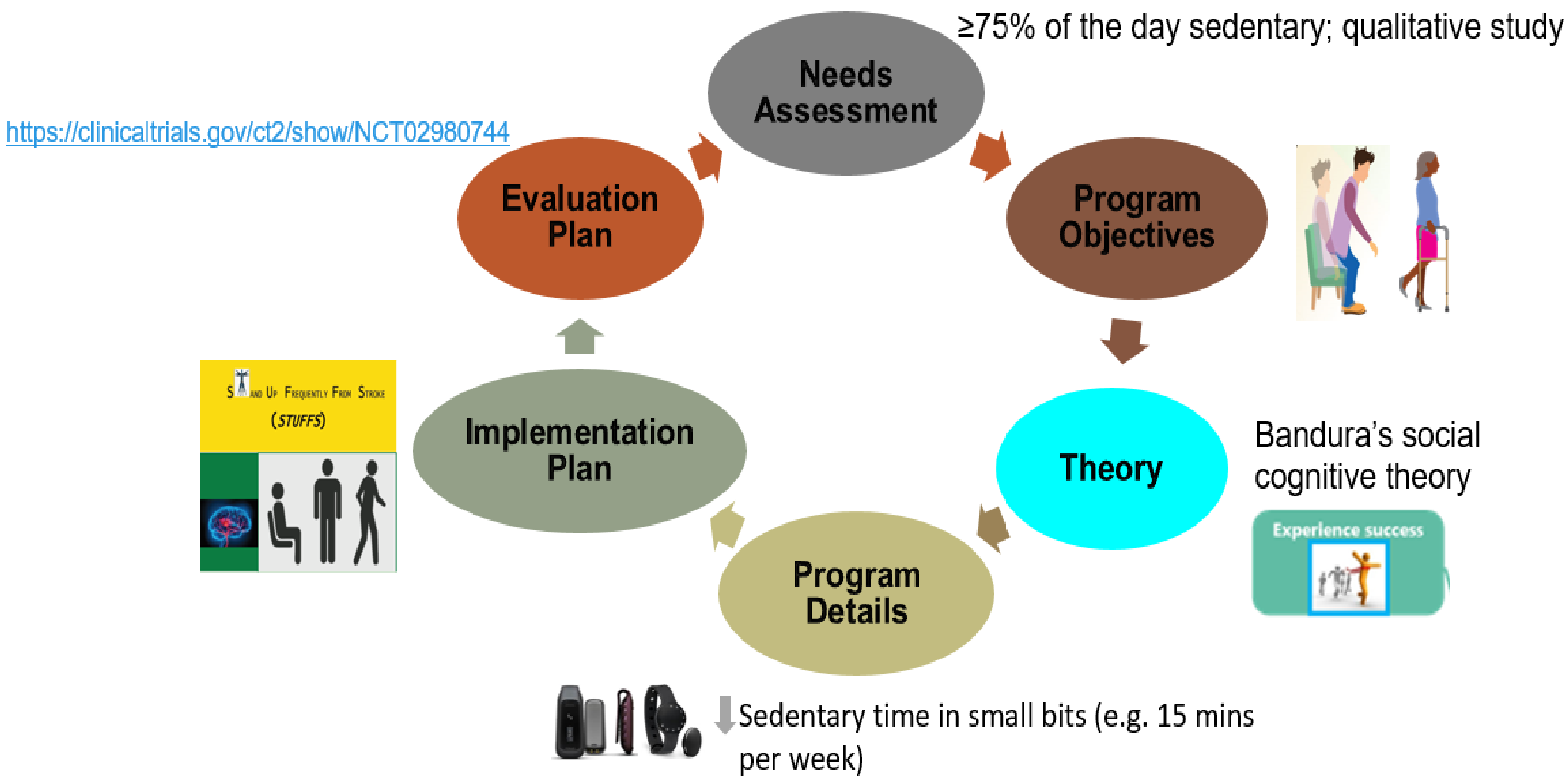

Figure 4.1. Pictorial representation of the Intervention Mapping steps and practical applications

Step 1*: *Logic model, including needs assessment

Literature review identified that sedentary behaviour was highly prevalent among people with stroke and there has been a consistent call among authors for the design of interventions to reduce sedentary behaviour.[19, 31, 139] The evidence from the literature review, as well as clinical experiences from working with persons with stroke including an understanding of their functional abilities and activity behaviour, led to the development of the *STUFFS* program. Moreover, prior sedentary behaviour interventions have shown promise with people with stroke,[36] older adults,[138] people with diabetes,[207] and multiple sclerosis.[164] Results from our qualitative study that assessed the perceptions of people with stroke about reducing sedentary behaviour showed that reasons for engaging in sedentary behaviour were related to comfort, watching television, difficulty with return to work, or leisure.[206] The common barriers to sitting less were the sequelae of stroke, depression, poor motivation, or lack of social and professional support, whereas early therapy and support, building motivation and confidence were facilitators.[206] The barriers and facilitators were considered in developing the *STUFFS* program.

Step 2. Program objectives and expected outcomes

We created a matrix of change objectives including how to achieve those objectives (see Table 4.1). The objectives of *STUFFS* intervention program were multi-faceted: The first goal was to increase awareness about the health risks of prolonged sedentary behaviour. The second goal was to reduce sedentary behaviour by empowering participants to frequently stand and take steps throughout waking hours. The third goal was to increase activity levels by accumulating at least 6,000 steps per day. Accumulating 6,000 steps per day is suggested as the threshold for reducing new vascular events after stroke.[208] The fourth goal was to maintain the activity behaviour even after the intervention has ended.

Table 4.1. Change matrix for reducing sedentary behaviour in people with stroke

Change objective	Determinants	Performance objectives	Behavioural outcomes	Clinical outcomes	Quality of life outcomes
Understand sedentary behaviour and the associated health risks	Knowledge	Gain understanding of sedentary behaviours and risks of prolonged sitting	Identify daily sedentary behaviours	N/A	N/A
Reduce time in sedentary behaviours	Knowledge Self-monitoring Self-efficacy	Take active role in self-management Reduce sedentary time (e.g. 15 minutes reduction per week)	Task self-efficacy Objective monitoring of sedentary time	Reduce sedentary time Accelerometer-assessed data (time sedentary)	Increase participation (measured by the Stroke Impact Scale)
Increase activity levels	Knowledge Self-monitoring Self-efficacy	Overcome barriers to increasing activity Increase activity levels (e.g. walk around for 5 minutes every half-hour) Increase sit-to-stand transitions Cues to action (display of daily progress, reminders)	Coping self-efficacy Activity monitoring Monitoring of sit to stand transitions Adherence to program	Increase activity levels (e.g. number of steps; achieve 6000 steps per day) Accelerometer-assessed data (time, standing, stepping, number of steps, and sit-to-stand transitions) Functional outcomes (gait speed, timed up and go)	Increase participation
Maintain activity levels after the intervention	Self-monitoring Self-efficacy	Build confidence to sustain activity levels	Scheduling self-efficacy Adherence to program	Increase or maintain activity levels and function (accelerometer-assessed data; function)	Increase participation

Step 3: Theory-based change methods and practical applications

The goal of *STUFFS* was to motivate individuals to frequently interrupt and reduce sedentary behaviour and the theoretical underpinning chosen was Bandura's social cognitive theory.[173] Appropriate strategies to enhance self-efficacy were developed (see Table 4.2). Three types of self-efficacy (i.e. task, coping and scheduling) have been conceptualized that affect behaviour change at various stages.[177] Task self-efficacy refers to the confidence for performing elemental aspects of behaviour and is related to initiation of behaviour change. For someone who has survived a stroke, the confidence to stand up and walk around for 5 minutes is considered task self-efficacy. Coping self-efficacy is the confidence for overcoming challenges associated with behaviour change and is related to maintenance of change. The confidence to stand and walk around for 5 minutes within a safe zone, even when a family member that usually assists is unavailable, is an example of coping self-efficacy. Scheduling self-efficacy is the confidence for managing time demands and inclusion of the behaviour change into one's schedule. Scheduling self-efficacy is the strongest predictor of persistence with behaviour change.[177] An example is an individual's daily plan to walk around for about 5 minutes, every half hour during waking periods, and their confidence to keep that schedule.

Table 4.2. Theoretical basis and applications

Determinants	Methods	Applications
Self-efficacy	Mastery Experience	Mastering behaviour in small steps, for example, aiming to reduce sedentary time by 15 minutes per week.
	Vicarious Experience	Providing activity charts of similar others to show that it is possible to sit less and move more.
	Verbal Persuasion	Talk to participants that they possess the capacity to stand and take steps frequently throughout the day.
	Physiological arousal	Educate participants that minor pains and aches with increasing activity is normal.
Goal setting	Proximal goals	Setting achievable short-term goals. For example, standing and walking for 3-5 minutes every half-hour.
	Distal goals	The long-term goal was to aim towards achieving at least 6000 steps per day.
	Action planning	Work with participants to identify strategies that will work for them. For example, standing and walking for 3-5 minutes every half-hour or doing 2 sets of 10 sit-to-stand tasks three times per day.
Self-monitoring	Self-evaluation and monitoring	Provide participants with tools that help them to monitor and evaluate daily progress. For instance, activity trackers that provide real-time feedback on daily progress.

Step 4: Program production

The main components of the *STUFFS* intervention include an assessment of usual activity behaviour, knowledge provision on harms of prolonged sedentary behaviour, strategies for behaviour change, and self-monitoring. Following an iterative process with clinicians and people with stroke, a program guide was developed (see Appendix J). Persons with stroke reviewed the program guide for content, readability and clarity of the intervention messages and protocol. Some modifications were made. For example, participants did not agree to stand up while eating, which was removed from the strategies to reduce sedentary behaviour. The Flesch Reading Ease level for the *STUFFS* program guide was 77.7 (on a 100-point scale). Higher scores mean easier understanding of the document. Microsoft Office reports that most standard documents are within the range of 60 to 70, which indicates that the *STUFFS* program guide was easy to read. The Flesch-Kincaid Grade Level was rated as 4.0, which meant that a fourth grader could understand the document.

Prior to beginning the intervention, it was important to establish usual activity behaviour. Baseline sedentary behaviour was monitored for 7 days using a research-grade activPAL (PAL Technologies, Glasgow, UK) accelerometer, sensitive to activity and posture and validated for use with people with stroke.[121] The *STUFFS* intervention began as a 2-hour individualized session with a participant and, where possible, a family member. All intervention visits were conducted face-to-face. The first task was to discuss the health consequences of prolonged sedentary behaviour. Next, participants were asked to look back at a typical day and discuss how they spent their day. The aim was to identify, from the participant's perspective, the behaviours that they considered as sedentary. The third activity was to view the graphical output from the activPAL (see Figure 4.2) and to identify periods of the day with prolonged bouts of sitting or lying and to discuss ways to make changes. For example, patient 1 in Figure 4.2 had frequent breaks in sedentary behaviour during waking hours, except from 20.00 to 21.00. The emphasis for this participant was to move more. On the contrary, patient 2 had long uninterrupted bouts of sedentary behaviour or very minimal movement between 06.00 and 12.00, 13.00 and 15.00, and the rest of the day. Thus the goal for patient 2 was to sit less and move more. Common change strategies employed by all participants included: 1) reducing sedentary time by 15 minutes each week, 2) planning regular breaks, such as standing and walking around for 3-5 minutes, every half-hour, during waking periods, and 3) performing two sets of 10 sit-to-stand transitions three times per day. Other action plans were included depending on the ability of the individual.

The likelihood of success with behaviour change interventions is often limited if people are not provided with appropriate resources and supports to realize the change.[157, 173] Self-monitoring may provide motivation to sit less and move more, and also allows participants the opportunity to monitor their daily activity levels in real time. Further, self-monitoring enables researchers to remotely view or monitor the daily activity levels of participants through online applications linked to the self-monitoring devices. It is however important to use dummy identification information to protect the privacy of participants. There are several consumer-based activity monitors with good self-monitoring attributes,[201] some of which have shown good reliability with people with stroke.[209] One consideration to make is the placement of the device. Although, there is evidence that ankle placement provides the most valid and reliable estimates for monitoring number of steps per day for short-term or laboratory-based studies,[209] patients' preference plays a major role in acceptability and use of the device. Anecdotally, patients have reported that it is easier and more convenient to wear the self-monitoring devices on the wrist for longer-term use. Researchers will need to decide on which is more important – adherence or accuracy of the data. Regardless of the placement position, any error observed with the devices will be systematic and users and researchers will be able to track change over time.

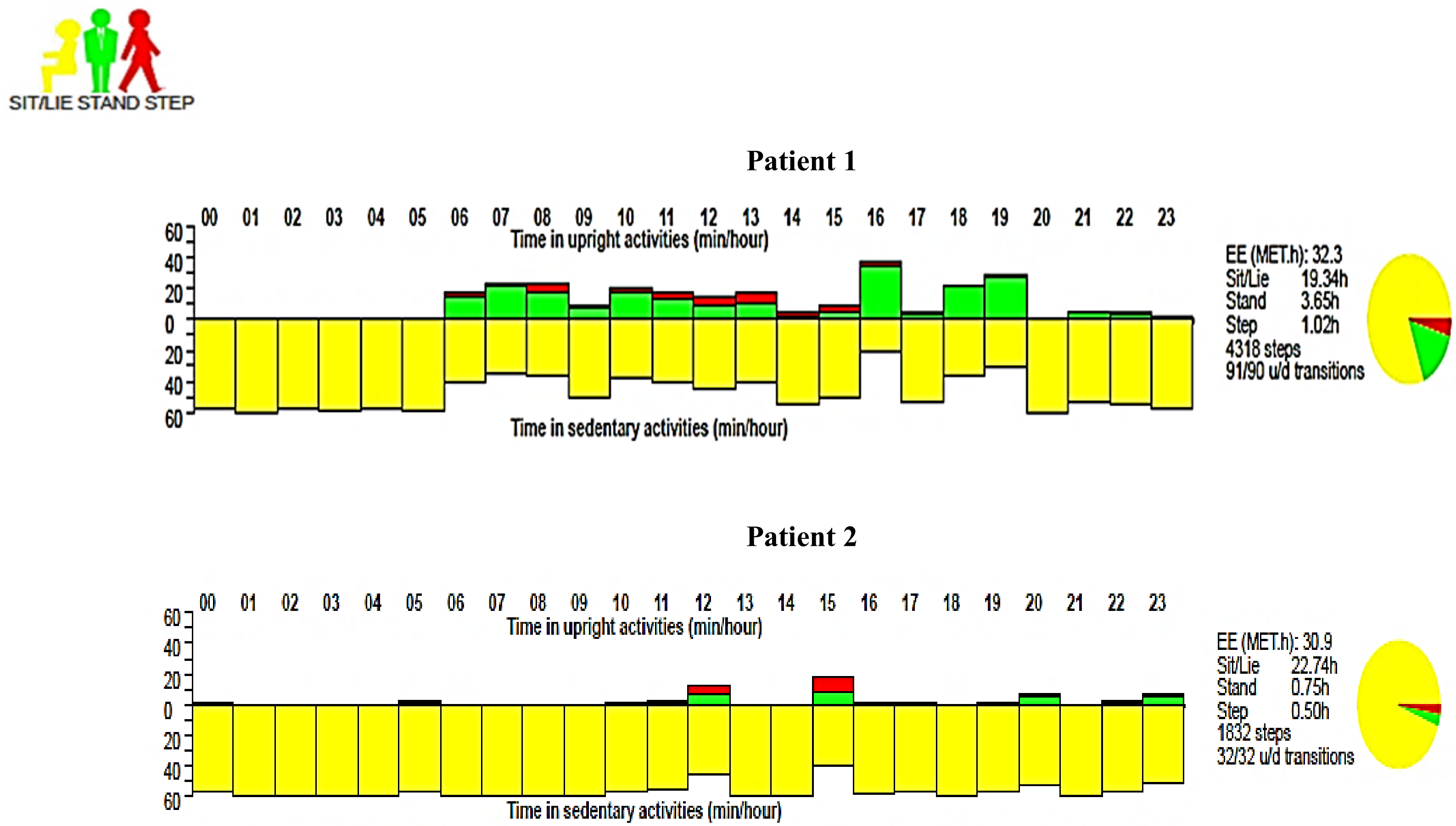

Figure 4.2. Sample graphical output from activPAL activity monitor for 2 patients showing different sedentary patterns

Step 5: Adoption and implementation plan

As part of the implementation plan for the *STUFFS* program, two physical therapists in an inpatient stroke rehabilitation unit agreed to help identify eligible participants. Participants were eligible to participate in the program if they were: 18 years and older; within 2 weeks of potential discharge to home from the inpatient rehabilitation hospital; able to stand up from a chair and walk at least 5 meters with or without gait aids; and able to understand two step commands. Interested participants signed a consent-to-contact form which was passed on to the researchers. The researchers met with the participants prior to their discharge from the hospital to discuss the study in detail and schedule an appointment for an initial home visit, which was within 2-4 weeks of discharge from the inpatient stroke unit.

Step 6: Evaluation plan

The evaluation plan for *STUFFS* was a test of the feasibility and longitudinal effects of an 8-week theory- and home-based sedentary behaviour change intervention for people with stroke being discharged from inpatient stroke rehabilitation (the details of the study will be presented in Chapter 6). We hypothesized that frequently standing and taking steps and using an activity tracker for self-monitoring would reduce sedentary behaviour and improve health-related outcomes (e.g. general mobility) in people with stroke (see Figure 4.3 for the outline of the evaluation plan). During the intervention period (weeks 1 to 8), participants wore a consumer-based activity monitor (different from the research-grade activPAL) mainly for self-monitoring and for the researchers to remotely view and monitor daily activity levels of the participants. As a way to evaluate participants' confidence for achieving the tasks in the *STUFFS* program, participants were asked to rate their confidence using the Multidimensional Self-Efficacy for Exercise Scale.[210] This scale measures the three components of self-efficacy: task, coping and scheduling. The scale was modified to include self-efficacy ratings for reducing sedentary time, moving more, and performing sit-to-stand transitions (see Appendix L). The Multidimensional Self-Efficacy for Exercise Scale has 9 items which begins with the phrase "how confident are you that you can…" followed by statements that represent components of self-efficacy (i.e. task, coping and scheduling). For example, task self-efficacy for moving more was assessed by "How confident are you that you can stand up and walk around for 3 to 5 minutes?" Each response was scored on a 100% scale, ranging from 0% (no confidence) to 100% (complete confidence). When confidence was lower than 70% for any of the tasks, the participant and researchers worked together to develop a plan that the participant will be confident in doing. Such modifications may include walking for 2 instead of 3 minutes.

