

A physiotherapist facilitated walking  
intervention using an activity tracker to  
improve daily step counts in people with  
stroke

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Thesis presented for the degree of  
Master of Physiotherapy  
University of Otago  
June 2019

## Abstract

### Background

Globally, stroke is a leading cause of long-term disability in adults. Participating in regular physical activity such as walking has multiple health benefits for stroke survivors and can reduce the risk of recurrent stroke. Despite this, physical activity levels are known to be low in people living with stroke. Activity trackers are increasingly being used to motivate individuals to increase physical activity and may be an effective strategy to increase participation in physical activity for people living with stroke.

### Objectives

The objectives of this study were a) to investigate whether an eight-week walking intervention using a commercially available activity tracker and a behavioural change intervention could increase daily step counts in people living with chronic stroke; b) to investigate the acceptability of the intervention.

### Methods

This study used a mixed methods design using an embedded approach with an experimental design. The quantitative method was quasi-experimental using a single group, pre-test, post-test design. Qualitative data was collected from a self-administered survey to investigate the acceptability of the intervention, and to provide context to the quantitative data. Participants were community dwelling, chronic stroke survivors (median time since stroke = 13.5 months). The intervention involved an individually, tailored eight-week walking programme monitored by a Fitbit™ Zip activity tracker. The intervention contained weekly face-to-face consultations for the first four weeks, to establish a progressive walking programme and promote exercise self-efficacy by incorporating strategies such as barrier identification, problem-solving, goal setting, self-monitoring and action planning. The primary outcome was the change in mean daily step counts. Secondary outcomes were resting systolic and diastolic blood pressure, walking endurance, stroke specific self-efficacy, health-related quality of life, adherence and acceptability of the intervention.

### Results

Eight participants completed the study. The mean daily step count increased by 1343 (SD = 2467) steps or by a mean change of 52% compared to baseline steps. There was no statistically significant change in the secondary outcome measures except for health-related

quality of life measured on the EuroQol-5D-5L VAS which increased by a mean of 14 points (SD=13.7). Participants were positive about the intervention and it appeared acceptable, although many barriers to completing the intervention were reported. Common barriers identified were lack of motivation, lack of time, fatigue, pain and environmental barriers such as unfavourable weather. There were no difficulties reported with regards to using the Fitbit™ Zip activity tracker.

### Conclusion

This study used a low-cost commercially available activity tracker device alongside a behavioural change intervention delivered by a physiotherapist. The results show it is possible to increase daily step counts in a population of chronic stroke participants and that the intervention was acceptable. More research with larger sample sizes, a comparison group and longer follow-up time is warranted to determine whether the increase in daily step count can be maintained.

## Acknowledgements

Firstly, I would like to extend my sincere thanks and appreciation to my supervisors, Dr Lynne Clay and Dr Cathy Chapple for their encouragement, guidance and invaluable feedback throughout the research and writing of this thesis. I would like to gratefully acknowledge the participants who took part in this study. Also, to my family, friends and my colleagues at the School of Physiotherapy, for their ongoing support throughout this journey.

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## List of Abbreviations

6MWT	six-minute walk test
ACSM	American College of Sports Medicine
BCI	behavioural change intervention
BMI	body mass index
BP	blood pressure
DALY	disability adjusted life year
EQ-5D-5L	EuroQol health survey
FBZ	Fitbit™ Zip
FES	falls efficacy scale
ICC	intraclass correlation coefficient
IQR	inter-quartile range
m	metres
MCID	minimal clinically important difference
ms <sup>-1</sup>	metres per second
QOL	quality of life
RPE	rate of perceived exertion
SCT	social cognition theory
SD	standard deviation
SSEQ	stroke self-efficacy questionnaire
VAS	visual analogue scale

## Chapter 1: Introduction

Globally, stroke is a leading cause of long term disability<sup>(1, 2)</sup> affecting approximately 9000 New Zealanders each year<sup>(3)</sup>. Primary impairments that contribute to disability after stroke are determined by the size and location of the stroke but may include muscle weakness, sensory changes, in-coordination, hyper- or hypotonia, fatigue, pain, cognitive changes and communication difficulties<sup>(4)</sup>. Five years after stroke, 71% of individuals still have some form of neurological disability<sup>(5)</sup> with 30% of all stroke survivors encountering a subsequent stroke within ten years<sup>(6)</sup>. Recurrent stroke is associated with several modifiable risk factors such as hypertension, diet, abdominal obesity, smoking and lack of physical activity<sup>(7)</sup>.

Physical activity is a broad term defined as any bodily movement produced by skeletal muscles that requires energy expenditure<sup>(8)</sup>. Participating in regular physical activity not only reduces the risk of recurrent stroke<sup>(7)</sup> but also reduces the risk of non-communicable diseases such as diabetes, obesity and cardiovascular disease, which arise from a sedentary lifestyle<sup>(9, 10)</sup>. Walking is a form of physical activity fundamental to humans and known to be important to stroke survivors<sup>(11)</sup>. Walking can be measured by duration, intensity or the number of steps taken per day. Community dwelling stroke survivors typically take less than 5000 steps per day<sup>(12-15)</sup> which is lower than their healthy, aged matched peers. There is strong, high-quality evidence that physical activity is safe, feasible and has a positive impact on physical function, cardiovascular fitness, fatigue and quality of life amongst stroke survivors<sup>(16-18)</sup>. Therefore, it is important that health professionals develop strategies to enable those affected by stroke to participate in physical activity in order to reduce the risk of recurrent stroke and other non-communicable disease.