The researchers called the participants on phone biweekly to troubleshoot about any concerns, and participants were also instructed to call the researchers if there were any urgent issues (e.g. device malfunction). The protocol for the evaluation phase was registered at www.clinicaltrials.gov (#NCT02980744). Ethics approval for the trial was approved by the institutional Health Research Ethics Board. A post-intervention exit interview was scheduled at the end of the intervention period to assess the acceptability and satisfaction with the program.

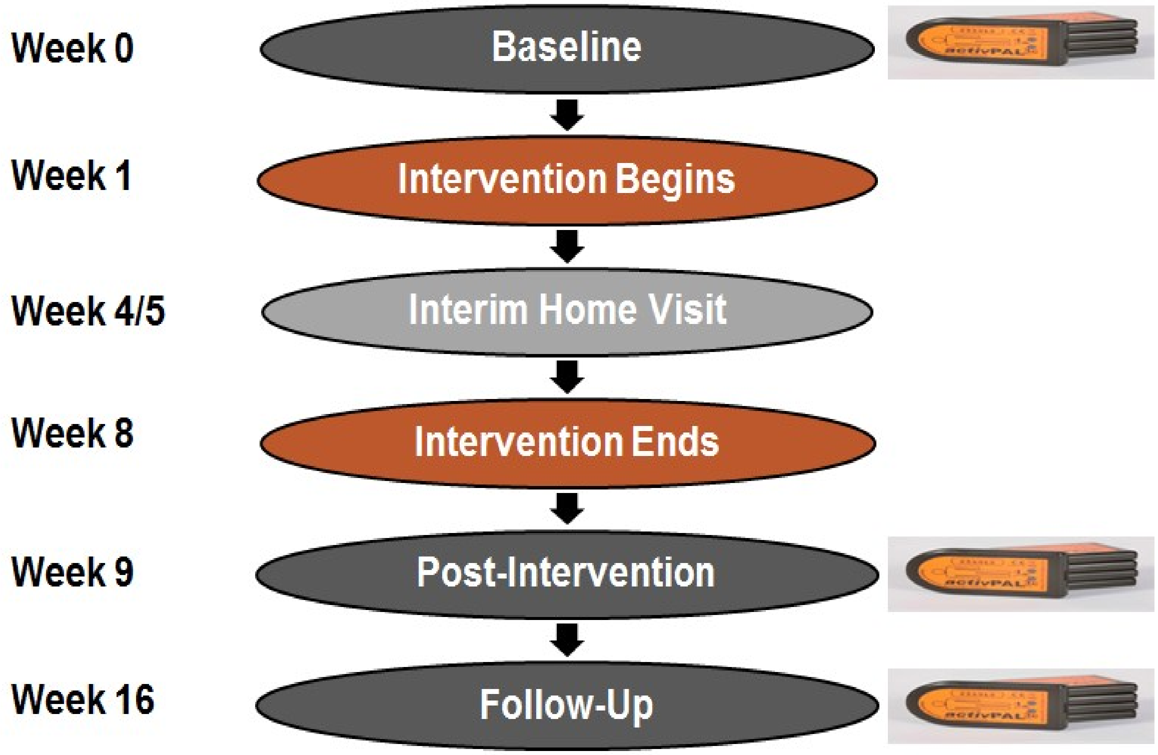

Figure 4.3. Evaluation plan for *STUFFS*

4.4 Discussion

Given that prolonged sedentary behaviour persists after discharge from organized hospital care,[35] until the chronic phase of stroke recovery,[19] sedentary behaviour change interventions are needed. This article is the first to describe the detailed steps, using the Intervention Mapping approach, in the design and development of a sedentary behaviour change program for people with stroke. There are concerns in the literature that stroke trials underreport the process of intervention development and interventions do not have adequate theoretical background.[57] The challenge with not adequately reporting the details of an intervention is that it is difficult to implement the intervention, to replicate the study, and to evaluate the efficacy of the intervention.[57] A major strength of this intervention development article is that it brings together theory, personal preferences of people with stroke, and pragmatic ways to change sedentary behaviour after stroke.

The Intervention Mapping steps and the systematic process followed in the design and development of *STUFFS* are important to ensure that the program is grounded in theory, but also helps in implementation of this type of program and in translating it to other populations with limited mobility. The theoretical foundations and the detailed description of the intervention design will help in the process evaluation of the intervention (i.e. what components worked and what needs to be modified). The development process received support from clinicians involved in stroke rehabilitation and expert opinion from a research team with experience in developing complex health promoting behaviours for chronic diseases. Similar approaches have been used in the development of intervention programs for risk-factor control and secondary prevention after stroke,[211] and self-management following acquired brain injury.[212]

An essential component of any behaviour change process is to identify and define where the behaviour occurs most commonly and where the intervention will be delivered. For people with stroke, the home environment is an appropriate target for changing sedentary behaviour. Although, previous sedentary behaviour change interventions, especially in the workplace, have shown success,[157] the process of adapting the program to other settings require that components of the intervention will need to be modified, the delivery channel may need to be changed, and the messaging often needs to be adapted to the particular population or setting. A systematic approach to adaptation of programs that have worked with other populations helps researchers to evaluate what worked well in such programs and to retain essential components of the existing program during the process of adaptation.[213] Furthermore, identifying key theory-based determinants and ways to achieve the stated objectives are important.

Building *STUFFS* program around social cognitive theory principles also helped with identifying key determinants such as knowledge of sedentary behaviour and the associated health risks, self-efficacy, self-monitoring, and goal setting. As part of the practical applications, it was important to break up the distal goal into smaller bits (i.e. proximal goals) to help individuals to experience success in reducing sedentary time. An individual's perceived confidence in being successful in one component boosts self-efficacy which plays a major role in behaviour change.[174, 200]Also, incorporating consumer-based activity trackers for self-monitoring and as cues-to-action may help to empower participants to experience success. Moreover, health behaviours are not just changed by thinking about it, but require a conscious effort by the individual.[173] The idea of monitoring oneself by using activity monitors that provide real-time feedback on daily progress helps to provide some motivation to sit less and move more. There is evidence that such self-management strategies mediate the relationship between self-efficacy and activity behaviour.[187]

Limitations

The whole process of intervention development takes time. For example, *STUFFS* was developed over a 2-year period beginning with the needs assessment in July 2014 and registration of the evaluation protocol in November 2016. However, it was important to involve people with stroke in the design of the intervention to ensure that it was appropriate and targeted to the population of interest and thus might facilitate uptake of this type of intervention. Although Intervention Mapping - a widely accepted and useful framework for developing complex behaviour change interventions, was used in this study, other frameworks also exist (e.g. Behaviour Change Wheel).[214, 215]

STUFFS program as currently designed involves in-person delivery at home. This method of delivery is helpful for people with limited mobility, as it overcomes the problem of accessibility, but limits the implementation of this type of intervention at the population-level. Future interventions may employ telehealth and internet-based delivery methods that might not require face-to-face contact.

4.5 Conclusion

In conclusion, Intervention Mapping was used to systematically design and develop a theory-based sedentary behaviour change intervention for people with stroke. Such programs are needed to interrupt and reduce prolonged sedentary time at home following resource-intensive inpatient stroke rehabilitation and organized hospital care.

CHAPTER 5

SLEEP DURATION, SEDENTARY BEHAVIOUR, PHYSICAL ACTIVITY, AND QUALITY OF LIFE AFTER INPATIENT STROKE REHABILITATION

Abstract

Objective: The aim of this study was to describe accelerometer-derived sleep duration, sedentary behaviour, physical activity and quality of life and their association with demographic and clinical factors within the first month after inpatient stroke rehabilitation.

Methods: Thirty people with stroke (mean ± SD; age: 63.8 ± 12.3 years; time since stroke: 3.6 ± 1.1 months) wore activPAL3 Micro accelerometer continuously for 7 days to measure whole-day activity behaviour. The Stroke Impact Scale and Functional Independence Measure were used to assess quality of life and function, respectively.

Results: Sleep duration ranged from 6.6 to 11.6 hours per day. Fifteen participants engaged in long sleep greater than 9 hours per day. Participants spent 74.8% of waking hours in sedentary behaviour, 17.9% standing, and 7.3% stepping. Of stepping time, only a median of 1.1 (IQR: 0.3-5.8) minutes were spent walking at a moderate-to-vigorous intensity (≥ 100 steps/min). Sedentary time, stepping time, and steps differed significantly by hemiparetic side ($p<0.05$), but not by sex or type of stroke. There were moderate to strong correlations between stepping time and number of steps with gait speed (Spearman $r = 0.49$, 0.61 respectively, $p<0.01$). Correlations between accelerometer-derived variables and age, time since stroke, and cognition were not significant.

Conclusions: People with stroke sleep for longer than the normal duration, spend about three quarters of their waking hours in sedentary behaviours and engage in minimal walking following stroke rehabilitation. Our findings provide a rationale for development of behaviour change strategies after stroke.

Ezeugwu VE, Manns PJ. Sleep duration, sedentary behaviour, physical activity, and quality of life after inpatient stroke rehabilitation. *J Stroke Cerebrovasc Dis*. 2017;26:2004-2012

5.1 Introduction

Immediately following a stroke, care of patients is usually comprehensive and diverse. Patients are often seen by a variety of health care professionals during the acute and subacute phases. Those admitted to a stroke unit or rehabilitation hospital receive intense therapy.[17] Once discharged from the hospital, the services that people with stroke access to help them maintain health and function are less organized and available.[18] The intensity of practice of functional skills, as well as general activity, can decrease substantially during that time. Although one study reported moderate improvement in activity with Early Supported Discharge teams after a median of 9 days post-discharge from hospital,[141] other studies have shown that people with stroke do not make significant change in activity after leaving the hospital.[19, 22] Ideally, this is a time period when progress should be at its fastest, yet activity levels remain the same.

Decreased physical activity after stroke leads to cardiovascular deconditioning and other negative health outcomes.[26] To that effect, physical activity and exercise guidelines for patients with stroke emphasize secondary prevention strategies including promotion of low- to moderate-intensity physical activity, muscle-strengthening exercises, and reduction of sedentary behaviour.[30] There is growing interest in the inter-relatedness of all behaviours (i.e., sleep, sedentary behaviour, and physical activity at different intensities) within a 24-hour period and how they affect an individual's health.[48, 95] Such interest led to the development of a 24-hour movement guideline (including sleep) in Canada.[95] Investigating whole-day activity behaviour is important for all age groups and people of all abilities.[48] For example, there is evidence that poor sleep habits (either short <6 hours or long sleep>8 hours),[216] prolonged sedentary behaviour,[82] and insufficient physical activity[217] are detrimentally associated with adverse health consequences in the general population and among adults with mobility disability.[37] In animal models, disturbance of sleep is also detrimentally associated with functional and structural recovery after stroke,[218] providing a rationale for studying sleep duration post stroke.

Two studies investigated profiles of physical activity and sedentary behaviour in individuals with chronic stroke (mean >4years since stroke) compared with healthy controls. Findings from one of the studies showed that people with stroke spend a median of 20.4 out of 24 hours (including sleep time) in sedentary behaviour and 12 minutes (0.2 hours) stepping at moderate intensity (i.e. $\geq$ 100 steps/min).[31] When sedentary time was adjusted for waking hours in the second study, people with stroke accumulated 74.8% (10.9 of 14.2 waking hours) in sedentary behaviour and only 4.9 minutes in moderate-to-vigorous physical activity.[139] Among healthy older adults without mobility disability from a population-representative sample, sedentary behaviour occupied 63.4% of their day while they spent 1.3% in moderate-to-vigorous physical activity.[37] Objectively monitoring whole-day activities, quality of life and level of functional independence immediately after inpatient stroke rehabilitation will help to determine how people with stroke are integrating into the community after discharge from formal rehabilitation.

This study had two objectives: 1) to objectively describe whole-day activities (including sleep) within one month after inpatient stroke rehabilitation, and 2) to explore the relationships between accelerometer-derived variables with age, time since stroke, gait speed, cognitive scores, and quality of life ratings.

5.2 Materials and Methods

5.2.1 Design and participants

This cross-sectional, cohort study was carried out with patients with ischaemic or haemorrhagic stroke, who were within 2-4 weeks of discharge from an inpatient stroke rehabilitation facility. Included participants were: (1) aged 18 years and older; (2) able to stand up from a chair and walk 5 metres with or without gait aids; and (3) able to understand two step commands. Thirty-three persons with stroke signed a consent-to-contact form and following screening, 30 participants were enrolled. Two participants with other diagnosis (brain tumor and cortico-basal degeneration) were excluded. The third was excluded for refusal to wear activity monitor.

5.2.2 Procedure

Ethical approval for this study was obtained from the institutional Health Research Ethics Board. Operational approval was granted by the health authority in the region permitting access to participants in the rehabilitation hospital. Two physical therapists at the inpatient stroke rehabilitation unit identified eligible participants based on the inclusion criteria. Participants signed written informed consent forms prior to enrolment. Data collection (including demographics and stroke-related data) took place in the participants' home within a window of 2-4 weeks after discharge from inpatient stroke rehabilitation. Weight was measured using a digital scale. Level of impairment was assessed using the Chedoke McMaster Stroke Assessment (CMSA) scale.[219] Scores were reported separately for the leg and foot on a scale of 1-7, with 1 indicating no active movement and 7 indicating normal movement. The Montreal Cognitive

Assessment (MoCA) scale[220] was used to assess for cognitive status. Information on use of walking aids and community services accessed was also obtained.

5.2.3 Accelerometry

The participants wore an activPAL3 Micro (PAL Technologies, Glasgow, Scotland) activity monitor continuously for 7 days on the midpoint of the anterior thigh of the non-hemiparetic leg. The activPAL3 Micro weighs about 10g and measures 23.5 × 43 × 5mm. The device was wrapped in a nitrile sleeve and affixed with a transparent dressing to make it waterproof and also to allow for continuous wear. Five activPAL3 Micro devices were used in this study. The functionality of the devices was tested as recommended by the manufacturer by placing each device horizontally on a flat surface for one hour, followed by vertical position for another hour. All the devices accurately identified start and end times in the placed positions. The activPAL3 Micro is able to detect sleep duration (broadly defined as time in bed including brief periods out of bed such as washroom visits),[221] and sedentary and non-sedentary behaviours via an inclinometer and triaxial accelerometer. The activPAL has been validated in persons with stroke,[121, 222] and provides accurate measurement of sedentary behaviour and detection of transitions from non-upright to upright positions or vice-versa.[121]

5.2.4 Function

The level of functional independence was determined using the mobility and locomotion subdomain of the Functional Independence Measure (FIM).[223] The functional tasks evaluated were bed mobility, transfer to the bed, transfer to tub or shower, transfer to a car, transfer to the floor, stairs, and ambulation. Each task was scored on a scale of 0 to 7 (0 = activity does not occur; 1 = total assistance [participant performs 0% - 24% of task]; 2 = maximum assistance

[25%-49%]; 3 = moderate assistance [50%-74%]; 4 = minimal assistance [75%-99%]; 5 = supervision or set-up; 6 = uses device, no physical assistance; 7 = independent). Although, the FIM has often being used in hospital-based studies and might be subject to ceiling effect, we used this tool so that researchers can compare our findings with those from hospital-based studies. Self-selected gait speed was measured using a stopwatch over the middle 5 meters of a 9-meter walkway.[224, 225]

5.2.5 Health-related quality of life

The Stroke Impact Scale version 3.0 was used to assess the impact of stroke on quality of life from the perspectives of people with stroke.[226, 227] The scale contains 59 items measuring 8 domains, including strength, memory and thinking, emotion, communication, activities of daily living, mobility, hand function, and participation. In addition, there is an item that rates a person's perceived overall recovery from stroke. It is also possible to collapse the 4 physical function domains (strength, hand function, activities of daily living, and mobility) into a single physical function composite.[226] The domain scores range from 0 to 100, with 100 being the best possible score.

5.2.6 Data processing

Data from the activPAL was processed using proprietary algorithm (activPAL™ version 7.2.32, Research Edition). Data files including event files were saved as Excel (Microsoft Corporation, US) spreadsheets. The activPAL™ classifies activity behaviour into time sedentary, standing, and stepping, as well as number of steps, stepping intensity, and sit-to-stand transitions. Sleep time was manually derived for each day using event files data from noon-to-noon the next day following a protocol described previously.[221] Although participants kept a sleep-wake diary, this approach was preferred to avoid recall bias associated with sleep-wake diaries.

Stepping intensity (i.e. number of steps/min) was classified as follows: sporadic (20-39), purposeful (40-59), slow (60-79), medium (80-99), brisk (100-119), and fastest (>120).[31, 228] However, the activPAL software does not classify a cadence with less than 20 steps/min as stepping, therefore the incidental stepping band (0-19 steps/min) was not included. Finally, we determined the proportion of individuals that were able to accumulate at least 3,000 steps at ≥100 steps/min (i.e. equivalent of moderate-to-vigorous physical activity).[228]

5.2.7 Statistical analyses

Analyses were done using STATA version 14 (Stata Corporation, Texas, US). Shapiro-Wilk test and histograms were used to examine for normality. Participants' demographics and stroke-related data were summarized using descriptive statistics - means and standard deviations, unless otherwise stated. A pie chart was created for the whole-day activities including sleep duration, time sedentary, standing and stepping. Boxplots were created for time spent in different cadence bands. Differences in accelerometer-derived variables were compared using t-test or Mann-Whitney U tests (non-normal data distribution) by sex, type of stroke and hemiparetic side. Bivariate correlations analysis using Pearson's product-moment or Spearman's rank (non-normal data distribution) correlation was used to explore correlations between accelerometer-derived variables with age, time since stroke, gait speed, cognitive scores, and quality of life ratings. Effect sizes were estimated for correlations as small (0.1), moderate (0.3), or large (0.5).[229]

5.3 Results

The demographic and clinical characteristics of the participants are summarized in Table 5.1. The participants had a median CMSA score of 6 (IQR: 6-7) for the leg and 6 (IQR: 5-7) for the foot. Thirteen non-injurious falls occurred within one month of discharge. Two participants had 1 fall each, four participants had 2 falls each, while one participant had 3 falls. Ten participants did not use a gait aid for most ambulation activities. Eleven used a four-wheeled walker, 5 used a quad cane, while 4 used a single cane.

5.3.1 Accelerometry

The participants slept for an average of 8.9 (SD: 1.3) hours per day (range: 6.6 to 11.6 hours) as shown in Figure 5.1. Twenty-two participants (73.3%) engaged in long sleep (≥8 hours per day). Of those that engaged in long sleep, 15 (50% of whole sample) engaged in long sleep greater than 9 hours per day. Four participants (13.3%) engaged in short sleep (<7 hours per day). Only 4 participants (13.3%) were within the normal sleeping range of 7-8 hours per day.