There is a growing trend to promote participation in physical activity as part of stroke rehabilitation. However, most studies have been conducted early after stroke and there is currently little evidence regarding the best strategies to enable and encourage stroke survivors to participate in regular, self-directed physical activity, especially after discharge from rehabilitation services. Few studies have investigated walking to increase physical activity in community dwelling, chronic stroke survivors. Chronic stroke is defined as greater than six months since the acute stroke event. Developing interventions based on health behaviour change theories and incorporating behavioural change interventions alongside more traditional physiotherapy approaches has been recognised as having potential<sup>(19-21)</sup>.

Behavioural change interventions that have successfully increased physical activity in stroke survivors include tailored counselling, goal setting, barrier identification and self-monitoring.

A novel way to include these behavioural change techniques is alongside the use of commercially available activity trackers. Activity trackers are wearable devices containing accelerometers that can measure step counts and walking duration alongside other health metrics<sup>(22)</sup>. Activity trackers are inexpensive, unobtrusive and allow the user to self-monitor daily step counts and provide immediate, tailored feedback to the user. Activity trackers are likely to be more effective at changing physical activity levels when they are incorporated alongside other behavioural change interventions<sup>(22, 23)</sup>. The use of an activity tracker alongside a behavioural change intervention may be an inexpensive and easy way to motivate community dwelling, chronic stroke survivors to increase physical activity levels via increasing their daily step counts and in doing so reduce the risk of recurrent stroke.

The objectives of this study are outlined below:

#### Primary objective

- a) Can an eight-week, individualised walking programme using a commercially available activity tracker and behavioural change components, increase daily step counts in people living with stroke?

#### Secondary objectives

- b) Is the intervention acceptable to the participants?
- c) What are the barriers the participants face in completing the intervention?
- d) What are the technical difficulties with using the activity tracker device with people with chronic stroke?

#### Structure of the thesis

This thesis comprises five chapters. This first chapter, the introduction, outlines the rationale for the study and the main objectives. Chapter two provides a narrative review of the main topics underpinning the thesis, in particular, physical activity levels in the stroke population, measurement of physical activity, physical activity recommendations, social cognition theory, behavioural change interventions and a critical review of the current research regarding promoting physical activity in chronic stroke survivors in a community setting. The mixed methods study design used for this study is outlined in chapter three. Chapter four contains the results of the study and these are further discussed in chapter five.

Chapter five also discusses the strengths and limitations of the study and suggests recommendations for future research.

## Chapter 2: Background

This chapter provides an overview of the relevant literature underpinning the thesis, in particular, physical activity levels in the stroke population, measurement of physical activity, physical activity recommendations, social cognition theory of behaviour change, behavioural change interventions, measuring acceptability of interventions, and a critical review of the current research regarding promoting physical activity in chronic stroke survivors in a community setting.

Stroke or cerebrovascular accident is defined as an episode of acute neurological dysfunction caused by ischaemia or haemorrhage that lasts more than twenty-four hours or leads to death, with no apparent cause other than a vascular origin<sup>(24)</sup>. The resulting interruption to cerebral blood flow causes oxygen deprivation to brain tissue which results in cell death causing irreversible neurological damage<sup>(24)</sup>. Primary impairments after stroke vary depending on the location of damage in the brain and the size of stroke. Common impairments typically include muscle weakness, changes to sensation, hypo- or hypertonia, in-coordination, communication difficulties and cognitive changes<sup>(17)</sup>. The incidence rate of stroke in New Zealand is the second highest amongst developed countries<sup>(25)</sup>, and affects approximately 9000 people each year<sup>(3)</sup>. Globally stroke is a leading cause of disability and the second leading cause of disability-adjusted life-years (DALYs)<sup>(2)</sup> with only one third of people who experience stroke making a full recovery<sup>(18)</sup>. Disability-adjusted life years measure disease burden and represent the years of productive life lost due to disability, and the potential life lost due to premature mortality<sup>(26)</sup>. Stroke is considered a preventable disease with 90% of first time stroke events attributable to modifiable risk factors<sup>(7)</sup>. Modifiable risk factors for stroke are hypertension, diabetes mellitus, dyslipidaemia, obesity, smoking, heart disease and physical inactivity<sup>(7, 27)</sup>.

Physical inactivity has been identified as one of the five key risk factors which account for more than 80% of the global burden of stroke<sup>(7)</sup>. Physical inactivity is currently the fourth leading cause of global mortality<sup>(10)</sup>. There is strong evidence that participating in regular physical activity has multiple health benefits for all adults<sup>(28)</sup>. Physical activity is a broad term that is defined as 'any bodily movement resulting from the contraction of skeletal muscle that increases energy expenditure above the basal level'<sup>(8)</sup>. The benefits of participating in regular physical activity include improving cardiovascular health by lowering total cholesterol, decreasing hypertension, lowering resting heart rate and reducing the risk

of developing diabetes<sup>(28, 29)</sup>. Similarly, increasing physical activity in people after stroke has been shown to improve cardiovascular fitness, balance, strength, gait<sup>(30)</sup>, cognition<sup>(31)</sup>, and reduce anxiety, depression, and risk of recurrent stroke<sup>(18)</sup>. Reducing the risk of recurrent stroke is particularly important as approximately 20-30% of people go on to have a subsequent stroke<sup>(6, 17)</sup> which often results in greater disability<sup>(6)</sup>.

### Physical inactivity after stroke

Physical inactivity after stroke is common and it is estimated that less than 30% of stroke survivors are sufficiently active<sup>(12, 15, 32-34)</sup>. Lack of physical activity is associated with reduced cardiovascular fitness<sup>(28)</sup>. Observational studies have reported that stroke survivors may have cardiorespiratory fitness levels up to 53% lower than healthy, gender and age matched peers when measured by maximal oxygen uptake<sup>(35, 36)</sup>. Within the chronic stroke population, Michael et al<sup>(34, 37)</sup> found many stroke survivors to be severely deconditioned and have cardiovascular fitness levels below that needed to perform simple activities of daily living.

Following stroke, there are a number of primary and secondary impairments that may increase the risk of an individual being physically inactive. These impairments include muscle weakness, altered sensation, changes to muscle tone, fatigue, and pain<sup>(16)</sup>. Further to that, skeletal muscle has been shown to undergo structural changes that include a reduction in cross-sectional area of the muscle, muscle-fibre size and force production<sup>(36, 38)</sup>. An increase in intramuscular fat further limits the ability of the muscle to generate force<sup>(36)</sup>. Together, these residual impairments and structural changes to skeletal muscle lead to impaired mobility and balance, which may affect participation in physical activity and other daily life activities<sup>(39)</sup> predisposing stroke survivors to a sedentary lifestyle. Physical activity is the most commonly reported leisure activity given up after stroke, even when the stroke is mild<sup>(39-41)</sup>. Stroke survivors may give up participation in physical activity following stroke for a variety of reasons including reduced awareness that physical activity is beneficial, lack of access to resources, and not knowing how to undertake physical activity safely<sup>(16)</sup>. In addition, low self-efficacy and fear have been suggested as factors that prevent participation in physical activity<sup>(42)</sup>. Besides physical impairments, multiple other barriers to participating in physical activity exist for individuals living with stroke including environmental barriers such as accessible and affordable facilities and transport<sup>(43, 44)</sup>. Therefore, it is not surprising

that community dwelling stroke survivors are less active than their healthy age-matched peers<sup>(12)</sup>, and typically walk less than 5000 steps per day<sup>(12-14)</sup>.

Community dwelling stroke survivors also spend more time in sedentary behaviour (equating to three hours per day more) than age-matched healthy controls<sup>(12, 15)</sup>. Sedentary behaviour is defined as any waking activity characterised by energy expenditure less than or equal to 1.5 metabolic equivalents (METs)<sup>(45)</sup>. Prolonged time spent in sedentary behaviours has been associated with higher levels of mortality and cardiovascular disease<sup>(46)</sup> independent of time spent in physical activity<sup>(47)</sup>. Within the chronic stroke population time spent in sedentary behaviour is known to be high and time spent in physical activity low<sup>(47)</sup>. Both high levels of time spent in sedentary behaviours, and inadequate time spent in physical activity may contribute to risk of recurrent stroke. It is therefore essential that rehabilitation programmes incorporate interventions to increase physical activity and to reduce sedentary behaviours within this population.

### Walking for health after stroke

Walking is the most commonly reported leisure time physical activity undertaken by adults<sup>(48)</sup> and being able to walk for accessing the community and participating in meaningful life activities is very important to stroke survivors<sup>(11)</sup>. Walking is an inexpensive, low-impact, equipment free way to increase daily physical activity. Promoting walking after stroke may reduce common barriers to physical activity such as transportation, access to facilities and associated costs. Regular walking has been shown to have multiple health benefits for all adults<sup>(49)</sup> reducing hypertension, risk of stroke, risk of cancer and depression even when the walking is of a low intensity<sup>(50)</sup>. A meta-analysis of twelve studies (n=606) investigating the health benefits of aerobic exercise in stroke survivors demonstrated a significant reduction in systolic and diastolic blood pressure and improved lipid profiles<sup>(51)</sup>. Four of the studies included in the review used walking as the primary mode of aerobic exercise. Since lowering blood pressure by five mmHg is associated with a 24% reduction in recurrent stroke risk<sup>(52)</sup> encouraging aerobic exercise after stroke is important. Walking after stroke can also improve health-related quality of life<sup>(53)</sup> with a positive association between quality of life and the number of steps taken per day found in a cohort(n=76) of chronic stroke survivors<sup>(54)</sup>. Walking for 20-30 minutes a day after stroke has been shown to improve health outcomes, reducing risk of death from recurrent stroke by 41%<sup>(55)</sup>.

## Measurement of daily physical activity

Accurate measurement of physical activity is important. Daily physical activity can be measured by indirect or direct measures. Indirect measures refer to self-report questionnaires requiring individuals to retrospectively record the amount, duration and intensity of the physical activity they undertake over a pre-determined time period. Self-report measures of physical activity are known to be unreliable and inaccurate in the stroke population due to high levels of recall bias which often result in individuals over-estimating their daily physical activity levels<sup>(56, 57)</sup>. Direct measures of physical activity, either by observation or with wearable step counting devices (accelerometers, pedometers and activity trackers) are the most accurate method of capturing daily physical activity in adults<sup>(58)</sup>. Direct observation, referred to as 'behavioural mapping'<sup>(59)</sup>, is difficult and impractical in community settings. Accelerometers are small, electromechanical devices that measure acceleration forces and are traditionally worn around the waist<sup>(60)</sup>.

Accelerometers are able to measure steps taken each day as well as the frequency, duration and intensity of the steps. Accelerometers however, are expensive and are unable to give immediate feedback to the user. Traditionally, accelerometers have been available only as research grade instruments requiring specialised software in order to download and interpret the activity captured by the device. Accelerometers are considered the gold standard for measuring free living physical activity in healthy adults<sup>(60)</sup> however, there is limited evidence regarding the reliability of accelerometers to measure physical activity in people with chronic stroke<sup>(61, 62)</sup>. After stroke, survivors may have asymmetrical gait patterns and walk at slow speeds<sup>(63, 64)</sup> making it difficult for accelerometers to detect steps<sup>(61)</sup>. In particular, accelerometers have been found to have problems detecting steps taken at speeds less than  $0.9\text{ms}^{-1}$ <sup>(65)</sup>. Walking speed after stroke is variable and related to the level of disability however, estimates of average walking speed in stroke survivors range from  $0.58\text{ms}^{-1}$ <sup>(63)</sup> to  $0.78\text{ms}^{-1}$ <sup>(64)</sup>.