The mean waking hours was 15.1 (SD 1.3) hours. Participants spent an average of 11.3 hours (74.8% of waking hours) in sedentary behaviour, 2.7 hours (17.9%) standing, and 1.1 hours (7.3%) stepping (see Figure 5.1). Sedentary time, stepping time, and number of steps differed significantly by hemiparetic side, but not by sex or type of stroke (see Table 5.2).The median number of steps for the whole sample was 2590 [IQR: 1891-5995] and median sit-to-stand transitions was 44.5 [IQR: 34.1-54.1].

Stepping intensity as classified into time bands of various cadences (i.e. steps/min) is shown in Figure 5.2. Participants spent most of their time in slow (60-70 steps/min) and medium (80-99 steps/min) cadence bands. Specifically, participants spent a median (IQR) of 4.7 (2.8-7.3) minutes per day in sporadic steps (20-39 steps/min), 8.8 (6.1-15.4) minutes in purposeful steps (40-59 steps/min), 13.0 (7.6-29.6) minutes in slow steps (60-79 steps/min), 11.9 (5.8-27.4) minutes in medium steps (80-99 steps/min), 1.2 (0.2-5.6) minutes in brisk steps (100-119 steps/min), and 0.2 (0.1-0.5) minutes in fastest steps (>120 steps/min). Only two individuals (6.7%) engaged in walking for at least 3000 steps per day (equivalent of 30 minutes of walking) at moderate-to-vigorous intensity (i.e. ≥100 steps/min), while three participants (10.0%) accumulated between 1000 and 3000 steps at that intensity.

5.3.2 Function

Overall, participants had a high level of functioning in all tasks. Most participants were independent or used a device for bed mobility, transfers to bed or vehicle, and ambulation. Thirty percent of participants could not get down on the floor, while 16.7% required supervision with stairs. Also, some participants required minimal to moderate assistance with bathroom transfer (16.7%) and transfers to vehicle (10.0%).

5.3.3 Health-related quality of life

Quality of life, measured by the Stroke Impact Scale, showed that the most impacted domains were (mean [SD]): strength (55.83 [23.09]), hand function (60.5 [35.87]), participation (54.59 [25.53]), and overall recovery (57.67 [20.07]). Other domains were less impacted, including memory (81.67 [21.73]), emotion (70.74 [18.25]), communication (84.17 [22.79]), activities of daily living (71.92 [23.80]), and mobility (76.30 [20.76]). Furthermore, the physical composite score (strength, hand function, activities of daily living, and mobility) was (66.14 [21.99]).

Table 5.1. Participant characteristics (n=30)

Characteristic	
Age (years) [range]	63.8 ± 12.3 [23-83]
Sex	17 men (56.7)
Marital status	21 (70.0) married or living with common law partner
Education	
None	1 (3.3)
Primary	2 (6.7)
High school	11 (36.7)
College	11 (36.7)
Postgraduate	5 (16.7)
Type of stroke	
Ischaemic	24 (80.0)
Haemorrhagic	6 (20.0)
Side of hemiparesis	Right 12 (40.0)
Handedness	Right 24 (80.0)
Time since stroke (months) [range]	3.6 ± 1.1 [2-6]
Length of inpatient rehabilitation (weeks) [range]	7.4 ± 4.2 [2-16]
Gait speed (m/s)	0.6 ± 0.3
Community services used	
None	12 (40.0)
Physiotherapy	7 (23.3)
ESD	1 (3.3)
Home care	6 (20.0)
More than one service	4 (13.3)
More than one comorbidity*	19 (63.3)
Weight (kg)	79.5 ± 20.3
MoCA	24.3 ± 4.8
Smoking status	
Non-smoker	24 (80.0)
Recently stopped	2 (6.7)
Smoker (current)	4 (13.3)

NOTE: Data are presented as mean ± SD or n (%) except where indicated as otherwise.
*Comorbidities included high blood pressure, diabetes, dyslipidemia.

Abbreviations: ESD, early supported discharge; MoCA, Montreal Cognitive Assessment (range: 0-30, normal ≥ 26)

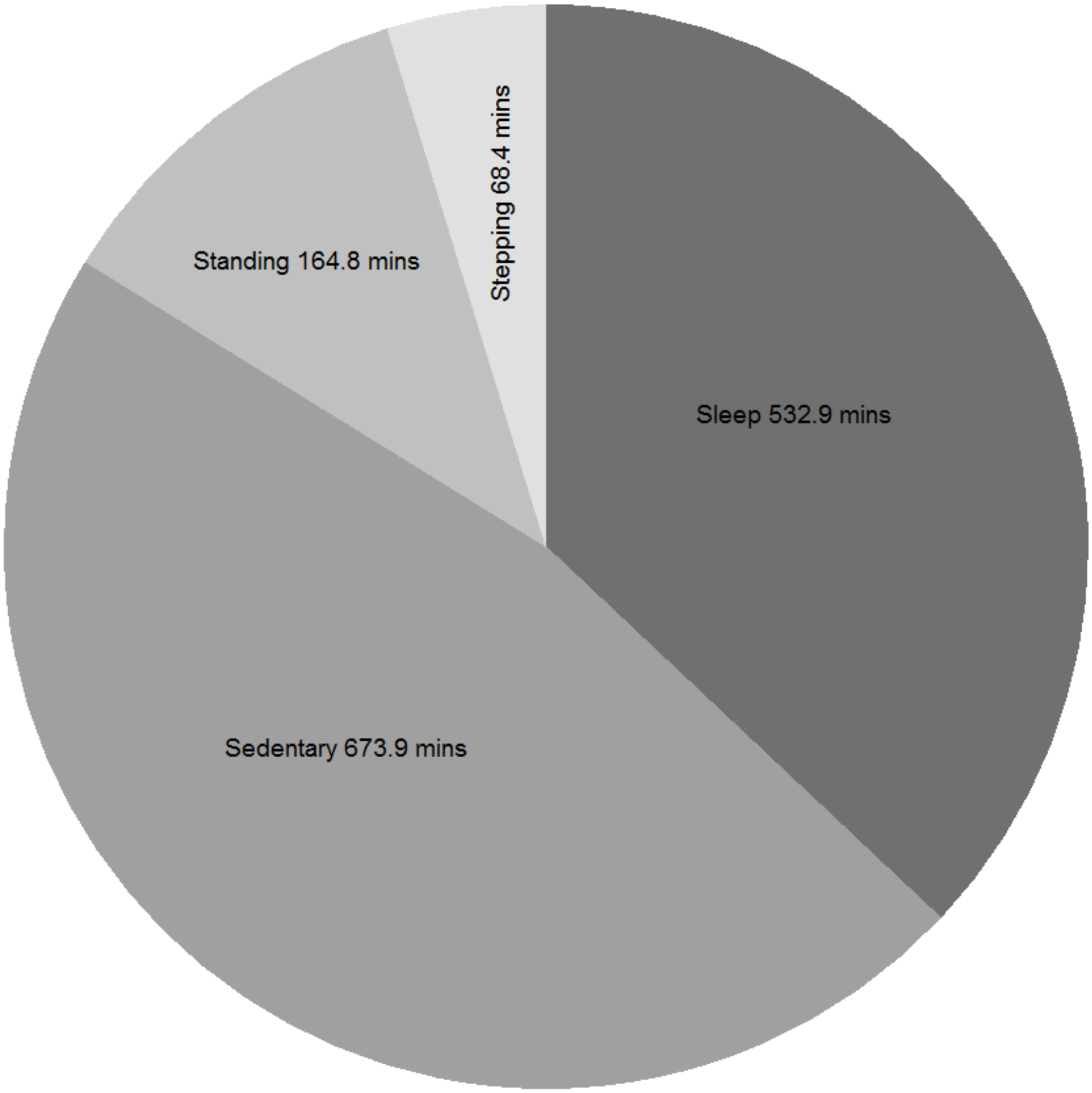

Figure 5.1. Whole-day activity behaviour after inpatient stroke rehabilitation

Table 5.2. Accelerometer-derived variables classified by sex, type of stroke and hemiparetic side

Variables	Sex		*P*	Type of stroke		*P*	Hemiparetic side		*P*
	Male (n = 17)	Female (n = 13)		Ischaemic (n = 24)	Haemorrhagic (n = 6)		Right (n = 12)	Left (n = 18)	
Sleep duration (mins/day)	521.8 ± 69.0	551.2 ± 93.7	0.331	535.7 ± 86.5	530.0 ± 56.2	0.880	522.1 ± 68.5	542.9 ± 88.5	0.500
Sedentary time (mins/day)	674.4 ± 102.5	678.3 ± 95.7	0.915	684.9 ± 101.0	640.9 ± 82.9	0.333	632.8 ± 117.2	704.9 ± 72.6	**0.046**
Standing time (mins/day)	167.1 ± 64.6	162.9 ± 94.0	0.887	156.1 ± 69.6	202.1 ± 101.3	0.197	192.5 ± 61.8	147.2 ± 82.7	0.117
Stepping time (mins/day)	78.3 ± 56.8	56.1 ± 50.5	0.276	68.3 ± 56.6	69.9 ± 49.3	0.951	96.3 ± 69.8	50.2 ± 31.6	**0.020**
Steps (n/day)†	4127 [2233 - 5995]	2373 [1874 - 3649]	0.187	2557 [1955 - 5877]	3610 [1508 - 6562]	0.959	4162 [2538 - 10881]	2216 [1510 - 4489]	**0.022**
Sit-to-stand transitions (n/day)†	46 [40 - 56]	39 [33 - 46]	0.161	45 [35 - 61]	44 [34 - 46]	0.534	45 [40 - 71]	40 [33 - 52]	0.290

NOTE: Values are mean ± SD except for steps and sit-to-stand transitions. † Non-normal data distribution reported as medians [IQR], Mann Whitney U test

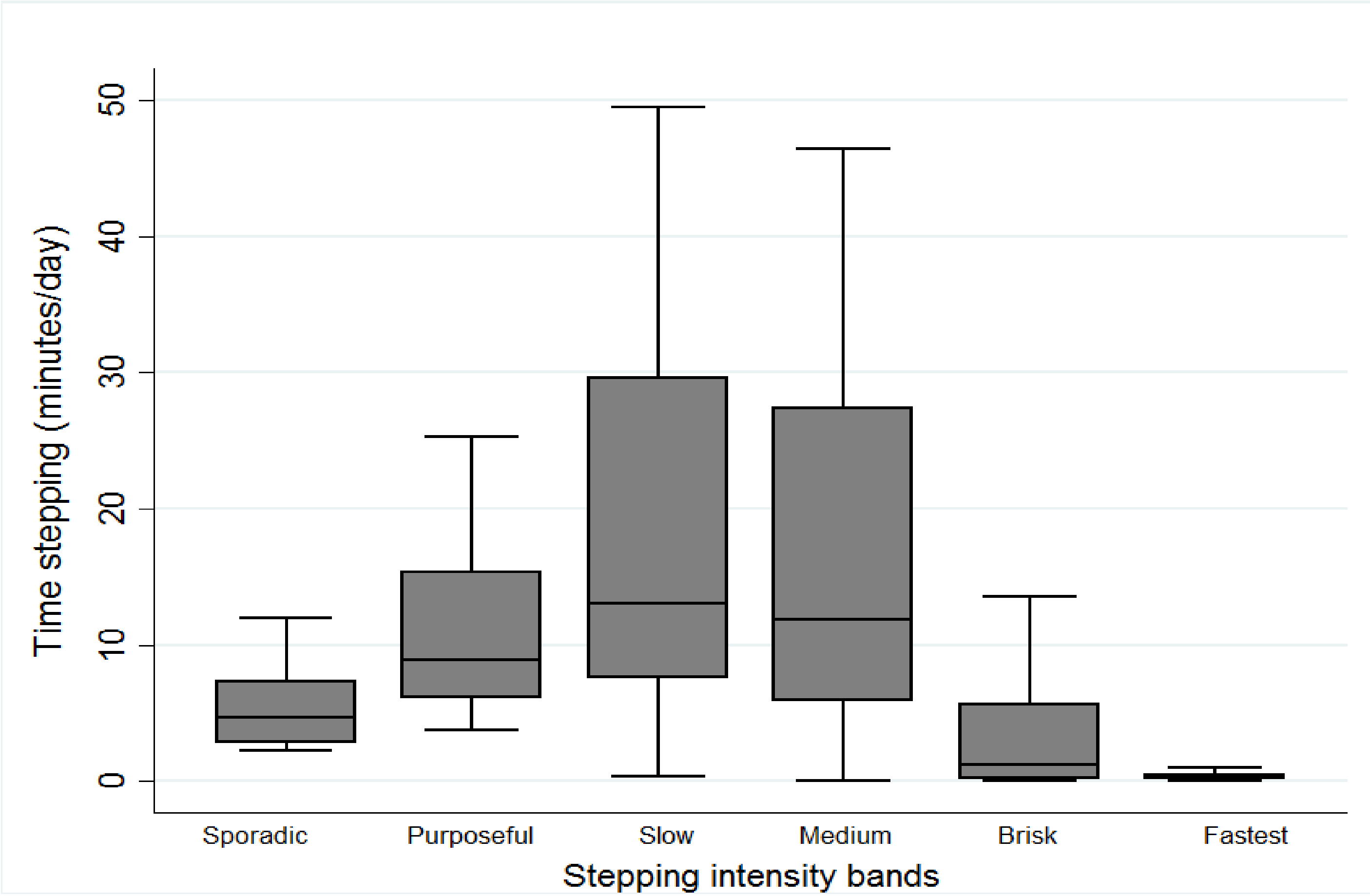

Figure 5.2. Stepping intensity classified into time bands of various cadences.

5.3.4 Correlations

Correlations between age, time since stroke, gait speed, cognitive scores, and Stroke Impact Scale (physical composite) with accelerometer-derived variables are shown in Table 5.3. Faster gait speed was significantly correlated with greater time stepping, average number of steps per day, and number of steps in the medium, brisk and fastest cadence bands (i.e. ≥ 80-99 steps/min). Higher sleep duration was significantly correlated with less time standing, less number of sit-to-stand transitions and lower number of purposeful steps. Higher sedentary time was significantly correlated with less standing time, stepping time, average number of steps, as well as less number of steps in all stepping intensity bands except brisk steps (i.e. 100-119 steps/min). In addition, higher sedentary time was correlated with better self-reported communication score ($r = 0.36$, $p= 0.04$). Higher standing time was significantly correlated with higher stepping time, average number of steps, sit-to-stand transitions, and number of steps in all stepping intensity bands. Higher self-reported mobility was significantly correlated with higher stepping time ($r = 0.35$, $p = 0.04$) and higher number of steps ($r = 0.38$, $p = 0.03$). Higher number of sit-to-stand transition was significantly correlated with higher time stepping and average number of steps, and also with higher number of steps in sporadic, purposeful, and slow cadence bands.

Table 5.3. Correlations between demographic and clinical parameters with accelerometer-derived variables (n=30)

	Age	Time since stroke	Gait speed	MoCA	SIS physical composite	Sleep duration	Sedentary time	Standing time	Sit-to-stand transitions
<u>Accelerometer variables</u>									
Sleep duration (mins)	0.04	0.30	-0.17	0.14	-0.09	-			
Sedentary time (mins)	0.05	-0.12	-0.28	-0.08	0.03	-0.01	-		
Standing time (mins)	-0.04	-0.07	0.32	-0.06	-0.01	-0.61**	-0.68**	-	-
Stepping time (mins)	0.16	-0.15	0.49**	0.16	0.04	-0.30	-0.61**	0.59**	0.58**
Steps/day (n)	0.18	-0.22	0.61**	0.11	0.15	-0.24	-0.65**	0.60**	0.47**
Sit-to-stand transitions (n)	0.15	-0.22	0.34	0.07	-0.03	-0.51**	-0.31	0.53**	-
Sporadic steps	-0.18	-0.05	-0.02	0.12	-0.27	-0.35	-0.43*	0.52**	0.60**
Purposeful steps	-0.03	-0.11	0.14	0.21	-0.09	-0.36*	-0.41*	0.44*	0.67**
Slow steps	0.17	-0.24	0.25	0.24	0.05	-0.23	-0.42*	0.29	0.46**
Medium steps	0.21	-0.18	0.79**	0.20	0.27	-0.21	-0.49**	0.47**	0.40*
Brisk steps	0.15	-0.20	0.74**	-0.09	0.33	-0.10	-0.33	0.38*	0.13
Fastest steps	-0.18	-0.14	0.47**	-0.02	0.14	-0.33	-0.42*	0.66**	0.33

NOTE: *Correlation significant at p<0.05 level (Spearman, two-tailed); **Correlation significant at p<0.01 level (Spearman, two-tailed).

Cadence bands: Sporadic steps (20-39 steps/min); purposeful (40-59 steps/min); slow (60-79 steps/min); medium (80-99 steps/min); brisk (100-119 steps/min); and fastest (>120 steps/min). Cadence bands were derived from steps/day and related to stepping time, no correlations were done.

Abbreviations: MoCA, Montreal Cognitive Assessment scale; SIS, Stroke Impact Scale

5.4 Discussion

The present study provides information related to sleep duration, sedentary time during waking hours, pattern of stepping, level of function, and patient-reported quality of life in the early period following inpatient stroke rehabilitation. This is a critical period for most people with stroke as they adapt to the home environment.

Sleep behaviours in this cohort of people with stroke were variable, with a few people having short sleep (<6 hours per day) and a large number (50%) engaging in prolonged sleep (>9 hours per day). The sleep time of 533 minutes in our sample is much higher than the average sleep time of 394 minutes reported in a study with active older adults (mean age 71.5 years).[230] It is unclear why people with stroke sleep for prolonged periods. Anecdotally, patients have complained of insufficient sleep during inpatient stay. The insufficient sleep might be related to sleep-disordered breathing which is common in acute stroke.[231] It is possible that the prolonged sleep behaviours might be a compensatory phenomenon following hospital admission. Furthermore, the weather may play a role, since people who live in colder climates receive less natural light during the winter season, which may encourage prolonged sleep. However, there is an associated clinical consequence of prolonged sleep. Physiologically, long sleep is associated with inflammatory biomarkers such as C-reactive protein[232] and greater white matter hyperintensity volume,[233] a marker of cerebral small vessel disease which might predict stroke recurrence.[233] It has been suggested in the literature that prolonged sleep duration could be a warning sign of impending stroke.[234] There is evidence that older adults who sleep for 9 or more hours have a higher prevalence of stroke,[235] and prolonged sleep duration is associated with cardiovascular morbidity and mortality.[216] People with stroke need to be educated and supported to reduce prolonged sleep. Besides sleep, activity behaviour during waking hours is another determinant of health.

Our findings enhance understanding of whole-day activity behaviour after stroke rehabilitation. One recent study looked at recovery of ambulation activity during the subacute period (≤ 4 months since stroke).[35] The authors reported that people with stroke engage in sedentary behaviour daily for an average of 19.8 out of 24 hours (including sleep time) at 1 month post-discharge from hospital. Interestingly, sedentary time did not change in the unadjusted results at 3 and 6 months post-discharge.[35] Participants were recruited from both acute stroke and rehabilitation units. Although not directly comparable to the volume of sedentary time in our study, due to inclusion of sleep time as sedentary time, the percentage of sedentary time per 24 hours in that study was 82.6%, which was higher than the 74.8% of waking hours in our cohort. Regardless of differences in methodology, large population-based studies have shown that older adults (aged 60 and older) with and without mobility disability spend an average of 595 and 551 minutes (69.0 and 63.4%) per day, respectively, in sedentary behaviour.[37] The proportion of time spent in sedentary behaviour in our cohort (676 minutes) is higher than that of older adults and also higher than the measured sedentary time in adults with multiple sclerosis with (533 minutes) and without (505 minutes) mobility disability.[111] Prolonged sedentary time is detrimentally associated with health indicators including larger waist circumference, unhealthy levels of blood glucose and insulin, diabetes, lower levels of physical functioning, and premature mortality.[40, 82, 112, 236] The period immediately after discharge from inpatient stroke rehabilitation might be a good time to continue to promote increased activity behaviour while reducing sedentary time in order to maintain or improve on the gains made from rehabilitation.

It is interesting that sedentary time was significantly higher and stepping time and number of steps lower among people with left hemiparesis. Similar findings had been reported in earlier studies. One study showed that people with right hemiparesis gain faster walking skills compared to those with left hemiparesis.[237] Another study reported that people with right infarct stroke (i.e. left hemiparesis) had slower gait speed and greater walking asymmetry compared to those with left infarct.[238] This suggests that people with left hemiparesis may need even greater support during and after stroke rehabilitation to improve non-sedentary behaviours including walking.

Whereas most of our participants were independent with ambulation, a third could not perform a transfer to the floor or vice-versa. Others required assistance with transfers to the bathroom or a vehicle, and supervision with stairs. Home-care services or Early-Supported Discharge do provide some assistance,[141] but such services are currently insufficient with many participants clamouring for more support. Patient-reported outcomes, such as the Stroke Impact Scale, are helpful in evaluating the impact of stroke from the perspective of the affected individual. Our findings showed that strength, hand function, participation, and overall recovery from stroke were the most impacted domains. Our results concur with a previous study that evaluated the quality of life of people with stroke at one month after stroke.[239]

We identified correlates of sedentary and physical activity behaviours that might be targeted in people with stroke. Although, walking ability may not fully account for the level of physical activity after stroke,[166] improving sit-to-stand transitions, standing time and walking speed are potential ways of increasing physical activity and reducing sedentary time in people with stroke. In this cohort, time in standing, stepping and average number of steps in all cadence bands except brisk steps (i.e. 100-119 steps/min) were negatively associated with sedentary time. Our findings also support an earlier report showing association of gait speed with stepping time and number of steps.[31] Higher gait speed might encourage walking in higher cadence bands which may lead to reduced sedentary time. A randomized clinical trial reported that daily feedback about gait speed performance during inpatient stroke rehabilitation led to a significant improvement in walking performance.[240] Using the number of steps in cadence ≥ 100 steps/min as a surrogate for moderate-to-vigorous physical activity, Tudor-Locke et al.,[241] suggested that older adults and special populations (i.e. with mobility disability) should accumulate at least 3000 steps/day in cadence ≥100 steps/min. In this study, only 2 individuals accumulated at least 3000 steps/day at that intensity which suggests that the majority of people with stroke do not meet guidelines for physical activity after inpatient rehabilitation.

A major strength of the present study is the objective measurement of whole-day activity behaviour (sleep duration, sedentary behaviour and physical activity) after stroke rehabilitation. However, it was not possible to objectively determine if the participants were actually sleeping or not. Moreover, we do not know if the large proportion of prolonged sleep reported in our study predates the stroke. Another limitation is that the activPAL classifies any steps less than 20 steps per minute as standing. Although this might misclassify very slow stepping as standing, our cohort had a mean gait speed of 0.6m/s, so it is unlikely that many of the steps were misclassified as standing. Lastly, the present study did not explore the correlations between level of activity and cardiovascular indicators such as blood pressure and heart health.

In conclusion, people with stroke sleep for long hours (prolonged time in bed), are sedentary for three-quarters of their waking hours, and engage in minimal brisk walk after inpatient rehabilitation. The present study points out some interesting findings about whole-day activity behaviour that needs to be explored further. It also provides some rationale for the development of interventions to reduce sedentary behaviour, to improve physical activity, and to reduce prolonged sleep in the community following stroke rehabilitation.

CHAPTER 6

THE LONGITUDINAL EFFECTS OF A THEORY- AND HOME-BASED SEDENTARY BEHAVIOUR CHANGE INTERVENTION AFTER STROKE

Abstract

Background: People with stroke spend over 75% of the day in sedentary behaviours. There is mounting evidence of the detrimental health effects of prolonged sedentary behaviour.

Objective: The purpose of this study was to evaluate the feasibility and effects of a sedentary behaviour change intervention on health, physical function, quality of life, and accelerometer-determined outcomes following inpatient stroke rehabilitation.

Methods: Thirty-four individuals with subacute stroke (time since onset, mean: 3.5 ± 1.1 months) took part in a sedentary behaviour change intervention involving frequently interrupting and replacing sedentary time with upright activities (standing and walking) over 8 weeks at home. A motivational wrist-worn activity monitor was used throughout the intervention. Impairment level, cognitive status, mobility, quality of life, and accelerometer-determined outcomes were assessed at baseline, post-intervention (week 9) and follow-up (week 16).

Results: Thirty-two participants had complete data at follow-up. There were significant improvements in walking speed, cognition, impairment, and self-reported quality of life after the intervention and at follow-up ($p < 0.05$). Sedentary time during waking hours decreased by 54.2 minutes ($p < 0.01$) at post-intervention and 26.8 minutes ($p = 0.05$) at follow-up, relative to baseline. However, the waking period was significantly less at post-intervention, but not at follow-up. The number of steps and time spent in upright (standing and stepping) were not statistically different over time.

Conclusions: Sedentary time during waking hours, impairment level, gait-speed, and cognition were improved following the intervention and at follow-up, but this did not translate into significant gains in upright activities.

6.1 Introduction

Stroke is a leading cause of adult disability globally.[242] Although the benefits of physical activity and exercise after stroke are well established,[30, 72] many people with stroke remain physically inactive.[49] Besides being inactive, accumulating evidence shows that people with stroke are sedentary for 75% of the day or more,[19, 139] compared to about 55% in the general population.[105] Engaging in prolonged sedentary behaviour is detrimentally associated with health outcomes in the general population,[43, 46] and in people with limited mobility,[37] regardless of exercise levels. The traditional approach to activity promotion after stroke that focuses only on increasing exercise ability does not decrease sedentary behaviour.[50, 51] Moreover, the trajectory of activity behaviour after stroke is disturbing, with daily number of steps decreasing instead of increasing from the subacute to the chronic phase of recovery.[49]

People with stroke experience several challenges including difficulty with ambulation,[35] fatigue,[243] cognitive problems,[244] and overall lower endurance[245] that interferes with sustained engagement in physical activity and promotes sedentary behaviour.[206] New thinking is needed to develop an effective long-term strategy that will reduce prolonged sedentary behaviour after stroke. One approach may involve replacing prolonged sedentary behaviour with bouts of light-intensity activity, at frequent intervals during waking hours.[48] This approach might be feasible and sustainable in reducing sedentary behaviour and improving total activity and clinical outcomes after stroke. Light-intensity physical activity is strongly inversely correlated with sedentary behaviour (Pearson's $r = -0.96$), which suggests that increasing light-intensity activity reduces sedentary behaviours.[52] Research has shown that habitual low-intensity physical activity provides a sufficient stimulus to improve blood lipids and glucose among older adults,[53] and is associated with reduced cardiovascular risk[149] and lower rates of major mobility disability in those with mobility impairments.[58] To date, the only sedentary behaviour change intervention after stroke targeted people with chronic stroke (mean time since stroke, 2.8 ± 2.6 years).[36] That study showed that it was safe to reduce sedentary behaviour after stroke, although the intervention group did not achieve better outcomes compared to the controls.

Complex behaviour change interventions often need a theoretical basis and a systematic process of intervention development.[57, 204] The use of wearable technology or mobile-health applications have been suggested to be of value in promoting activity behaviour in chronic diseases such as stroke.[246, 247] Although sedentary behaviour is highly prevalent in the acute and subacute phases of stroke recovery,[34, 35] no sedentary behaviour change intervention research has been done in this area. This study had 2 main aims: first, to determine the feasibility of a theory- and home-based sedentary behaviour change intervention within the first 6 months after stroke, including evaluation of the reach, retention, and satisfaction with the program; and second, to investigate the longitudinal effects of the intervention on health, physical function, quality of life, and accelerometer-determined sedentary and upright behaviours in persons with subacute stroke.

6.2 Methods

6.2.1 Participants

This longitudinal intervention study involved people with stroke (haemorrhagic or ischaemic) aged ≥18 years, within 1 month of discharge to home from inpatient rehabilitation, and able to walk 5 metres with or without assistance. Individuals with neurological problems other than from stroke, and those medically unstable or unable to give informed consent to research participation were excluded.

6.2.2 Recruitment

Prior to discharge from inpatient stroke rehabilitation, two physical therapists from the stroke rehabilitation unit in a local rehabilitation hospital consecutively identified eligible participants discharged to home within Edmonton, Canada and surrounding areas. Interested participants signed a consent-to-contact form which was passed on to the researchers. The researchers then visited potential participants prior to their discharge from the hospital to explain the study in detail. Subsequent visits were conducted at home, within a window of 2-4 weeks after discharge. A written informed consent was signed before enrolment into the study.

6.2.3 Intervention

The intervention titled "**ST**and **U**p **F**requently **F**rom **S**troke (***STUFFS***) was based on social cognitive theory.[173] The *STUFFS* intervention was 8 weeks in length and included reducing sedentary time by 15 minutes each week, walking around for 3-5 minutes every half-hour, and performing two sets of 10 sit-to-stand transitions 3 times per day. Depending on the ability of the individual, they were encouraged to exceed these minimum targets. Table 6.1 outlines the study timeline and the activities carried out at each time point. At the outset of the intervention, the output from baseline activPAL (PAL Technologies Ltd., Glasgow, Scotland) monitoring for 7 days provided data on usual activity behaviour. The activPAL is an accelerometer, which detects activity and posture and is validated for use with people with stroke.[121]

Table 6.1. Study outline and the activities at each time point

Time Period	Event
Week 0 (2-4 weeks post discharge from the hospital)	**Baseline measurements** Participant characteristics, impairment, quality of life, 7 days of activity monitoring with activPAL to determine usual activity behaviour.
Week 1	**Intervention begins** Review of activity monitor data, discuss behaviour change strategies, complete action plans related to activity, including wearing a self-monitoring device, functional check-up 1 (5-meter walk test, timed-up and go).
Week 4/5	**Interim home visit** Review and update of action plans, functional check-up 2.
Week 8	**Intervention ends**
Week 9	**Immediate post-intervention measurements** Reassessment of baseline measures including participant characteristics, impairment, and quality of life, 7 days of activity monitoring with activPAL, functional check-up 3, and exit interview.
Week 16	**Final follow-up measurements** Reassessment of baseline measures including participant characteristics, impairment, and quality of life, 7 days of activity monitoring with activPAL, functional check-up 4.

The graphical outputs for each of the 7 days of the activPAL recordings were reviewed with the participant and a family member where feasible. Action plans were developed that targeted periods of the day with prolonged bouts of sedentary behaviour or minimal levels of activity. Self-efficacy for the action plans were assessed using a 9-item scale adapted from the Multidimensional Self-Efficacy for Exercise Scale.[210] This scale measured participant confidence on a scale of 0 (no confidence) to 100 (complete confidence) to sit less, move more, or perform sit-to-stand transitions (see Appendix L). The self-efficacy scale measures the three components of self-efficacy (task, coping and scheduling).[210]

All participants received a wrist-worn Misfit Flash activity monitor (Misfit, San Francisco, California) - a self-monitoring and motivational tool used throughout the 8-week intervention period. The Misfit monitor was chosen as it did not need to be recharged (battery life lasts about 6 months) and has good self-monitoring attributes such as real-time feedback on daily progress and customizable goal setting capability.[201] The target number of steps was set at 6,000 steps per day, suggested to prevent new vascular events after stroke.[208] The device has lights on a dial which when tapped indicate the user's activity level for the day. Users can also receive instantaneous feedback on the number of steps and distance walked per day via the device app, and the researchers accessed that information remotely.

6.2.4 Procedure

Ethics approval for the study was granted by the institutional Health Research Ethics Board and the protocol registered at www.clinicaltrials.gov (#NCT02980744). Outcomes were measured at baseline (week 0), post-intervention (week 9) and follow-up (week 16) as shown in Table 6.1. The feasibility outcomes including reach (proportion of participants enrolled relative to eligible participants), retention (participants enrolled who completed the study), and patient satisfaction with the program were monitored and evaluated. Demographic and stroke-related information, including type of stroke, time since onset, affected side, total length of hospital admission and length of inpatient rehabilitation were collected. Participants' weight, blood pressure and waist circumference were measured using standard protocols. Chedoke-McMaster Stroke Assessment (CMSA) for leg and foot were used to assess lower-extremity impairment.[219] Mobility at home was assessed using 5-metre walk (average of 3 measurements) and timed-up and go tests, both validated measures for walking speed and general mobility.[224, 248] The Montreal Cognitive Assessment (MoCA)[249] was used to assess cognitive status. Stroke-specific quality of life was assessed using the Stroke Impact Scale.[226] Information on use of walking aids and any community-accessible services were also obtained. At post-intervention and follow-up periods, health, physical function, quality of life, and accelerometer-determined outcomes were repeated.

6.2.5 Data processing

The activPAL's date- and time-stamped data were downloaded and processed into time sedentary, standing and stepping, number of steps and sit-to-stand transitions using the proprietary algorithm (activPAL3™ version 7.2.32, Research Edition). Processed files from the activPAL were exported to Excel (Microsoft Corporation, Redmond, WA) spreadsheets. Waking periods were derived for each day using activPAL event files from noon of one day to noon the next day following a protocol described by Winkler et al.[221] Using the proprietary algorithm, cadence (i.e. number of steps/min) was classified as follows: sporadic (20-39), purposeful (40-59), slow (60-79), medium (80-99), brisk (100-119), and fastest (>120).[228] However, the activPAL software classify steps less than 20 steps/min as standing, therefore the incidental stepping band (0-19 steps/min) was not included.

6.2.6 Statistical analyses

A priori sample size computation showed that 25 people with stroke would be sufficient to determine change in sedentary time,[36] assuming single group, two-tailed test with a power of 0.8 and alpha of 0.05. A sample of 34 persons were recruited to account for any potential dropouts. Descriptive statistics (means and standard deviations) were used to summarize participant demographics and clinical characteristics. The Shapiro-Wilk test and histograms were used to examine for normality. Feasibility outcomes (reach, retention, and satisfaction) were calculated and reported as percentages. The scores for each of the self-efficacy components were averaged (i.e. average scores for 3 questions for each of task, coping and scheduling) for each action plan. Cronbach's alpha was used to assess the agreement between the 3 questions for each self-efficacy component. Linear mixed effects models were used to determine change in outcomes across the three time points. An unstructured variance-covariance structure (i.e. each time point was assumed to have its own variance) was used. Mixed effects models are more robust in dealing with repeated measures compared to traditional methods such as repeated measures ANOVA.[250] The fixed effect part of the model included the outcome variable adjusted for the participants' age and sex (known covariates of activity behaviour). Random effect was specified at the participant level. All analyses were done using STATA version 14 (Stata Corporation, Texas, US) at a significance level of $P < 0.05$.

6.3 Results

6.3.1 Feasibility

Reach: A total of 44 eligible participants signed a consent-to-contact form. Of the eligible participants, 37 (84.1%) agreed to proceed with the study and signed the written informed consent form. Two participants (4.5%) with other diagnoses and 1 participant (2.3%) who refused to wear the activity monitor were excluded (see Figure 6.1). Thirty-four participants (77.3%) of the total eligible were enrolled in the study at baseline.

Retention: Of the 34 participants enrolled at baseline, 33 (97.1%) were retained at post-intervention (week 9), and 32 (94.1%) at follow-up (week 16).

Satisfaction and adherence: The average satisfaction (on a scale of 0 to 100, with 100 being the best possible score) with the *STUFFS* program was 88.9%. All participants, except one who already had an Apple watch, used the wrist-worn Misfit Flash activity monitor throughout the intervention period showing that adherence to using the self-monitoring devices was good.