Another method of measuring step count is with the use of a pedometer. Traditional pedometers are either spring loaded or piezo-electric. Spring loaded pedometers are worn on the hip and detect the upward movement of the hip which causes a lever to record that a step has occurred<sup>(66)</sup>. Piezo-electric pedometers are able to sense vertical motion of the hip which deforms a small crystal that then emits an electrical charge and counts a step<sup>(66)</sup>. Piezo-electric pedometers are able to detect motion in three planes meaning they are more

accurate than spring-loaded pedometers at counting steps at slower gait speeds<sup>(67)</sup>. Pedometer use has been studied in adults with diabetes, chronic obstructive pulmonary disease, arthritis, neuromuscular disease and healthy sedentary adults to measure and promote physical activity<sup>(68)</sup>, as pedometers have the ability to give immediate feedback to the user regarding the number of steps taken. However, pedometers have been used infrequently to measure and/or increase physical activity in people living with stroke. The majority of research in this area is observational in nature and focuses on the feasibility and/or the reliability of pedometers rather than their effectiveness<sup>(69-71)</sup>. Carroll et al<sup>(70)</sup> investigated the feasibility of pedometer use in fifty stroke participants. Piezoelectric pedometers (OMRON HJ-113-E) were worn at each hip and around the neck whilst participants completed the six-minute walk test (6MWT)<sup>(70)</sup>. Compared to manual step counting from a video recording, Carroll et al<sup>(70)</sup> found the pedometers did not detect steps at speeds less than  $0.5\text{ms}^{-1}$ . Positioning the pedometer on the affected hip also resulted in recording significantly fewer steps when compared with positioning the pedometer at the non-affected hip or around the neck. Carroll et al<sup>(70)</sup> concluded that pedometers were feasible to use in a stroke population with only ten percent of participants requiring assistance to don the pedometer and ten percent not able to read the step counts. Elsworth et al<sup>(71)</sup> used a different pedometer, the Yamax digiwalker, to evaluate step accuracy in a population of adults with neurological conditions. The sample included people with stroke (n=20), multiple sclerosis (n=16), muscular dystrophy (n=5), spinal cord injury (n=1) and traumatic brain injury (n=1). The pedometer was found to undercount steps although in contrast to Carroll et al<sup>(70)</sup>, this was not related to gait speed.

More recently, a new generation of pedometers often termed 'activity trackers' have become available. Activity trackers contain tri-axial accelerometers and also have the benefit of giving immediate feedback to the user. These commercially available devices are inexpensive and measure a variety of metrics including step counts. As a result, there is now a multitude of inexpensive, step-counting activity tracker devices available. In fact, a systematic review looking at direct measures of physical activity in stroke survivors included 91 papers and identified 29 different devices that were used to measure physical activity<sup>(72)</sup>. However, few of these devices have been validated in the stroke population. Unlike pedometers that need to be worn on the hip, activity trackers can be worn at the waist, in a pocket or at the wrist. Placement of the activity tracker device may affect the accuracy with

distal lower limb placement of step counting devices improving step count accuracy in people with slower gait speeds<sup>(73-75)</sup>. Singh et al<sup>(73)</sup> demonstrated this by asking healthy adult volunteers to walk at speeds between 0.2ms<sup>-1</sup> and 1.0ms<sup>-1</sup> and at varying cadences. The activity tracker used was the Fitbit™ Zip (FBZ) which is designed to be worn clipped to the waistband of pants or to be placed in a pocket. The most accurate placement at slower speeds was found to be at the ankle<sup>(73)</sup>. This improvement in accuracy may be due to larger angular accelerations occurring at the ankle compared to the hip<sup>(73)</sup>. A similar device, the Fitbit™ One has also been shown to have higher accuracy when worn at the ankle in those with walking speeds between 0.4ms<sup>-1</sup> and 0.9ms<sup>-1</sup> in both older adults<sup>(75)</sup> and in stroke survivors<sup>(74)</sup>. The disadvantage of wearing the activity tracker more distally is that this may limit the ability of the user to don and doff the device independently and restrict their ability to self-monitor their step counts.

### Walking recommendations for stroke survivors

Currently, the optimal number of steps per day for health benefits in adults remains unknown. Ten thousand steps a day has become a popular target for healthy adults<sup>(76)</sup> however this is likely to be unachievable for those people living with stroke who have residual impairments, reduced maximum oxygen uptake (VO<sub>2</sub>max) and structural changes to skeletal muscle. Physical activity guidelines<sup>(77-79)</sup> for both healthy individuals and for individuals living with stroke focus on minutes accumulated per day rather than steps taken per day. The recommendations for individuals living with stroke are to participate in moderate intensity aerobic exercise on three or more days for 20-60 minutes, which can be accumulated in bouts of 10 minutes throughout the day<sup>(16)</sup>. Moderate intensity is defined as working at 55-80% of maximum heart rate or 11-14 on the 15-point Borg scale<sup>(80)</sup>. The fifteen point Borg Scale of rate of perceived exertion described by Borg<sup>(80)</sup> is outlined in Figure 1.