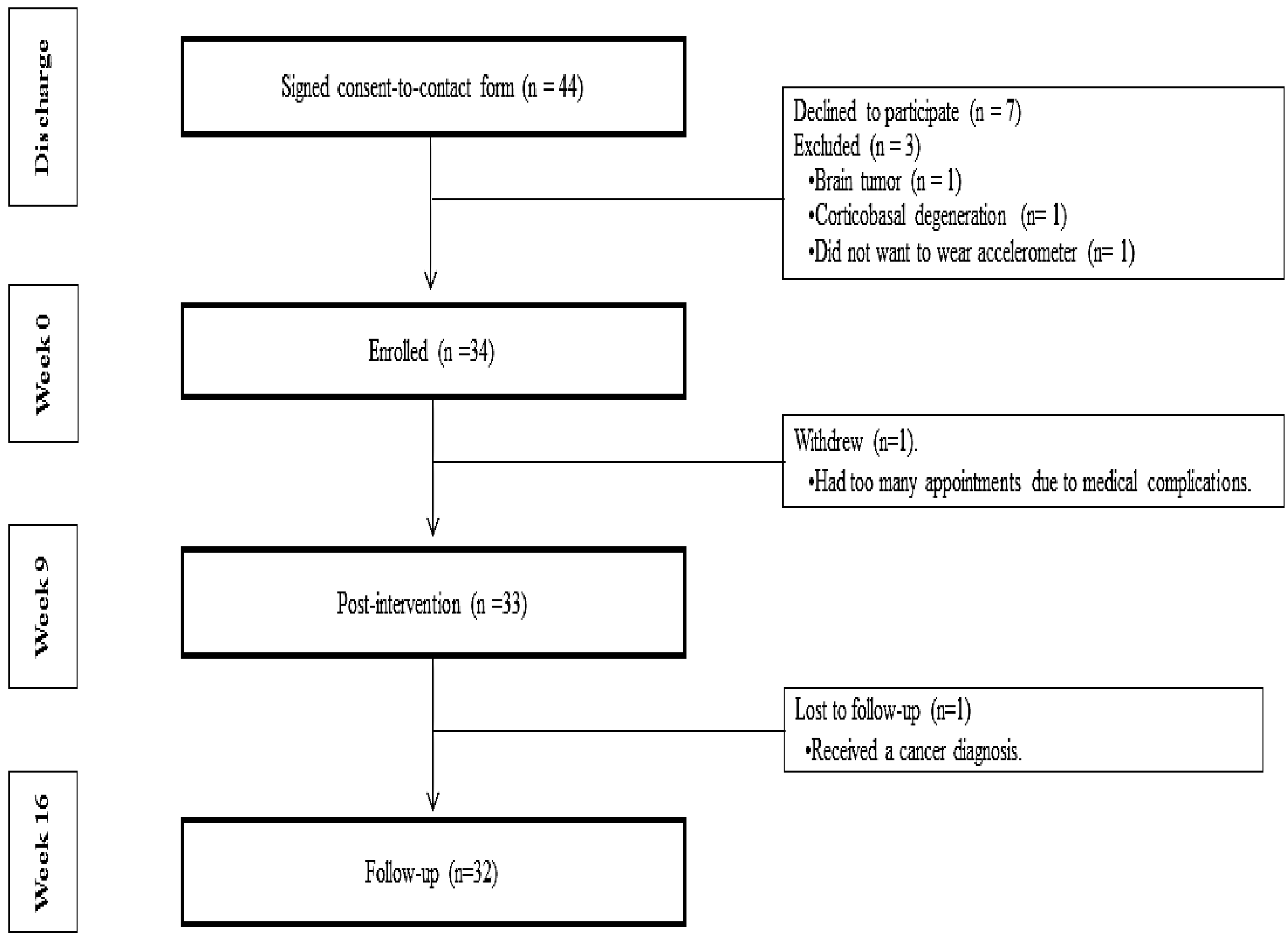

Figure 6.1. Flow of participants through the study

6.3.2 Participants

Participant characteristics are presented in Table 6.2. Nineteen males and 15 females, with a mean ± standard deviation (SD); age: 64.6 ± 12.6 years; time since stroke: 3.5 ± 1.1 months, participated in the study. The majority of paticipants (76.5%) had ischaemic stroke, while 44.1% had right hemiparesis. Participants spent an average of 6.5 ± 3.4 weeks in inpatient stroke rehabilitation. Twenty-seven participants (73.5%) used a form of walking aid to assist mobility.

6.3.3 Health, physical function, and quality of life outcomes

The changes in health, physical function, and quality of life outcomes are presented in Table 6.3. Compared to baseline, there was a minor, but statistically significant, increase in body mass index of 0.6 ± 0.2 kg/m^2 at follow-up, but not at post-intervention. There were statistically significant improvements in systolic blood pressure, MoCA (cognition), and CMSA scores (impairment) for leg and foot at post-intervention, and in MoCA, and CMSA at follow-up. Also, gait speed and timed up and go scores, as well as all quality of life ratings, except hand function (with significant improvement only at follow-up), showed significant improvements at post-intervention and follow-up periods.

Table 6.2. Participant characteristics (n=34)

Characteristic	
Age (years)	64.6 ± 12.5
Sex	19 men (55.9)
Marital status	24 (70.6) married or living with common law partner
Education	
None	1 (2.9)
Primary	2 (5.9)
High school	13 (38.2)
College	13 (38.2)
Postgraduate	5 (14.7)
Type of stroke	
Ischaemic	26 (76.5)
Haemorrhagic	8 (23.5)
Side of hemiparesis	Right 15 (44.1) Left 19 (55.9)
Time since stroke (months)	3.5 ± 1.1
Length of hospital admission (weeks; acute care & rehabilitation)	10.5 ± 4.7
Length of inpatient rehabilitation (weeks)	6.5 ± 3.4
Gait aid	
None	9 (26.5)
Four-wheeled walker	13 (38.2)
Quad cane	5 (14.7)
Single cane	7 (20.6)
More than one comorbidity*	19 (55.9)
Smoking status	
Non-smoker	30 (88.2)
Smoker	4 (11.8)
Community services utilized	
None	14 (41.2)
Physical therapy	9 (26.5)
Early Supported Discharge†	1 (2.9)
Home care	7 (20.6)
More than 1 service	3 (8.8)

NOTE: Data are presented as mean ± SD or n (%). *Comorbidity includes high blood pressure, diabetes, and dyslipidemia. †Early Supported Discharge refers to a stroke rehabilitation program designed to accelerate the transition from hospital to home

Table 6.3. Health, functional, and quality of life outcomes at baseline, post-intervention, and at follow-up, adjusted by age and sex

Variable	Baseline (n = 34)	Post-intervention (n =33)	Follow-up (n =32)	Change Baseline to Post-intervention			Change Baseline to Follow-Up		
				Mean Change Scores ± SE	95% confidence interval	*P*	Mean Change Scores ± SE	95% confidence interval	*P*
Body Functions									
BMI (kg/m^2)	27.2 ±0.8	27.4 ± 0.8	27.9 ± 0.8	0.2 ± 0.2	-0.1 to 0.6	0.19	0.6 ± 0.2	0.3 to 1.0	<0.01
SBP (mmHg)	124.5 ± 2.2	117.3 ± 2.2	119.9 ± 2.2	-7.2 ± 2.3	-11.8 to -2.6	<0.01	-4.6 ± 2.4	-9.3 to -0.1	0.05
DBP (mmHg)	74.4 ± 1.2	71.7 ± 1.2	73.3 ± 1.2	-2.7 ± 1.5	-5.7 to 0.2	0.07	-1.1 ± 1.5	-4.1 to 1.8	0.45
MoCA	24.6 ± 0.60	25.9 ± 0.6	27.2 ± 0.6	1.3 ± 0.4	0.5 to 2.1	<0.01	2.6 ± 0.4	1.8 to 3.4	<0.01
CMSA Leg	6.0 ± 0.2	6.4 ± 0.2	6.5 ± 0.2	0.4 ± 0.1	0.1 to 0.6	<0.01	0.5 ± 0.1	0.3 to 0.7	<0.01
CMSA Foot	5.5 ± 0.3	5.7 ± 0.3	5.8 ± 0.3	0.2 ± 0.1	0.1 to 0.5	0.04	0.3 ± 0.1	0.1 to 0.5	0.03
Mobility									
Gait speed (m/s)	0.7 ± 0.1	0.9 ± 0.1	0.9 ± 0.1	0.2 ± 0.1	0.1 to 0.3	<0.01	0.2 ± 0.1	0.2 to 0.3	<0.01
TUG (secs)	19.0 ± 1.5	15.1 ± 1.5	14.3 ± 1.5	-3.8 ± 0.7	-5.1 to -2.5	<0.01	-4.7 ± 0.7	-5.8 to -3.2	<0.01
Quality of Life (Stroke Impact Scale)									
Strength	55.6 ± 4.1	66.7 ± 4.1	71.1 ± 4.1	11.1 ± 2.6	5.0 to 15.1	<0.01	15.5 ± 2.6	9.3 to 19.5	<0.01
Memory	81.5 ± 2.6	87.6 ± 2.7	89.4 ± 2.7	6.1 ± 2.9	0.5 to 11.8	0.03	7.9 ± 2.9	2.2 to 13.6	<0.01
Emotion	72.1 ± 3.0	79.2 ± 3.1	77.4 ± 3.1	7.0 ± 2.4	2.3 to 11.7	<0.01	5.2 ± 2.4	0.4 to 9.9	0.03
Communication	84.8 ± 2.6	92.7 ± 2.6	93.4 ± 2.7	7.9 ± 2.8	2.5 to 13.5	<0.01	8.6 ± 2.8	3.2 to 14.2	<0.01
ADL	73.1 ± 3.4	79.5 ± 3.4	84.0 ± 3.4	6.4 ± 2.4	1.7 to 10.9	<0.01	10.9 ± 2.4	6.1 to 15.5	<0.01
Mobility	77.6 ± 2.9	84.0 ± 2.9	85.8 ± 3.0	6.4 ± 2.1	2.2 to 10.5	<0.01	8.2 ± 2.2	3.9 to 12.4	<0.01
Hand function	61.9 ± 5.5	68.6 ± 5.5	74.0 ± 5.6	6.7 ± 3.4	-0.1 to 13.3	0.06	12.1 ± 3.5	5.0 to 18.5	<0.01
Participation	54.7 ± 4.1	69.9 ± 4.2	69.1 ± 4.2	15.2 ± 4.2	6.7 to 23.3	<0.01	14.4 ± 4.3	5.7 to 22.5	<0.01
Recovery	58.7 ± 3.1	69.7 ± 3.2	72.0 ± 3.2	11.0 ± 3.0	5.1 to 17.0	<0.01	13.4 ± 3.1	7.3 to 19.4	<0.01

NOTE: Values are mean ± SE. Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; MoCA, Montreal Cognitive Assessment; CMSA, Chedoke McMaster Stroke Assessment; TUG, timed up and go; ADL, activities of daily living.

6.3.4 Accelerometry: Sedentary behaviour and physical activity

Within-subjects differences in accelerometer-determined outcomes across time, including time awake, sedentary during waking period, standing, stepping and upright; and the number of steps and sit-to-stand transitions are presented in Table 6.4. At baseline, post-intervention and follow-up periods, the number of valid wear days were: 6.8, 6.7, and 7.0, respectively; the average waking hours per day were: 15.1, 14.5, and 15.0 hours, respectively; and of the waking periods, participants spent 74.2%, 71.4% and 72.0%, respectively, in sedentary behaviour. Sedentary time during waking hours decreased by 54.2 minutes ($p < 0.01$) at post-intervention and by 26.8 minutes ($p = 0.05$) at follow-up, relative to baseline. However, compared to baseline, participants also spent significantly less time awake at post-intervention, but not at follow-up.

Although the improvement in the volume of steps was small, there was a shift in the pattern of stepping. Figure 6.2 shows the pattern of stepping at all time points with the percentage of day spent stepping and the median number of steps in different cadences, including sporadic [20-39 steps/min], purposeful [40-59 steps/min], slow [60-79 steps/min], medium [80-99 steps/min], brisk [100-119 steps/min], and fastest [>120 steps/min]. The pattern of stepping was similar for sporadic and purposeful steps at all time points. But there was a slight shift to a greater proportion of steps in the higher stepping intensity bands at post-intervention and follow-up. There was no significant change in the number of sit-to-stand transitions over time.

Table 6.4. Accelerometer-determined outcomes at baseline, post-intervention, and at follow-up, adjusted by age and sex

				Change Baseline to Post-intervention			Change Baseline to Follow-Up		
Variable	Baseline (n=34)	Post-intervention (n=33)	Follow-up (n=32)	Mean change Scores	95% confidence interval	*P*	Mean change Scores	95% confidence interval	*P*
Waking period†	908.1 ± 14.8	867.8 ± 14.9	898.6 ± 15.2	-40.3 ± 13.2	-66.2, -14.4	<0.01	-9.5 ± 13.5	-35.9, 17.0	0.59
Sedentary time while awake†	673.7 ± 15.6	619.5 ± 15.7	646.9 ± 16.0	-54.2 ± 13.7	-81.1, -27.5	<0.01	-26.8 ± 14.0	-54.3, 0.6	0.05
Standing time†	166.3 ± 12.7	178.6 ± 12.8	181.3 ± 12.9	12.3 ± 7.5	-2.3, 27.2	0.10	15.0 ± 7.7	-0.1, 30.1	0.05
Stepping time†	68.1 ± 8.2	69.7 ± 8.2	70.4 ± 8.3	1.6 ± 4.8	-8.0, 10.9	0.78	2.3 ± 4.9	-7.3, 11.9	0.75
Upright time†	234.4 ± 18.8	248.3 ± 18.9	251.7 ± 19.1	13.9 ± 10.4	-6.6, 34.2	0.19	17.3 ± 10.6	-4.4, 37.3	0.12
Steps‡	4511.5 ± 659.1	4887.4 ± 661.6	4769.6 ± 668.5	375.9 ± 328.7	-276.1, 1012.4	0.26	258.1 ± 336.4	-422.9, 896.0	0.48
Sit-to-stand transitions‡	49.8 ± 3.3	48.3 ± 3.2	47.0 ± 3.3	-1.5 ± 1.7	-4.9, 1.8	0.37	-2.8 ± 1.7	-6.1, 0.5	0.07

NOTE: Values are mean ± SE; †minutes per day; ‡number per day; upright time is the sum of standing and stepping time.

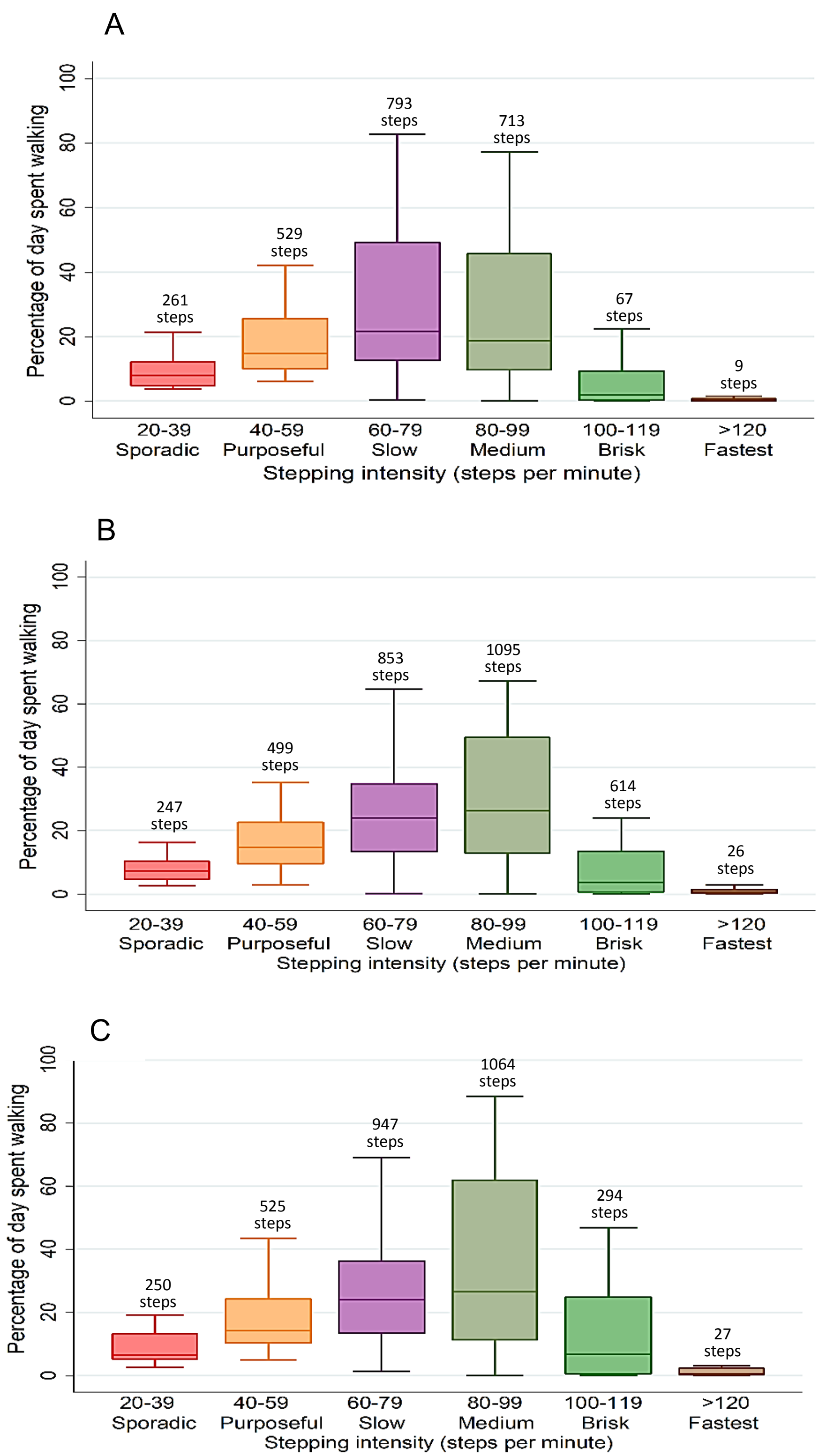

Figure 6.2. Pattern of stepping at baseline (A), post-intervention (B), and follow-up (C) showing percentage of day spent walking and the median number of steps in different cadence bands

6.3.5 Self-efficacy

The self-efficacy scales adapted from the Multidimensional Self-Efficacy for Exercise Scale showed good internal consistency in our sample for sit less (Cronbach's $\alpha = 0.90$), move more (Cronbach's $\alpha = 0.91$), and sit-to-stand transitions (Cronbach's $\alpha = 0.76$). The self-efficacy scores for sit less, move more, and sit-to-stand transitions were high at the onset of the intervention (>80%) and did not change significantly over time (data not shown), except for coping self-efficacy for move more (78.6 ± 3.7) at baseline. The coping self-efficacy for move more did not change significantly at post-intervention, but increased to 87.0 ± 3.7, $p = 0.02$) at follow-up.

Task self-efficacy for sit-to-stand transitions was significantly correlated with change in waking hours ($r = 0.40$) and sedentary time ($r = 0.44$), $p < 0.05$ at post-intervention. Task ($r = 0.37$) and coping self-efficacy ($r = 0.53$), $p < 0.05$ for sit-to-stand transitions were correlated with change in sedentary time at follow-up. In addition, the scheduling self-efficacy for sit less ($r = 0.38$), move more ($r = 0.56$), and sit-to-stand transitions ($r = 0.36$), $p < 0.05$ were correlated with change in sedentary time at follow-up.

6.4 Discusssion

This study examined the longitudinal effects of a theory-based sedentary behaviour change intervention, delivered at home, on health, physical function, quality of life, and accelerometer-determined outcomes in persons with stroke. The intervention program resulted in statistically significant reduction in sedentary behaviour during waking hours and was acceptable to people with stroke. We had high retention of participants at post-intervention and follow-up periods. Our findings concur with those from a previous study which showed that it was feasible to reduce sedentary behaviour after stroke.[36] A novel aspect of this study is the use of consumer-based physical activity monitor for self-monitoring by the users - as a source of motivation.[201] It also enabled the researchers to remotely view the daily activity levels (number of steps) of the participants.

In the present study, participants made significant gains in walking speed and timed up and go test time, cognition, and self-reported quality of life across all time periods. On the contrary, previous observational studies with people with stroke showed that gait speed and functional ability do not change significantly within the first six months after discharge from the hospital.[19, 35] Thus the functional improvements observed in this cohort may be attributable to the effects of the intervention. However, this needs to be explored further in future trials with a control arm. The statistically significant improvement in impairment (CMSA) for the leg and foot is not clinically significant.

Although participants reduced their sedentary time during waking hours from 11.2 hours per day to 10.3 hours at post-intervention, and to 10.8 hours at follow-up, their sedentary time was still within the "danger zone" for increased risk of cardiovascular events.[46] A similar intervention with people with chronic stroke achieved a reduction in sedentary time of 30 minutes from 12.0 hours to 11.5 hours using data standardized to 16 hours waking period.[36] There were variations in the level of sedentary behaviour change in our cohort. While 23 out of 33 participants decreased their sedentary time at post-intervention relative to baseline, 10 participants increased sedentary time. At follow-up, 21 out of 32 participants decreased sedentary time, but 11participants increased their sedentary time.

Logically, one would expect that sedentary behaviour will be replaced by upright activities such as standing and low-intensity walking.[87] In the present study, relative to baseline, participants increased their upright activities (standing and stepping) by 14 minutes at post-intervention and 17 minutes at follow-up. The improvement in upright activity (standing and stepping) is not different from that reported in an intervention with people with chronic stroke.[36] Participants in that study improved standing time by 16.5 minutes and stepping time by 4.7 minutes in the unadjusted results.[36] What was surprising was that the waking period in our cohort decreased by 40 minutes at post-intervention and 9 minutes at follow-up, relative to baseline. In the chronic stroke study, there was a reduction of 18 minutes in the waking period in the intervention arm following the sedentary behaviour change program.[36] There is evidence that replacing sedentary time with sleep may be associated with better self-regulation strategies including setting and maintaining personal goals, and faster reaction time with challenging tasks among older adults.[251] However, the reduced waking period (i.e. increased time in bed) as time since stroke increases is worrisome. Prolonged sleep is detrimentally associated with health indicators such as C-reactive protein[232] and white matter hyperintensity volume,[233] and could be a warning sign of an impending stroke.[234] Our previous cross-sectional study using baseline data from this cohort showed that individuals spend prolonged time in bed (i.e. longer than the normal 7-8 hours) following inpatient stroke rehabilitation.[199] It appears that the prolonged time in bed continues even up to 4 months following discharge from rehabilitation. Healthcare providers may need to be more aware of the prolonged time in bed that occurs after stroke and potentially offer counsel and support individuals in this regard. Some patients have reported that they were informed by health professionals to “take a rest” as prolonged sleep was part of recovery.[206]

Additional research is needed to further explore whole-day activity behaviours and substitutions that may happen when one behaviour is altered.

Longer-term maintenance of behaviour change after an intervention has ended is an important aspect of the behaviour change process. In the present study, there was a trend towards significance in the maintenance of sedentary behaviour change at follow-up, relative to baseline. Although not significant, the upright time was also maintained at follow-up. The factors that predict longer term maintenance of behaviour change include coping and scheduling self-efficacy. While scheduling self-efficacy remained high across all time points in the present study, coping self-efficacy was significant only at follow-up, but not at post-intervention. Coping self-efficacy represents the confidence to overcome challenges that may occur in the course of a given task.[210]

The pattern of stepping also needs to be discussed. The steps taken per day were highly variable between participants. Overall, participants took the largest proportion of steps within the slow cadence band (60-79 steps/min) at baseline. But a larger proportion of steps were taken at higher cadence bands (>80 steps/min) during the post-intervention and follow-up periods. Walking at higher cadence bands is important since a stepping intensity of ≥100 steps/min is considered moderate intensity activity in adults.[241] One study that explored metabolic equivalents of tasks after stroke suggested that walking after stroke was more of a low-intensity activity, but that study did not report on the pattern of walking (i.e., whether walking was slow or brisk).[252] Regardless of the intensity of stepping, there is evidence that substituting sedentary time with standing or stepping is beneficially associated with cardiometabolic markers.[87] Future studies may consider validating the metabolic equivalents at different intensities of stepping after stroke.

Limitations

Participants in this trial were people with stroke who went through inpatient stroke rehabilitation, with the expectation that they would improve enough to be able to return home. Thus, our sample excluded people with lower potential and those who did well enough to go straight home from acute care. Future studies should consider sedentary behaviour change programs involving people with stroke at different levels of functioning. Our small sample and the variability in behaviour change might have limited our capacity to detect intervention effects on time spent standing, stepping or number of steps. Future larger-scale studies, including those with a control arm, will be required. Such studies might consider stratifying participants based on baseline sedentary time, gender, or other stroke-specific factors. It is possible that the duration of the intervention (8 weeks in the present cohort and 7 weeks in the study with chronic stroke)[36] is too short to achieve marked improvements in upright behaviours (standing and stepping). Activity monitors underestimate steps at slow walking speeds.[253] The mean walking speed in our cohort was 0.7 m/s at baseline and 0.9m/s at other time points, so it is unlikely that this may have affected the accuracy of our results. Lastly, the Misfit Flash monitor we used for self-monitoring has not been validated for people with stroke. This device was chosen because it did not need to be recharged and has been reported to have good self-monitoring attributes.[201] There will be need to validate the Misfit Flash in people with stroke in future studies.

6.5 Conclusion

After an 8-week home-based sedentary behaviour change intervention for people with stroke, sedentary time reduced significantly by 54 minutes at post-intervention and with a trend towards significance of 27 minutes reduction at follow-up. There were significant improvements in walking speed, time required to complete timed-up and go test, cognition, and self-reported quality of life at post-intervention and follow-up periods. Satisfaction with the intervention was good and the retention rate at both post-intervention and follow-up time points were high. However, the improvements in time standing and stepping as well as the number of steps did not change significantly over time. This study provides valuable information related to the feasibility of this type of intervention and will inform future sedentary behaviour works with individuals with stroke.

CHAPTER 7

GENERAL DISCUSSION AND CONCLUSIONS

7.1 Discussion of research findings

The purpose of this project was to develop and test a theory- and home-based sedentary behaviour change program after inpatient stroke rehabilitation. Prior to this thesis, the way to reduce sedentary behaviour in people with stroke was not known. Using the Intervention Mapping framework, a sedentary behaviour change program was developed and evaluated in a cohort of people with stroke.

The first step in the Intervention Mapping framework is a needs assessment. The needs assessment began with a review of the literature for prevalence of sedentary behaviour and existing interventions on reducing sedentary behaviour after stroke. The evidence from the literature showed that people with stroke spend over 80% of the day in sedentary behaviours.[19, 31, 139] Using a qualitative study design, we explored the meaning of sedentary behaviour for people living with stroke and how they thought they might be able to change sedentary behaviour in their day-to-day lives. The main aim of using qualitative research methodology was to advance knowledge based on participants' lived accounts, their beliefs and experiences, where units of analyses were ideas, thoughts or concepts.[254, 255] The first study in this thesis (Chapter 3) entitled, "Reducing sedentary behaviour: perspectives of ambulatory individuals with stroke" provided in-depth insight on how people with stroke understood the concept of sedentary behaviour and the associated health risks. Furthermore, it explored the reasons for engaging in those behaviours, the barriers and facilitators to reducing sedentary behaviour, and the strategies for behaviour change. The ubiquitous nature of sedentary behaviours makes it particularly difficult to target. Knowing about a behaviour is a pre-condition for change,[173] but it often does not lead to change. It was important to explore other factors that might affect behaviour change. The whole-day approach to activity promotion,[48] through frequently interrupting sitting by standing and walking around throughout the day (e.g. every half-hour) was perceived as doable by people with stroke.[206] Studies have suggested that interrupting sedentary time every 30 minutes could lower the detrimental health risks associated with prolonged sedentary behaviour.[153] Overall, the results of the needs assessment showed that prolonged sedentary behaviour was prevalent after stroke and that people with stroke were willing to embrace strategies that will reduce their sedentary behaviours. The qualitative study informed the development of the sedentary behaviour change intervention.

The process that was followed in the design and systematic development of the sedentary behaviour change intervention was described in Study II (Chapter 4) in a paper entitled, "Using Intervention Mapping to design and develop a home-based sedentary behaviour change intervention after stroke: STand Up Frequently From Stroke (*STUFFS*)." The *STUFFS* intervention program that was developed involved objective monitoring of sedentary behaviour and total activity in people with stroke in their home environment and included strategies such as standing up and walking around at frequent intervals throughout the day. There is evidence that replacing sedentary behaviour with standing and/or stepping is associated with beneficial health indicators.[87] Each 2-hour per day spent standing is beneficially associated with lower fasting blood glucose, cholesterol levels, and triglycerides.[87] While each 2-hour spent stepping per day is associated with lower body mass index, waist circumference, triglycerides, and cholesterol.[87]

A review of sedentary behaviour change interventions in healthy adults classified the strength of interventions into categories – very-promising, quite-promising, and non-promising.[157] Very-promising interventions include a significant reduction in at least one sedentary behaviour metric within the intervention group and the reduction in that metric was greater than that of a comparator group.[157] Quite-promising interventions include evidence of either a significant reduction in a sedentary behaviour metric in the intervention group or a reduction in a sedentary behaviour metric that was greater than that observed in a comparator arm.[157] In non-promising interventions, there is neither an evidence of change in a sedentary behaviour metric in the intervention group nor any change observed relative to a comparator arm.[157] Of the sedentary behaviour change interventions that are promising, those that have targeted education, training skills, persuasion, environmental restructuring, problem solving, goal setting, feedback on behaviour, self-monitoring, social support, or behaviour substitution were the quite promising or very promising interventions.[157] The *STUFFS* program included components of behaviour change that have been identified to be quite promising or very promising such as education, training skills, persuasion, problem solving, goal setting, feedback on behaviour, self-monitoring, social support, and behaviour substitution.[157]

At the outset of evaluating the *STUFFS* program, we objectively assessed usual, whole-day, activity behaviours for 7 days at baseline as reported in Chapter 5 in a paper entitled, "Sleep duration, sedentary behaviour, physical activity, and quality of life after inpatient stroke rehabilitation." Sleep duration was operationally defined as time in bed. The participants were within 2-4 weeks of discharge from inpatient stroke rehabilitation. It was found that after inpatient rehabilitation, half of people with stroke spend greater than 9 hours per day in bed, compared to the normal 7-8 hours of recommended sleep time per day. The prolonged time in bed might be related to the perception that individuals need to rest to recover after stroke, which was reported in Study 1 (Chapter 3). However, prolonged time in bed and prolonged sleep may have adverse health consequences.[216] In addition to the prolonged period in bed, people with stroke spent three quarters of their waking period in sedentary behaviours. Ideally, this is a time period when people with stroke should make more progress and advance on the gains made from resource-intensive inpatient rehabilitation. Unfortunately, many people with stroke have expressed concern that they do not receive substantial support once they leave organized hospital care. More needs to be done to encourage people with stroke to sit less and move more. The median number of sit-to-stand transitions, which represents the total number of breaks in sedentary time per day, was 44.5 in the present study. This is about half the number of breaks in sedentary behaviour reported in a study with older adults,[37] which means that people with stroke spend time in longer sedentary bouts compared to older adults. The number of breaks in sedentary behaviour in our cohort is not different from numbers reported in chronic stroke studies. [31,139]

While the cross-sectional study cannot provide any causal information, or establish whether the prolonged period in bed or sedentary behaviour predates the stroke, it does provide important findings related to whole-day activity behaviour and some potential strategies for behaviour change. The number of sit-to-stand transitions, standing time, and stepping (time and number) were inversely related to sedentary time, which suggests that increasing the time spent standing and stepping and the number of sit-to-stand transitions and steps might lead to a reduction in sedentary time. A main strength of this study was the robust measurement of whole-day activity behaviour using the activPAL activity monitor which is sensitive to transitions in posture - the most accurate way to distinguish sedentary from non-sedentary behaviours.[113]

The effects of the *STUFFS* program on health, physical function, quality of life, and accelerometer-determined outcomes were reported in Chapter 6. The study was entitled, "The longitudinal effects of a theory- and home-based sedentary behaviour change intervention after stroke." The feasibility results showed that 32 out of 34 participants were retained in the study after 17 weeks. The program was well received by participants with a satisfaction score of 89%. The findings from testing the intervention showed that there were significant beneficial improvements in systolic blood pressure, cognition, physical function, and patient-reported outcomes. For example, gait speed improved by 0.2m/s from 0.7m/s at baseline to 0.9m/s at post-intervention which was maintained at follow-up. The increase of 0.2m/s is clinically significant.[256] A previous chronic stroke study showed that walking speed accounts for about 22% of the variance in prolonged sedentary behaviours.[166] This suggests that there are factors other than the speed of walking that influence engagement in sedentary behaviours. The scores on the timed-up and go test decreased from 19.0 to 15.1 seconds. Although significant, these individuals may still be at high risk of falls.[257] An individual's balance may affect their sedentary levels. For example, every one point increase on the Berg Balance Scale is associated with an increased upright time of 4.3 minutes in people with stroke.[258] Results from the cross-sectional paper using baseline data (Chapter 5) showed that 30% of the participants could not get down on the floor, and 17% required supervision or some assistance with stairs or the bathroom, which suggests that balance was still a problem.

With the accelerometer-determined outcomes, compared to baseline values, we found that participants significantly reduced sedentary time during waking hours by 54 minutes at post-intervention, with a trend towards significance of 27 minutes reduction at follow-up. The reduction in sedentary time during waking hours in our cohort was higher than the 30 minute reduction reported in an intervention with patients with chronic stroke.[36] However, our finding that participants significantly decreased their waking hours at post-intervention, but not at follow-up, confounds how the change in sedentary time may be interpreted. The percentage of waking hours spent in sedentary behaviour was 74.2% at baseline and 71.4% at post-intervention. This implies that sedentary time during waking hours reduced by 2.8% from baseline to post-intervention after accounting for the differential waking periods. A previous observational chronic stroke study (> 4years post-stroke) reported waking period similar to our findings.[139] English and colleagues in a stroke study that had age-matched healthy controls reported that people with stroke were awake for 14.2 hours per day compared to 15.5 hours per day in controls.[139] This is similar to the waking period of 14.5 hours per day reported at post-intervention in our study. Though not significant, participants in our cohort improved standing time by 12.3 minutes after the intervention and by 15 minutes at follow-up, relative to baseline values. This was similar to the improved standing time of 16.5 minutes reported in an intervention with people with chronic stroke.[36]

Taken as a whole, the results of this project provide valuable information that furthers our understanding about sedentary behaviour after stroke and how it can be changed. A summary of the main findings from these studies is shown in Table 7.1.

Table 7.1. Summary of research findings

Study 1 (Chapter 3)	There is limited awareness of the health risks of prolonged sedentary behaviour in people with stroke. Strategies involving self-monitoring, using cues-to-action, and frequently interrupting sedentary behaviour (e.g. standing and walking around every half-hour) were acceptable approaches for behaviour change.
Study 2 (Chapter 4)	A **ST**and **U**p **F**requently **F**rom **S**troke (***STUFFS***) program was designed and developed to reduce prolonged sedentary behaviour after stroke. The program provides opportunities to increase awareness about the health risks of prolonged sedentary behaviour, feedback on usual activity behaviour, action planning on ways to change behaviour and incorporates use of a self-monitoring tool.
Study 3 (Chapter 5)	People with stroke spend prolonged time in bed and engage in prolonged sedentary behaviours after discharge from inpatient stroke rehabilitation.
Study 4 (Chapter 6)	An 8-week sedentary behaviour change intervention resulted in reduction of sedentary behaviour during waking hours, improvements in physical function and patient-reported outcomes, but did not significantly improve upright activities after stroke.

7.2 Strengths of the thesis

For people with limited mobility such as after a stroke, who often have difficulty with getting up from a chair or taking steps, it is not difficult to understand that engaging in moderate-to-vigorous intensity physical activity and meeting recommendations for physical activity is challenging. With the recent addition of reducing sedentary behaviour in the best practice guidelines for people with stroke,[16, 30] the findings from this project provide important insights on the volume and pattern of whole-day activity behaviours after inpatient stroke rehabilitation. In addition, this thesis provides information on how to reduce sedentary behaviour after stroke. This work has resulted in the development of a novel sedentary behaviour change intervention for people with stroke that may also be translatable to other populations with limited mobility. The *STUFFS* program was acceptable to people with stroke and was feasible to deliver within the home environment. Moreover, people with stroke were engaged in the development of the intervention to make it appropriate for the targeted population.

One main effect of this type of intervention is that people with stroke become more aware of their sedentary behaviours and there is that increased motivation to sit less and move more. Through a qualitative exploration of the views of people with stroke, this thesis identified that misperceptions do exist. Some people with stroke felt that it is only when they exercise for 10 or more minutes that they get benefits and would sit instead if they were not engaging in exercises. One individual perceived that lying was healthier than sitting. By measuring the whole-day activity behaviour for a 7-day period after inpatient rehabilitation, the findings from this thesis showed that people with stroke spend prolonged time in bed and in sedentary behaviours. Clinicians and the health system will need to provide more education on the health consequences of prolonged time in bed (i.e. different from the normal 7-8 hours per day) and prolonged sedentary behaviour prior to discharge from the hospital. If people do not know how their behaviours might affect their health, they will not be motivated to change such detrimental habits.

The process of changing undesirable health behaviours to desirable health-promoting behaviours is complex.[259] This process goes from providing information on the risks of undesirable health behaviours to empowering and supporting individuals to effect a change.[173, 259] There have been concerns in the literature that stroke rehabilitation trials underreport the intervention development process and this often affects replication of intervention studies.[57] In this thesis, we followed the Intervention Mapping protocol to design and develop a theory- and home-based sedentary behaviour change intervention. This is an example of the recommended translatable process to be followed in developing and reporting of interventions for people with stroke.[57, 204] In addition, there is value in this type of transition (i.e. hospital to home) program that monitors and reduces sedentary behaviour after stroke rehabilitation but also allows for a systematic and staged withdrawal of contact with organized hospital care. Participation in the *STUFFS* program provided a mechanism for actively linking participants back to their clinicians when the need arose. For example, in 3 different scenarios, we identified participants with increasing depression, recurrent falls, and one individual who did not have home-care support and was struggling to cope at home. An important aspect of such a program is that it served as a bridge between the patients and the clinicians and supplemented the Early Supported Discharge program, which is offered to only a small fraction of people with stroke.[141] It may be necessary to integrate sedentary behaviour change programs with the Early Supported Discharge program that is currently in existence.