Score	Rate of perceived exertion
6	none
7	very, very light
8	
9	very light
10	
11	fairly light
12	
13	somewhat hard
14	
15	hard
16	
17	very hard
18	
19	very, very hard
20	

Figure 1: The 15-point Borg Scale of Rate of Perceived Exertion

It is recommended that individuals with stroke should also participate in strength and flexibility exercises 2-3 days/week<sup>(16)</sup>. There is however emerging evidence that any amount of physical activity is better than none and individuals should be encouraged to participate in physical activity, even if it is below the recommended guidelines<sup>(81, 82)</sup>. Billinger et al<sup>(16)</sup> describes the need for physical activity prescription after stroke to be “customized to the tolerance of the patient, stage of recovery, environment, available social support, physical activity preferences, and their specific impairments, activity limitations and participation restrictions”. Similarly, the American College of Sports Medicine (ACSM) recommends adults living with disabilities who are unable to meet these physical activity guidelines should regularly engage in physical activity according to their ability and avoid inactivity<sup>(77)</sup>. Health benefits are seen with even small increases in activity and small increases in physical activity are associated with significant reductions in risk of mortality and morbidity<sup>(28, 83)</sup>. For example, the recommendation of 30 minutes/day can be accumulated in five minute bouts and still have beneficial cardiovascular effects<sup>(84)</sup>.

Thirty minutes per day of moderate-vigorous physical activity translates to approximately 7000-10000 steps/day in healthy, older adults and at least 3000 steps should be taken at a cadence of 100 steps/minute to meet the guidelines of 30 minutes a day of moderate intensity exercise<sup>(85, 86)</sup>. Table 1 outlines the recommended daily step counts for healthy adults and their classification in terms of activity levels<sup>(76)</sup>. Individuals living with a disability are recommended to aim for 6500-8500 steps/day<sup>(85)</sup> however, this recommendation was determined by measuring step counts in a diverse sample population that did not include individuals living with stroke. More recently, Kono et al<sup>(87)</sup> concluded that 6000 steps/day was the optimal number of steps required to prevent subsequent vascular events in a cohort of people (n=186) with mild stroke or transient ischaemic stroke. This is comparable to Ayabe et al<sup>(88)</sup> who recommended 6500-8500 steps/day were needed for prevention of secondary cardiovascular disease, and that below 5000 steps/day was likely to promote coronary disease progression. The specific number of steps per day and the intensity at which these steps are accumulated to prevent cardiovascular health benefits in stroke survivors is not yet known.

Table 1: Recommended daily step counts for healthy adults<sup>(76)</sup>

Steps taken per day	Classification
<5000	sedentary
5000-7499	low active
7500-9999	somewhat active
10000-12499	active
>12500	highly active

Physical activity guidelines<sup>(78, 79)</sup> focus on accumulating moderate to vigorous intensity exercise however more recently studies have shown that even physical activity performed at a low intensity is of benefit<sup>(81)</sup>. The benefits of low intensity exercise may be particularly relevant to individuals who are otherwise physically inactive. For example, a study conducted in non-exercising individuals (n=2417) showed that the number of accumulated steps taken per day was more strongly associated with health than the time spent walking at moderate intensity or above (as measured by accelerometry)<sup>(50)</sup>. Similarly, a large pooled analysis of US and European data<sup>(89)</sup> including over 600,000 individuals found that individuals who performed physical activity in doses below the recommended physical activity

guidelines had a reduced rate of mortality over 14.2 years compared with their physically inactive peers. This suggests that even short bouts of physical activity can have beneficial health effects especially when compared to remaining inactive. It is estimated that people living with stroke spend 75% of their day being sedentary<sup>(90)</sup> which increases the risk of future cardiovascular events including recurrent stroke<sup>(91)</sup>. Breaking up sedentary behaviour with small bursts of physical activity is proposed to help reduce hyperglycaemia and blood pressure<sup>(92)</sup>. English et al also reported a decrease in blood pressure in stroke survivors (n=19) walking at a light intensity for just three minutes every 30 minutes when compared to sitting uninterrupted for eight hours<sup>(91)</sup>. As physical inactivity has become a global pandemic responsible for multiple poor health outcomes<sup>(10)</sup>, promoting moving at any intensity is better than remaining inactive. This may be especially relevant for stroke survivors who are unable to meet physical activity guidelines.

### Increasing walking in people with stroke

Incorporating physical activity into stroke rehabilitation is now best practice and is recommended in recent stroke guidelines<sup>(93)</sup>. However, few studies have investigated walking in stroke survivors outside of the clinical or hospital setting. As a result, there are currently no recommendations as to the best way to promote long term participation in physical activity following stroke<sup>(19, 20)</sup>. Studies regarding the use of pedometers or activity trackers have focused on the feasibility and reliability of the devices rather than the efficacy of the intervention<sup>(69, 70)</sup>.

A Cochrane Review published in 2018 included four randomised controlled trials that used activity trackers to increase physical activity in adult stroke survivors<sup>(22)</sup>. Intervention length was generally short, with three of the studies having a mean duration of less than three weeks. These three studies were conducted in inpatient rehabilitation settings and concluded when the individual was discharged from the rehabilitation centre. Only one of the included studies was conducted with people living with chronic stroke (time since stroke greater than six months)<sup>(94)</sup>. In addition to the study by Danks et al, only two other studies have investigated the efficacy of step-tracking devices to increase walking in chronic stroke populations with positive results. These studies<sup>(69, 94, 95)</sup> are limited by small sample sizes, lack of comparison groups and heterogeneity regarding the program content, intervention length and outcome measures used. Danks et al conducted a small study (n=16) in people with chronic stroke (mean time since stroke = 51 months) using a StepWatch Activity

Monitor<sup>(94)</sup>. The StepWatch Activity Monitor works more like a traditional accelerometer and does not give immediate feedback to the user. Participants in this study had weekly counselling sessions for four weeks, and step goals were increased by 25% each week. Participants only received feedback regarding the step counts at weekly counselling sessions. Step counts at the final assessment increased by a mean 1100steps/day which was statistically significant ( $p < 0.05$ ). Another small pilot study investigated outcomes of a community based pedometer monitored walking program in eleven individuals with chronic stroke with a mean time since stroke of 12.2 years<sup>(69)</sup>. The intervention duration was six weeks and participants also received weekly telephone coaching (five sessions). Participants wore a piezoelectric pedometer on the non-hemiparetic limb and recorded daily step counts and rate of perceived exertion scores in exercise diaries<sup>(69)</sup>. The primary outcomes were the six-minute walk test for walking endurance and the ten-metre walk test for gait speed. No change was seen in either of these outcomes and the authors did not report changes in step counts<sup>(69)</sup>.

More recently, Paul et al<sup>(95)</sup> developed a mobile smartphone application (app) called STARFISH that visualised the physical activity completed by the user as fish swimming. The mobile app incorporated behavioural change strategies of feedback, self-monitoring and social support<sup>(95)</sup>. Participants were placed into groups of four with each individual being represented by a fish avatar. Participants were stroke survivors with a mean time since stroke of more than three years. Participants were randomised to either a control group ( $n=8$ ) or the intervention group ( $n=15$ ). The intervention group used the mobile app for six weeks and had two face-to-face appointments during the intervention period. Participants received individualised, weekly step goals each week and users could earn rewards in the app by meeting their target step goal. Participants in the intervention group increased mean daily step counts by 39% and increased the time spent walking by 20 minutes. Mean daily step counts decreased by 20% in the control group.

A consistent finding from the studies described above is that activity trackers are most likely to be effective when combined alongside a behavioural change intervention<sup>(22, 69, 94, 95)</sup>. This is a similar conclusion to another systematic review which found that interventions that include behaviour change interventions are likely to be more effective at improving real-world walking after stroke than those that used exercise alone<sup>(21)</sup>. Stretton et al reported that the behaviour change interventions that showed the largest effect sizes were goal-

setting, barrier identification and self-monitoring. Similarly, Preston et al<sup>(96)</sup> used a self-management programme incorporating education, goal-setting, barrier identification, self-monitoring and feedback to promote physical activity to people with mild disability after stroke (n=20). This single group, pre-post intervention study increased physical activity by 27 minutes/day after the 12-week intervention. Participants were able to choose what type of physical activity to participate in with 87% opting for walking which provides further evidence that walking is important to people after stroke.

The optimal length of interventions designed to increase physical activity in stroke survivors is unknown. A recent review of the literature suggested that in adults with acquired brain injury, behavioural change programmes need to be eight to twelve weeks in duration<sup>(97)</sup>. However, this was a limited review including only five studies with only one study focusing on exercise beliefs and behaviours. The other included studies looked more broadly at self-management after stroke to promote physical activity and therefore, included multiple health behaviours making it difficult to determine if the strategies used to promote healthy behaviours relating to diet, stress reduction, and medication use are also useful to improve physical activity. Three studies included in the review delivered the intervention in a group setting. It is possible that an intervention delivered on an individual basis may be more effective over a shorter time duration as the intervention can be tailored to the individual.

Despite the lack of use within the stroke population, pedometers have been used in other neurological conditions, both as a strategy to increase physical activity and as a way to objectively measure physical activity. Pedometer-based walking programmes have been successfully used to increase physical activity in people living with multiple sclerosis<sup>(98, 99)</sup> and traumatic brain injury<sup>(100, 101)</sup>. Studies have all recognised that behaviour change interventions are an important component of the intervention and should be incorporated alongside pedometer use. It is thought that pedometers increase physical activity levels by helping individuals self-monitor their physical activity behaviour, and by facilitating goal setting<sup>(68, 102)</sup>. Setting a step goal and monitoring achievement or progress towards that goal using an exercise diary or mobile app, have been identified as being key motivational factors that increase physical activity<sup>(68)</sup>. Besides increasing the number of steps taken per day, in healthy adults, pedometers have also demonstrated positive health benefits including decreasing body mass index<sup>(68, 103, 104)</sup> and reducing blood pressure<sup>(68)</sup>. It is unknown whether such health benefits translate to people living with stroke.

## Social Cognition Theory

Changing health behaviours is complex. Emerging evidence recommends that all interventions that propose to change health related behaviours should be based on theory<sup>(32, 105, 106)</sup>. There are multiple theories of health behaviour change, however, one of the most commonly used models for understanding and promoting behaviour change is the Social Cognition Theory (SCT) of self-regulation<sup>(107)</sup>. The SCT describes how behaviour change and motivation is mediated by cognitive, behavioural, personal and environmental factors<sup>(107)</sup>. The SCT focuses on perceived self-efficacy and on the importance of self-regulation as a source of behaviour change. Self-efficacy is a theoretical construct and is described as how confident an individual is to manage a specific task. Self-efficacy is situation and task related. Increasing self-efficacy has previously been recognised as an important foundation for motivation that leads to behaviour change<sup>(108)</sup>. An individual's perceived self-efficacy determines the goals individuals set for themselves, how much effort they invest in achieving these goals and their resilience or persistence when faced with setbacks or obstacles<sup>(109, 110)</sup>. More broadly, self-efficacy beliefs determine how people feel, think, motivate themselves and behave with regards to their health<sup>(109)</sup>. Having higher exercise self-efficacy has been identified as one of the most consistent predictors of participating in regular physical activity<sup>(111, 112)</sup>. Bandura<sup>(108)</sup> proposes that there are four main sources of self-efficacy:

1. Mastery experiences
2. Vicarious experiences
3. Information from credible sources/verbal persuasion
4. Physiological/emotional feedback

Bandura<sup>(108)</sup> suggests that the best way to increase self-efficacy is through mastery experiences which refer to a successful performance of a given task. Breaking down large goals, into small, achievable tasks can help improve self-efficacy. For example, simply telling someone that they should walk 10,000 steps or perform 150 minutes of moderate physical activity is unlikely to result in success. Vicarious experiences are gained through comparison or modelling of others in a similar situation. For individuals who are uncertain of their capabilities to perform certain tasks, seeing other people's achievements can help the individual to believe that they also possess the capabilities to perform the same task<sup>(108)</sup>. Verbal persuasion from a credible source such as family, friends or health providers, can

increase an individuals' self-efficacy although this is the most unreliable source. Self-efficacy can also be increased by the physiological and emotional feedback they receive. Robinson-Smith and Pizzi suggest that interventions designed to enhance self-efficacy should include all four domains<sup>(113)</sup>.