7.3 Practical implications and recommendations

In the general population, the clinical and research focus has been on moderate-to-vigorous intensity physical activity or exercise for a long time. Guidelines were developed based on exercise research, but exercise time, as currently recommended, occupies only a small fraction of the day (less than an hour). For many people with stroke, engaging in the recommended level of exercise is challenging. Moreover, the traditional approach to activity promotion after stroke that focuses only on increasing exercise ability does not decrease sedentary behaviour.[50, 51] Encouraging people with stroke to engage in light-intensity activities, at frequent intervals throughout the day may be feasible and sustainable, as a first step, towards promoting activity. For instance, “sit less and move more” messaging may be more acceptable for many people with stroke at the start of programs aimed at improving activity behaviour. When people experience success in sitting less and taking more steps, it enhances their confidence to engage in more activities.

There should be a good balance between sleep (7-8 hours per day is normal), rest period during waking hours (people should aim for ≤7 hours per day), and daily activity behaviour (7-8 hours per day). A graduated reduction in sedentary time may be reasonable after a stroke. For individuals who are sedentary for more than 13 hours/day, an initial target might be to limit total rest period (excluding sleep) to no more than 10 hours per day, which means total activity time needs to be around 6-7 hours per day; this includes light-intensity activity such as moving around the house at frequent intervals and exercise. When people are successful in limiting sedentary time to less than 10 hours or for individuals who are sedentary for less than 10 hours per day, they can be encouraged to work towards accumulating less than 7 hours per day in total sedentary time. A graduated reduction in sedentary behaviour aligns with the principles of social cognitive theory.[172, 173] The mindset when people are leaving the hospital that they are going home to rest and recuperate need to be addressed early on prior to discharge. It is crucial to overcome that mindset and get back to one's feet immediately after leaving the hospital.

Besides the total sedentary time per day, the frequency of breaks in sedentary time is also important. People with stroke need to get up and take steps at frequent intervals. It has been suggested that 6,000 steps per day may be an initial target level to prevent new vascular events after stroke.[208] In addition, there is evidence that frequent interruptions in sedentary time and walking around regularly are beneficially associated with health outcomes in the general population.[87] It has been suggested that interrupting sedentary time every 30 minutes could lower the detrimental health risks associated with prolonged sedentary behaviour.[153]

Some strategies to consider for reducing sedentary behaviour in people with stroke include:

- Planning to regularly get up and move around at frequent intervals throughout the day.
- Using a high table or counter for support in standing while talking on the phone or reading.
- Walking around during television advertisement.
- Keeping the remote near the television may encourage getting up to change channels or adjust volume.
- Doing light housework such as sweeping.
- Using a device (alarm or activity monitor) as a reminder to get up at frequent intervals, or use of activity monitors to track daily activity and monitor any changes over time.

- Appropriate walking aids to protect against falls, since fear of falls may be a barrier to reducing sedentary behaviours.

7.4 Limitations of the thesis

Some specific limitations that pertain to the individual studies are already discussed in the respective chapters. Additional limitations will be discussed here.

Participants in the cross-sectional and intervention studies (Studies 2 & 4) were enrolled within 2-4 weeks of discharge from inpatient stroke rehabilitation. This cohort included people with high potential to return home after resource-intensive inpatient rehabilitation. We did not measure sedentary behaviour prior to discharge from the hospital, and do not know if transitioning from hospital to home is associated with a change in sedentary behaviours. However, a previous stroke study (without intervention) within the same facility showed that the number of steps taken per day did not change from pre-discharge to 2 and 6 weeks post-discharge from the hospital, although minutes of activity improved.[22] Future studies should measure sedentary behaviour while the patients are still within the hospital and at home, prior to commencing the intervention.

The use of a single-group design without an independent control arm was also a limitation. Future efficacy trials, including randomized controlled trials, of this intervention will be needed.

The non-significant improvement in upright activities (standing and stepping) needs to be discussed. Several factors including participant characteristics such as age, educational level, intrinsic motivation, adherence and duration of the intervention, social support, and balance might affect engagement in upright tasks. For example, a longitudinal study that observed activity behaviour within the first 6 months after stroke, reported that time spent in the upright increased as the participants' balance improved.[258] In the present study, it is possible that the 8-week intervention period may be too short to achieve a substantial behaviour change. Our findings concur with previous sedentary behaviour change interventions that were similar in duration - 7 weeks in people with stroke[36] and 8 weeks in people with acquired brain injury,[260] that did not show significant effects in improving upright behaviours. In the study with people with stroke, English and colleagues[36] reported that upright time improved by 21.2 minutes (16.5 minutes standing and 4.7 minutes stepping) in the intervention group compared to 38.1 minutes in controls. With people with acquired brain injury (including stroke), Jones and colleagues[260] reported that upright time (reported as change from sitting or lying) improved by 24 minutes after the intervention and by 12 minutes at follow-up, relative to baseline.

The association between functional capacity and sedentary behaviour after stroke is not well understood.[166, 261] Studies have suggested that physical ability does not fully account for the levels of sedentary behaviour after stroke.[166] In the present study, participants improved their gait speed significantly after the intervention, yet activities done in the upright were minimal. It is possible that other factors not considered may influence engagement in upright activities. For example, Danks and colleagues suggested that improving balance self-efficacy may moderate the relationship between walking capacity and walking activity after stroke.[261] In other words, fear of falling might have limited the upright time reported in this thesis. Improving balance confidence may not only improve upright behaviours at home but might also enhance community ambulation in people with stroke. Although we used timed-up and go test – a measure of general mobility and balance, which correlates well with the Berg Balance Scale, future studies should include balance-specific measures.

The cadence (stepping intensity) categories used in this thesis are well established and have been used in a previous study with people with stroke,[31, 241] however the metabolic equivalents of the cadence bands are not known in people with stroke. A proxy of ≥100 steps/min was used as a cut-off for moderate-to-vigorous intensity activity in this thesis.[31, 241] This cut-off was proposed for healthy adults and will require validation in people with stroke.

7.5 Future research directions

In this thesis, our focus was on people with stroke and how to support them to reduce sedentary behaviour. The logical next step will be to explore the perspectives of clinicians including rehabilitation professionals (e.g. physical therapists and occupational therapists), nurses and physicians about reducing sedentary behaviour after stroke. Such information will be helpful in understanding current practices and the beliefs about the benefits of targeting sedentary behaviour reduction. If clinicians who work every day with people with stroke are not fully aware of the health risks of prolonged sedentary behaviour, they may not be well positioned to help others. Additional qualitative studies are required to address this gap.

Although feasibility and pilot studies (e.g. *STUFFS*) are important in an emerging field such as sedentary behaviour, in a bid to advance research in this area there will be need for larger studies with greater sample sizes as well as trials with a control arm (e.g. RCTs) to test the efficacy of this type of intervention. Further, studies will need to explore the variability in activity behaviour and potential compensation that might occur between days, especially outpatient therapy days and other days to help understand the interaction between days in therapy and activity behaviour. Information on how compensation or variability affects patterns of activity may be helpful in designing future intervention programs.

The discussion around what truly constitutes a break in sedentary time needs to be explored further. For example, the default value of 10 seconds for minimum sitting or minimum upright period may affect how the activPAL interprets repeated sit-to-stand transitions done in quick successions, which is often used in everyday clinical practice and clinical measurements. It is logical to set the default value at 10 seconds to minimize movement artifact but that limits the accuracy of the activPAL in detecting repeated transitions done within a bout of 10 seconds. This is not peculiar to the activPAL. In an earlier publication using Actigraph with people with multiple sclerosis,[111] we suggested that there is a need for standardization in the minimum period that activity monitors should recognize as a break.

Future studies should explore the associations between whole-day activity behaviour post-stroke (including sleep, sedentary behaviour, standing, stepping, and sit-to-stand transitions) and cardiometabolic health such as blood pressure, lipid profile, and coagulation factors. Also, the associations with brain-specific markers such as white matter hyperintensity - a marker of cerebral small-vessel disease that might predict stroke recurrence - may be needed.[233] In addition, at the cellular level, the mechanisms underlying “sedentary physiology” in people with stroke has not been studied.[48, 101] More research is needed to examine the influence of prolonged sedentary behaviour or reducing sedentary behaviour on lipoprotein lipase activity in people with stroke.[48, 97]

Additional research is needed to explore the effects of a longer-term sedentary behaviour change intervention in people with stroke. It has been suggested in the literature that interventions for reducing sedentary behaviour should be categorized as short term (up to 3 months duration), medium term (3 months to 1 year duration), or long term (longer than 1 year duration).[262] Future studies with people with stroke may consider intervention programs that will last for at least 6 months, beginning in the early period after discharge from the hospital. Besides the duration of the intervention, the frequency of coaching behaviour change is important. It is possible that the frequency of behaviour change coaching in the *STUFFS* program was not sufficient. Participants were coached only once at the beginning of the intervention on their sedentary behaviour levels and areas of the day where changes needed to be made. The follow-up phone calls and the interim home visit (midway through the intervention) were related to troubleshooting about self-monitoring devices and functional check-up, respectively. Future iterations of the program or other similar studies should consider more frequent coaching, for example weekly. A previous intervention with people with multiple sclerosis[164] involved weekly one-on-one behaviour coaching using Skype™.

The *STUFFS* program was developed to enhance self-efficacy to sit less and move more and the program was delivered at home by face-to-face contact with the participants. Future iterations of *STUFFS* or other intervention programs of this nature should consider other means of intervention delivery such as via Skype or using the internet that will allow for the delivery of the intervention at the population level. Also, during the delivery of the program, there was an instance when the spouse of one participant suggested that interventions like this should be dyad-focused, and should involve both partners in a more formal way. Bakas and colleagues in a statement for healthcare professionals from the American Heart Association and American Stroke Association recommended that behaviour-change interventions involving problem solving or goal setting should be tailored to the needs of the caregivers and people with stroke.[263] The authors reported that dyad interventions were found to be more effective in improving outcomes for people with stroke compared to interventions focused only on the person affected by stroke.[263, 264] Dyad sedentary behaviour change interventions should be explored in future trials.

7.6 Conclusions

Prolonged sedentary behaviour is a problem after stroke and many people with stroke are not aware of the health risks associated with prolonged sedentary behaviours. Using objective assessments, within the first month of discharge from inpatient stroke rehabilitation, the findings from this thesis showed that people with stroke spend prolonged time in bed, with 50% longer than 9 hours per day. In addition, participants spent three quarters of their waking hours per day in sedentary behaviours. It was feasible to modify sedentary behaviour after stroke using a theory-based intervention, delivered at home, which included self-monitoring. However, there were no significant improvements in the activities done in the upright.

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APPENDIX A

OPERATIONAL APPROVAL FOR RESEARCH STUDY I

RESEARCH TITLE:
A qualitative exploratory study on sedentary behaviour in people with stroke: what is it and how might you change it?

Expected Start Date:	2014-10-07
Expected End Date:	2015-06-01
Expected Number of Research Subjects:	15
Research Category:	Observational
Research Type:	Qualitative
REB / REB #:	HREB / Pro00047950

PI INFORMATION:

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STUDY COORDINATOR: Study Coordinator

Name:	Victor Ezeugwu
Zone:	Edmonton
Phone:	780-438-5053
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AREA IMPACT:

1) Will AHS staff from this area be expected to participate and/or carry out any duties related to this study??

YES 1 Physiotherapist (Out Patient Services), as contact person at GRH, will be involved only once at meeting with potential participants.

2) Will AHS staff from this area require any training or education??

YES 1 Physiotherapist, <30 minutes, training on inclusion criteria provided by study coordinator.

3) Are you expecting this AHS area to provide you with supplies and/or equipment? ?

NO

4) Funding Type: Investigator-initiated / No Funding

NOTE: If the area being impacted determines that there are costs associated with your research, they will contact you prior to issuing Operational Approval.

QUESTIONS SPECIFIC TO THE AREA:

PROTOCOL SYNOPSIS:

To date, no sedentary behaviour interventions have been developed and tested in persons with stroke. This qualitative study is designed to inform intervention development. The purpose of this study is to explore sedentary behaviour in stroke survivors including: 1) their understanding of the concept of sedentary behaviour; 2) their perspectives on the evidence about the health effects of sedentary behaviour; 3) their perspectives on ways that sedentary behaviour could be changed within their day to day life.

This study uses a qualitative research method using interviews. Purposive sampling will be used. Males and females will be recruited. Participants will have a self-reported history of a stroke and will be at least 18 years of age. We expect to interview 12-15 persons with stroke. In our experience, data saturation (i.e. no new themes identified in iterative data analysis) typically occurs at or before 15 participants.

Page 1 of 2 O/A #25763 Status: Approved

APPENDIX B

OPERATIONAL APPROVAL FOR RESEARCH STUDY II

RESEARCH TITLE:

The feasibility of a home-based transition intervention to reduce sedentary behaviour and improve function within the first 6 months after stroke

Expected Start Date:	2015-03-16
Expected End Date:	2016-08-31
Expected Number of Research Subjects:	25
Research Category:	Interventional
Research Type:	Outcomes Research
REB / REB #:	HREB / Pro00053129

PI INFORMATION:

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STUDY COORDINATOR:	Study Coordinator
Name:	Victor Ezeugwu
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Phone:	780-438-5053
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AREA IMPACT:

1) Will AHS staff from this area be expected to participate and/or carry out any duties related to this study??

YES 1-2 Physical Therapists, identify potential participants on the inpatient and the outpatient stroke service, maximum time per week - 30 minutes.

2) Will AHS staff from this area require any training or education??

YES 1-2 Physical Therapists, about 30 minutes meeting with PI and study coordinator to ensure understanding of the purpose of the study, and the inclusion criteria (to help identify those who are appropriate to participate).

Communication strategies between team members will be discussed (i.e. email, phone etc ¿ when). An information session for staff
will also be held¿ the researchers will conduct a 30-45 information session for staff. Information about the study will be provided, and questions answered.

3) Are you expecting this AHS area to provide you with supplies and/or equipment? ?

NO

4) Funding Type: Investigator-Initiated Grant

NOTE: If the area being impacted determines that there are costs associated with your research, they will contact you prior to issuing Operational Approval.

QUESTIONS SPECIFIC TO THE AREA:

PROTOCOL SYNOPSIS:

Page 1 of 2 O/A #27504 Status: Approved

The objective of this study is to test the feasibility of an 8-week home-based transition intervention for people with stroke being discharged from hospital.

This transition intervention will focus on reducing sedentary behaviour (i.e. too much sitting) and increasing light intensity activity such as standing and progressing general mobility goals. This two pronged intervention (activity and function) is not duplicating any organized services that are currently available in the community. It focuses on activity and allows a systematic and staged reduction of contact with the health care system.

Outcomes assessed at baseline, and at 2 and 4 months post-intervention include physical activity, sedentary behaviour, walking speed, general mobility, and quality of life.

Stroke survivors, aged 18 years and above who are able to stand up independently and walk about 10 metres with or without aid will be recruited within one month of discharge from hospital. Feasibility outcomes will include reach and retention, patient satisfaction with program and estimated cost. The results of this feasibility study will inform new service delivery options for stroke survivors in the community. The findings will also provide pilot data for future studies and larger grant proposals to compare outcomes of an intervention group versus a usual care group.

SUBMITTED BY / ASSESSORS / APPROVERS:

Requested By: Victor Ezeugwu — Date Requested: 2015-01-07

Funding for this study is supported by Grant from the Glenrose Rehabilitation Hospital Foundation.

Assessed By: Gail Melnychuk — Date Assessed: 2015-02-09

Assessed By: Gary Faulkner — Date Assessed: 2015-02-09

APPENDIX C

RECRUITMENT POSTER I

Is sitting too much a health risk factor?

We want to talk to you about your perspectives on sedentary (sitting) behaviour.

- Who: People who have had a stroke
- Where: Corbett Hall, Stroke Recovery Association or Glenrose Rehabilitation Hospital
- When: By appointment – we can accommodate most schedules including evenings and weekends.

- What: We'll ask to see you once for an interview session for about 30 - 45 minutes to discuss your perspectives on sitting behaviours and ways to change how much we sit.
- Cost: There is no cost.

If you are interested or would like more information about this study, titled **'Exploring sedentary behaviour in people with stroke: what is it and how might you change it?'** please contact:

Trish Manns: trish.manns@ualberta.ca; or

Victor Ezeugwu: ezeugwu@ualberta.ca

APPENDIX D

RECRUITMENT POSTER II

Sitting too much is a problem after stroke!

Are you interested in sitting less? Please read the information below about the opportunity to participate in a program.

Title of Study: The feasibility of a home-based transition intervention to reduce sedentary behaviour and improve function within the first 6 months after stroke.

- **Who can be involved**? People who had a stroke.
- **Where will the study take place:** At your home (or other place of your choosing).
- **When**: We can accommodate most schedules including evenings and weekends. We'll set up an appointment to see you.
- **What will we ask you to do?** We'd like to see you 5 times.
    - **Visit 1.** You'll have a small activity monitor on your thigh for 7 days to monitor usual activity, and we'll take some starting measurements (walking speed).

- **Visit 2.** This is the start of the intervention, we'll work with you to develop an individualized activity plan to sit less and move more.
- **Visit 3.** A quick visit to update the plan and check how things are going.
- **Visit 4.** End of the formal intervention. Wear the activity monitor on your thigh again. Check how things are going in terms of walking.
- **Visit 5**. Follow up appointment. Wear the activity monitor one last time.

Why participate? You will learn about your activity levels in the first six months after stroke. This will help you to track your progress and make as many gains as possible. You will also benefit from home visits by a physical therapist to help you to progress in terms of reducing your sitting time, increasing your physical activity, and walking at home and in the community.

- **Benefits**: It is free. You will receive a free activity monitor.

If you would like more information including more detail about the proposed timeline of visits, please contact us:

Victor Ezeugwu: ezeugwu@ualberta.ca or

Trish Manns: trish.manns@ualberta.ca

APPENDIX E

CONSENT TO CONTACT FORM I

Consent to Release Contact Information

I (**Participant's name**),____, give my permission to ____, to give my name and contact information to Dr. Trish Manns. The information (name, contact information) provided to Dr. Manns (or her Research Assistant, Victor Ezeugwu) indicates my willingness to be contacted to discuss participation in an interview research study (Titled: Sedentary behaviour in people with stroke: what is it and how might you change it?). I know that signing this form does not mean that I consent to participate in the study only that I consent to be contacted.

Participant's Tel No:____

Participant's Email:____

This consent is effective today _______________________. I know that I can revoke my consent at any time.

Signed _______________________________

Date ___________________________________

APPENDIX F

CONSENT TO CONTACT FORM II

Consent to Release Contact Information

I (**Participant's name**),____, give my permission to ____, to give my name and contact information to Dr. Trish Manns. The information (name, contact information) provided to Dr. Manns (or her Research Assistant, Victor Ezeugwu) indicates my willingness to be contacted to discuss participation in a research study (Titled: **The feasibility of a home-based transition intervention to reduce sedentary behaviour and improve function within the first 6 months after stroke**).

I know that signing this form does not mean that I consent to participate in the study only that I consent to be contacted.