In relation to increasing physical activity in chronic stroke survivors, an individual's self-efficacy could be improved by:

- a) Setting small, graded walking goals in order to gain positive mastery experiences.
- b) Providing vicarious experiences through discussing how other people with stroke have improved their physical activity and the strategies they used to do so, or attending group exercise sessions.
- c) Face-to-face meetings with a physiotherapist or health professional to help increase an individual's belief about their ability to increase their physical activity and reach their weekly step goal.
- d) Physiological feedback

After stroke, self-efficacy has been shown to be an important mediator between performance capability, activity and participation<sup>(114)</sup>. Individuals who have a higher sense of self-efficacy after stroke have better mobility, self-reported health related quality of life and are more independent with activities of daily living compared to individuals with lower levels of self-efficacy irrespective of their level of disability<sup>(115)</sup>. A programme underpinned by the SCT and based on the principles of self-efficacy that has been successful in stroke patients is the Bridges self-management programme developed by Fiona Jones<sup>(116)</sup>. Bridges uses an individualised approach to self-management with the aim to empower people with stroke through increasing their skills in areas such as problem-solving and decision making<sup>(116)</sup>. The Bridges programme is based on seven main principles: problem-solving, reflection, goal setting, accessing resources, self-discovery, taking action and building knowledge.

### [Strategies to promote behaviour change in regards to physical activity](#)

A behavioural change intervention (BCI) is defined as “an observable, replicable and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour”<sup>(117)</sup>. Using behavioural change interventions enables a clearer understanding of which intervention components are associated with changes in the target behaviour<sup>(118)</sup>. Behavioural change interventions have been labelled the ‘active ingredients’

of an intervention<sup>(117)</sup>. Multiple behavioural change interventions relevant to health behaviour change have been identified<sup>(117)</sup>. There is a lack of high-quality research identifying how to use behavioural change interventions to promote physical activity in stroke survivors. A recent scoping review<sup>(119)</sup> outlining exercise interventions and behavioural change strategies for people with disabilities included 132 studies of which 20 studies were undertaken in people with stroke. Although only 24 of the included studies (18%) used behavioural change interventions, all but one of the studies incorporating behavioural change interventions demonstrated statistically significant increases in physical activity. The evidence supporting the use of behavioural change interventions to increase physical activity in stroke survivors comes from a diverse range of studies that include different forms of physical activity, heterogeneity regarding delivery method (group vs individual vs telephone coaching) and differing length of programmes. As most interventions to promote physical activity have included more than one BCI, it is difficult to distinguish which techniques, or combination of techniques are most effective for increasing physical activity in this population.

The behaviour change interventions that have been identified as important to improve exercise self-efficacy and physical activity behaviours amongst inactive adults include goal setting<sup>(68, 120)</sup>, action planning<sup>(121-123)</sup>, tailoring of information/feedback<sup>(123-125)</sup>, self-monitoring<sup>(120, 126, 127)</sup>, and providing information about the consequences of the behaviour<sup>(32, 123)</sup>. Amongst people living with chronic stroke, there is evidence that interventions that include goal setting<sup>(21, 32, 128)</sup>, barrier identification<sup>(21, 125)</sup>, and action planning<sup>(32)</sup> may be effective in increasing physical activity.

### Goal setting

Goal setting is consistently recognised as an important behavioural change intervention and having a daily step goal has been shown to be a key predictor of increasing physical activity in pedometer based walking programmes<sup>(23, 68, 129)</sup>. Goal setting is also closely associated with self-efficacy, in that when people with higher levels of self-efficacy set goals, they set higher goals than people with lower levels of self-efficacy<sup>(130)</sup>. This is important because evidence suggests that difficult goals produce higher levels of effort<sup>(130)</sup>. People with higher self-efficacy have also been shown to be more committed to assigned goals and use better strategies to achieve their goals<sup>(130)</sup>. Achieving set goals results in mastery experiences which enhance self-efficacy.

Pedometer based studies have used difference methods to set step goals. In the study by Danks et al, step goals were increased if the individual met the step count on three days in the previous week and the new goal was set by adding 25% each week until the individual reached ten thousand steps per day<sup>(94)</sup>. Similarly, Paul et al<sup>(95)</sup> increased weekly steps by a fixed 5% each week but required individuals to have met the previous week's goal on five out of seven days. The disadvantage of using a percentage based goal is that participants with higher baselines will have higher incremental steps and this could get to point where it is unachievable. Sullivan et al used a more individual approach not based on a fixed percentage and, guided by an algorithm that considered fatigue, rate of perceived exertion and shortness of breath<sup>(69)</sup>. Tudor-Locke et al suggests it is possible that setting and working towards any goal that represents an increase over baseline steps is of much greater importance than how the goal was set<sup>(131)</sup>. Daily physical activity goals have been shown to be more effective at increasing physical activity in inactive adults when compared to weekly goals<sup>(132)</sup>. This differs from current physical activity guidelines which recommend a goal number of minutes across the week rather than accumulating physical activity on a daily basis. While individuals with high self-efficacy might strive to reach a higher/harder target, for others a weekly step goal could be seen as unachievable and therefore act as a deterrent.