Participant's Tel No:____

Participant's Email:____

This consent is effective today _______________________.

I know that I can revoke my consent at any time.

Signed _______________________________

Date _________________________________

APPENDIX G

INFORMATION LETTER I

Information Letter for Participants

Title of Study: Exploring sedentary behaviour in people with stroke: what is it and how might you change it?

Principal Investigator and Contact Information:
Trish Manns PhD: trish.manns@ualberta.ca

Study Coordinator and Contact Information:
Victor Ezeugwu PhD Student: ezeugwu@ualberta.ca

You are being asked to take part in a research study. This letter provides you with information about the study. Please read the information below and ask questions about anything you don't understand. Your participation is entirely voluntary.

What is the purpose of this study? The purpose of this study is to understand your perspectives on sedentary behaviour and how it could be changed in your everyday life.

What will be done if you take part in this research study?
We'll ask to meet with you one time, for about 30-45 minutes. At the start, we'll ask a few questions about you such as your age and the date of your stroke. After that, the interview will start. We would like to audio tape the interview, so the recorder will be turned on. Question we'll ask include questions about your knowledge and understanding of sedentary behaviour. We'll ask you for ideas about how you might change sitting behaviour in your day to day life. The audio recorder can be turned off at any time depending on your preference.

What are the possible discomforts and risks of participation? There is minimal to no risk associated with the interview session. We will ask you about your knowledge and understanding of sedentary behaviour and how you think it can be changed. We don't think there will be any uncomfortable questions, but if there are, please just say you don't want to answer that question.

What are the possible benefits to you or to others? What we learn through these discussions will help us to know if and how we should move forward with programs to change sedentary behaviour. By participating in this study, you will be helping to ensure these programs are suitable for stroke survivors.

How will your privacy and the confidentiality of your research records be protected? All data including specific information about you (i.e. age, time since stroke) will be kept in a locked file cabinet or on password protected computer. The information will be kept for at least 5 years after the study is done. All participants will be identified only by a number. Your name or any other identifying information will not be attached to the information you gave. Your name will also never be used in presentations or publications of the study results.

How can you withdraw from this study? If you want to stop participating in the study, you can contact Trish Manns at 780-492-7274. You are free to withdraw your consent and stop participation in the study at any time. If you decide to stop participating, or decide not to participate at all, it will not affect your relationship with your healthcare providers, the clinic, association or hospital in any way.

Who may you contact if you have concerns about this research study?
If you have questions about your rights as a research participant, please contact HREB Health Panel B Coordinator, Charmaine Kabatoff at charmaine.kabatoff@ualberta.ca or (780) 492-0302.

APPENDIX H

INFORMATION LETTER II

Information Letter for Participants

Title of Program: The feasibility of a home-based transition intervention to reduce sedentary behaviour and improve function within the first 6 months after stroke

Principal Investigator and Contact Information:
Trish Manns PhD: trish.manns@ualberta.ca

Program Coordinator and Contact Information:
Victor Ezeugwu PhD Student: ezeugwu@ualberta.ca

You are being asked to take part in a research program. This letter provides you with information about the program. Please read the information below and ask questions about anything you don't understand. Your participation is entirely voluntary.

What is the purpose of this program? The objective of this program is to test the feasibility of a home-based transition intervention for patients with stroke. A new part of this program is the use of activity monitoring to increase awareness of activity at home.

What will be done if you take part in this research program? If you agree to participate we would like to see you 5 times at home. What will be done at each time point is outlined below:

Time After Discharge	Event
Week 0	**Baseline Measurements and Activity Monitoring** Baseline measures (walking, stroke impact), 7 days of activity monitoring at home with activPAL (will measure sitting, standing, and stepping time) (see Figure).
Week 1	**Intervention Begins** Review of activity monitor data, discuss behaviour change strategies, complete action plans related to activity, including wearing a watch-like activity monitor for 8 weeks (see Figure), functional check-up 1 (walking, aids).
Week 4/5	**Interim Home Visit** Review and update action plans, functional check-up 2.
Week 9	**Intervention Ends** Reassessment of baseline measures including participant characteristics, impairment, and quality of life, 7 days of activity monitoring with activPAL, functional check-up 3.
Week 16	**Follow-up Final Assessment**

Figure

.

ActivPal (Worn on the front of thigh)

Misfit activity monitor

The Intervention: The intervention is designed to help you with ways to increase your everyday activity. Part of the intervention is getting an understanding of what your activity is right now – that's why we do baseline measurements of activity. The activity monitors we ask you to wear are less than half the size of a deck of cards (**Figure**), and are worn attached to the front of your unaffected thigh and wrist. We ask that you wear the activPAL monitor on the thigh for 7 days, after which we'll pick it up. We will ask you to wear the Misfit Shine on your wrist for 8 weeks of the intervention as it keeps track of your daily activity and gives you real-time and daily feedback.

At each home visit we will do a functional check-up. What this means is that we will work with you to practice strategies to be successful with everyday things like walking, walking in the yard, getting in and out of a car. We'll also review your home exercise program and update it if need be. At that time we'll ask about community services you use – so we can get a sense of your journey after you left the hospital.

What are the possible discomforts and risks of participation? Taking part in this program, you will be seen a few extra times after you go home; to see how you're doing and to monitor your activity. We think it is a good thing to see you a few times at home so we can help answer questions, and help you continue getting better after you go home. Wearing an activity monitor on your leg and wrist is, in our experience, not uncomfortable.

What are the possible benefits to you or to others? You will learn about your activity levels in the first six months after stroke. This will help you to track your progress and make as many gains as possible. You will also benefit from home visits by a physical therapist to help you to progress in terms of your walking at home and in the community. In addition, you will receive a free activity monitor.

How will your privacy and the confidentiality of your research records be protected?
All information (consent forms, questionnaires, and activity monitor files) collected in this program will be kept in a locked file cabinet or on password protected computer. The information will be kept for at least 5 years after the program is done. Your name or any other identifying information will not be attached to the information you gave. Your name will also never be used in presentations or publications of the program results.

How can you withdraw from this program? If you want to stop participating in the program, you can contact Trish Manns at 780-492-7274. You are free to withdraw your consent and stop participation in the program at any time. If you decide to stop participating, or decide not to participate at all, it will not affect your relationship with the Glenrose or anywhere else you may receive services related to your stroke.

Who may you contact if you have concerns about this research program?

If you have questions about your rights as a research participant, please contact HREB Health Panel B Coordinator, Charmaine Kabatoff at charmaine.kabatoff@ualberta.ca or (780) 492-0302.

APPENDIX I

CONSENT FORM

Title of Project: The feasibility of a home-based transition intervention to reduce sedentary behaviour and improve function within the first 6 months after stroke

Name of Principal Investigator: Dr. Trish Manns
Contact Information: Phone: 780-492-7274 Email: trish.manns@ualberta.ca
Name of Study Coordinator: Victor Ezeugwu
Contact Information: Phone: 587-938-4305 Email: ezeugwu@ualberta.ca

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	Yes	No
Do you understand that you have been asked to participate in a research study?	☐	☐
Have you received and read a copy of the Information Sheet?	☐	☐
Do you understand the benefits and risks involved in taking part in this research study?	☐	☐
Have you had an opportunity to ask questions and discuss this study?	☐	☐
Do you understand that you are free to refuse to participate or withdraw from the study at any time, without having to give reason, and that your information will be withdrawn at your request?	☐	☐
Has the issue of confidentiality been explained to you? Do you understand who will have access to your records, including personally identifiable information?	☐	☐

This study was explained to me by: ________________________________

I agree to take part in this study. Yes ☐ No ☐

______________________________ ____________________
Signature of Research Participant Date

____
Printed Name

* A copy of this consent form must be given to the participant.

APPENDIX J

STUFFS PROGRAM GUIDE

SAND UP FREQUENTLY FROM STROKE

(*STUFFS*)

STUFFS is a program aimed at reducing your sitting time and improving your physical activity and function.

By taking part in this program you will increase the amount of time that you are more active (i.e. standing and taking steps).

Research has shown that reducing the amount of time spent sitting and lying down helps to reduce the risks that cause another stroke and improve overall health and wellbeing.

This workbook will be your guide to this program. It contains research evidence on sitting and health, and tips to reduce sitting time, as well as activities we will do.

If you have questions or concerns, please contact the program coordinator, **Victor Ezeugwu** (Doctoral Student @ U of A).

Tel: 780-492-8968; Email: ezeugwu@ualberta.ca

Health Consequences of Sitting for Long Periods

Sitting down is something that we do all the time, whether at home, travelling or at work. Unfortunately, sitting for a prolonged period can cause a range of health issues. Even when we have visited the gym or exercised for 30 minutes, we still sit down for most of our day.

Recent studies have shown that people who survived a stroke spend over 80% of the day sitting down. Prolonged sitting is linked to obesity, heart disease, diabetes, premature deaths, deep vein thrombosis, and even sleep problems.

The good news is that sitting less might help with reducing your risk of developing these health problems.

Sand Up Frequently From Stroke (*STUFFS*)

ACTIVITY 1

Reflection on sitting time (including lying down)

Common activities that involve sitting for a long time are:

- Eating
- Watching TV
- Talking on the phone
- Using a computer/internet
- Playing a game
- Reading
- Travelling
- Sleeping

Think about a typical day (e.g. yesterday). How much time did you spend sitting?

What were the activities you were doing when you were sitting?

Morning	***Time***
• ____	____________
• ____	____________
• ____	____________
• ____	____________
Afternoon	
• ____	____________
• ____	____________
• ____	____________
• ____	____________
Evening	
• ____	____________
• ____	____________
• ____	____________

Daily Activities

STAND UP FREQUENTLY FROM STROKE (*STUFFS*)

ACTIVITY 2

Feedback from Activity Monitor

We will compare your sitting time estimate with the sitting time from the monitor you wore on your thigh for 7 days. This monitor measured the amount of time you spent sitting, standing and walking.

What do you think about your sitting time measured from the monitor? How does this compare to your earlier estimate? Are you sitting more or less than you thought?

Using the results from the monitor, let’s identify which part of the day you spent most of your sitting time and what activities you were doing.

- ______________________________________
- ______________________________________
- ______________________________________
- ______________________________________
- ______________________________________
- ______________________________________
- ______________________________________
- ______________________________________
- ______________________________________

Sand Up Frequently From Stroke (*STUFFS*)

NOW, LET'S TALK ABOUT WAYS TO REDUCE SITTING

A simple strategy to reduce the amount of time you sit is to plan it in advance. One of the simplest strategies is to replace sitting with standing, when you are doing activities.

Some possible ways to reduce sitting time:

- **Planning regular breaks, like every half-hour you stand up and walk around for 5 minutes.**
- Standing while dressing
- Standing while reading the newspaper
- Standing while using the telephone
- Standing up during commercials on TV
- Keeping the TV remote control near the TV, so you walk to TV to change channels
- Walking to the kitchen every hour to drink water.
- Helping with house chores (sweeping, folding clothes, and doing dishes).
- **Performing sit-to-stand tasks (2 sets of 10), three times a day or more.**

These are some ways to reduce sitting – you probably have some ideas as well! Let's brainstorm…

ACTIVITY 3

Action Plans

Next, we will identify which of your activities we can modify, how much, when and how often.

Action Plan 1

- ____
  ____
  ____

Action Plan 2

- ____
  ____
  ____

Action Plan 3

- ____
  ____
  ____

Action Plan 4

- ____
  ____

Sand Up Frequently From Stroke (***STUFFS***)

SOMETHING TO HELP YOU TO ACHIEVE YOUR ACTION PLANS

We will give you a small device to help you with your plans to reduce sitting throughout the program.

This tool monitors your daily activity level and will provide you with information on your daily progress.

Please Note: The goal of this program is for you to reduce your sitting time by at least 60 minutes at the end of the program.

APPENDIX K

FUNCTIONAL ASSESSMENT CHECKLIST

Participant #____________________ Visit _____________ Date__________________

Functional Check-List

1. Falls since visit (number, describe injurious or not) _______________________________

   ____

2. Functional Tasks (use FIM scoring system and provide comment as appropriate)
   a. Bed Mobility:____
   b. Transfers:

      into bed____

      into bath____

      into car____

      Floor to stand____

Comments/suggestions of things to practice____

____

   c. Stairs____
   d. Ambulation:

Comments/suggestions of things to practice (use of walking aids, orthosis, outdoor, indoor , stairs)

____

____

____

3. Outcome Measures
   a. Preferred walking speed (5m / average time):

   Trial 1________Trial 2_________Trial 3__________. Average time: ________

   Calculated Walking speed in m/sec:________________

   b. Timed Up and Go:_________ secs

4. Home exercise program review and update (if appropriate):

____

____

____

5. Use of community resources (CRIS, early supported discharge, exercise programs, others):

____

____

____

6. Patient main goal ____

7. Therapist concerns? Any need for referral?

FIM Scoring System

7	Complete independence
6	Uses device, no physical assist
5	Supervision or set up
4	Minimal assist
3	Moderate assist
2	Maximal assist
1	Total assist
0	Activity does not occur

APPENDIX L

SELF-EFFICACY ASSESSMENT FORMS

Participant #_________________ Visit # _____________________Date _______________

A: Self-efficacy to reduce sedentary behaviour

Reducing sedentary behaviour involves sitting less (e.g. standing while dressing, standing while reading, standing while using the telephone, or standing during TV commercials).

1. How confident are you that you can reduce your sitting time by at least 15 minutes/day?

   (no confidence) 0%...100% **(complete confidence)**
2. How confident are you that you can follow directions from the activity monitor to reduce sitting by at least 15 minutes/day?

   (no confidence) 0%...100% **(complete confidence)**
3. How confident are you that you can perform all your activity plans to reduce sitting by at least 15 minutes/day?

   (no confidence) 0%...100% **(complete confidence)**
4. How confident are you that you can reduce sitting by 15 minutes/day even if you feel discomfort?

   (no confidence) 0%...100% **(complete confidence)**
5. How confident are you that you can reduce sitting by 15 minutes/day even when you lack energy?

   (no confidence) 0%...100% **(complete confidence)**
6. How confident are you that you can reduce sitting by 15 minutes/day even when you don't feel well?

   (no confidence) 0%...100% **(complete confidence)**

7. How confident are you that you can include reducing sitting time by at least 15 minutes/day in your daily routine?
(no confidence) 0%...100% **(complete confidence)**

8. How confident are you that you can consistently reduce your current sitting time by at least 15 minutes/day?
(no confidence) 0%...100% **(complete confidence)**

9. How confident are you that you can arrange your schedule to include reducing sitting time by at least 15 minutes/day?
(no confidence) 0%...100% **(complete confidence)**

Participant #_________________ Visit # _____________________Date _______________

B: Self-efficacy to increase light-intensity activity

Increasing light-intensity activity involves moving more (standing and walking around very frequently e.g. 5 minutes every half-hour).

1. How confident are you that you can stand up and walk around for 5 minutes?
   (no confidence) 0%...100% **(complete confidence)**
2. How confident are you that you can follow cues from the activity monitor to stand up and walk around for 5 minutes?
   (no confidence) 0%...100% **(complete confidence)**
3. How confident are you that you can perform standing and walking for 5 minutes in order to meet your daily activity goal?
   (no confidence) 0%...100% **(complete confidence)**
4. How confident are you that you stand up and walk for 5 minutes even when you feel discomfort?
   (no confidence) 0%...100% **(complete confidence)**
5. How confident are you that you can stand up and walk for 5 minutes even when you lack energy?
   (no confidence) 0%...100% **(complete confidence)**
6. How confident are you that you can stand up and walk for 5 minutes even when you don't feel well?
   (no confidence) 0%...100% **(complete confidence)**

7. How confident are you that you can include standing up and walking for at least 5 minutes frequently during the day (e.g every half-hour)?
(no confidence) 0%...100% **(complete confidence)**
8. How confident are you that you can consistently stand up and walk for at least 5 frequently during the day (e.g. every half-hour)?
(no confidence) 0%...100% **(complete confidence)**
9. How confident are you that you can arrange your schedule to include standing up and walking frequently during the day (e.g. every half-hour?)
(no confidence) 0%...100% **(complete confidence)**

Participant #_________________ Visit # _____________________Date _______________

C: Self-efficacy to improve function

Improving function involves your ability to engage in everyday tasks and requires building strength and endurance (For example, doing sets of 10 sit-to-stand transitions - 3 times/day).

1. How confident are you that you can perform at least 10 sit-to-stand transitions?
   (no confidence) 0%..100% **(complete confidence)**
2. How confident are you that you can keep to your plan to complete at least 10 sit-to-stand transitions?
   (no confidence) 0%..100% **(complete confidence)**
3. How confident are you that you can perform at least 10 sit-to-stand transitions at different times of the day (e.g. morning, afternoon, or evening)?
   (no confidence) 0%..100% **(complete confidence)**
4. How confident are you that you can perform at least 10 sit-to-stand transitions even when you feel discomfort?
   (no confidence) 0%..100% **(complete confidence)**
5. How confident are you that you can perform at least 10 sit-to-stand transitions even when you lack energy?
   (no confidence) 0%..100% **(complete confidence)**
6. How confident are you that you can perform at least 10 sit-to-stand transitions even when you don't feel well?
   (no confidence) 0%..100% **(complete confidence)**

7. How confident are you that you can include at least 10 sit-to-stand transitions in your daily routine?
   (no confidence) 0%..100% **(complete confidence)**

8. How confident are you that you can consistently perform at least 10 sit-to-stand transitions every day?
   (no confidence) 0%..100% **(complete confidence)**

9. How confident are you that you can arrange your schedule to include at least 10 sit-to-stand transitions per day?
   (no confidence) 0%..100% **(complete confidence)**

APPENDIX M

POST-INTERVENTION EXIT INTERVIEW GUIDE

a. What were your initial impressions of the STUFFS program – were you excited? How did you like the idea of sitting less and moving more? (PROBE – information about activity monitors if they don't address – what would an ideal monitor look like?)

b. Tell me about the program. How did thing progress over the 8 weeks? (Probe – were there some challenges, independence with walking, falls etc…).

c. How satisfied were you with the program – on a scale of 0 to 100, with 100 being extremely satisfied, where will you rate your satisfaction?

d. Have you noticed any changes since you started the program (probe – spasticity, motor function, pain, ROM, energy levels, psychological…). Explain (probe for details and timing of changes).

e. If you were to tell a potential participant about your experiences with the STUFFS program – what would you tell them?

f. Ask participant to do a cost/benefit analysis (was it worth the time/effort?)

g. Follow-up on goals question (reduction in sedentary time and self-efficacy scores (remind participant of goals – were they reached, adjusted?).

At close – are there other things you'd like to mention about your STUFFS experience – topics that I didn't ask about?