#### Barrier identification and problem-solving

Many barriers exist that prevent people from regularly engaging in physical activity<sup>(44, 133)</sup>. Early identification of potential barriers has been recognised as an important strategy for increasing and maintaining physical activity participation in chronic stroke<sup>(69, 94)</sup>. Recognition of barriers enables the individual with or without a health care professional to problem solve solutions to the identified barriers. Problem-solving is defined as the process of "prompting the individual to analyse factors that may influence the behaviour and generate or select strategies that include overcoming barriers and increasing facilitators"<sup>(117)</sup>.

#### Action and coping planning

Many people who are inactive desire to increase the amount of physical activity they participate in, but do not know how<sup>(121)</sup>. Action planning is a BCI whereby individuals are encouraged to make detailed plans about how, when and where they will achieve their goals<sup>(121)</sup>. Action planning increases the likelihood of goal attainment<sup>(122)</sup>. A coping plan identifies the potential barriers to the achievement of the action plan and incorporates strategies to overcome the perceived barriers<sup>(134)</sup>. Important characteristics of action plans

are that they are developed by the individual, that they are short in nature, for example, one week, and re-evaluated regularly<sup>(135)</sup>. For action plans to be effective, the individual also needs to be confident in their ability to follow the action plan. It is suggested that individuals should rate their confidence at completing the action plan on a scale from zero to ten. If the score is less than seven, the action plan should be modified<sup>(135)</sup>.

Action plans have been used widely in self-management programmes to enhance behaviour change and are described as a strategy of making a commitment to achieve skills mastery<sup>(135)</sup>. Due to their short duration and regular re-evaluation, action plans are able to provide tailored feedback to the individual. The use of action and coping plans involve problem-solving and being able to identify potential barriers and strategies to overcome these barriers. In this way, action plans can help build self-efficacy. Both action planning and coping planning have been shown to be successful in establishing long-term behaviour change and increasing physical activity levels in people with stroke<sup>(32)</sup>. Evidence suggests that action plans should be used alongside coping plans to increase their effectiveness<sup>(136)</sup>.

### Feedback

Whilst goal setting is fundamental to behaviour change, effective feedback on progress towards goals is also important<sup>(123)</sup>. Feedback on the behaviour is important however, it is not currently known what the most effective type, timing and frequency of feedback is in order to increase physical activity levels. Providing positive feedback on past performance enhances self-efficacy<sup>(123, 137)</sup> although feedback alone is not likely to result in long-term behaviour change and needs to be used alongside other behavioural change strategies<sup>(125)</sup>. Feedback is particularly important when individuals are starting to change their behaviour and not fully confident in their ability to maintain the behaviour change<sup>(123)</sup>. During this time giving positive feedback about small successes may help enhance self-efficacy while, negative feedback is likely to have the opposite effect and result in a decrease in self-efficacy<sup>(108)</sup>. Therefore, based on the SCT it would seem important to focus on progress made towards set goals even if the goal itself was not achieved.

### Self-monitoring

Self-monitoring promotes an individual's awareness of their behaviour and is fundamental for behaviour change<sup>(126)</sup>. Interventions that encourage individuals to self-monitor their behaviour are more likely to achieve behaviour change<sup>(127)</sup>. Self-monitoring could increase self-efficacy by providing accurate information to the individual about actual behaviour and

by providing mastery experiences. Self-monitoring by recording step counts in an exercise diary can provide a visual record of progress and provides an opportunity for social persuasion, allowing health professionals and support persons to reinforce an individual's efforts. Participants in a qualitative study investigating strategies to reduce sedentary time in stroke survivors, suggested activity trackers would enable them to self-monitor their activity behaviour and act as encouragement to be more active<sup>(138)</sup>.

#### Education on consequences of the behaviour

Individuals are more likely to initiate successful behaviour change if they perceive that there are positive, favourable outcomes associated with it<sup>(123)</sup>. For example, if individuals do not perceive being more physically active as being beneficial, they are unlikely to increase their level of physical activity even if they have high levels of self-efficacy. Therefore, it's not surprising that providing information on the consequences of the behaviour for example the benefits of being more physically active is associated with increases in physical activity levels<sup>(123)</sup>. Providing education on the consequences of the behaviour is clearly aligned with the concept of outcome expectations in the SCT. In a study promoting walking in a sample of older adults, Notthoff and Carstensen demonstrated that positive messages were more likely to increase walking than negative messages<sup>(139)</sup>. This would suggest that educating about the benefits of exercise may be more successful than discussing the deleterious effects of remaining inactive such as an increased risk of recurrent stroke.

#### Measuring acceptability

Acceptability is defined as the extent to which participants express favourable attitudes towards an intervention<sup>(140)</sup>. Acceptability of interventions is important to measure as if the recipients of an intervention deem it to be acceptable, they are more likely to adhere<sup>(141)</sup>. Acceptability is also important to measure when new interventions are developed, or when interventions are being implemented in new target populations<sup>(140)</sup>. Developing acceptable interventions links closely to the healthcare model of person-centred care. Person-centred care emphasises equal partnerships between healthcare providers and the health care users<sup>(142)</sup>. Using a person-centred model has been associated with better adherence and satisfaction, establishment of trusting relationships with healthcare providers and improvements in self-management<sup>(143)</sup>. Therefore, it is important to evaluate the

acceptability of interventions, in particular for the target population or users of the intervention.

Acceptability is not an attribute of an intervention, but rather a subjective evaluation of the intervention made by individuals who experience the intervention<sup>(141)</sup>. Acceptability can be measured before, during or after an intervention is delivered. Acceptability can be measured by conducting interviews or by using surveys to gauge participants perceptions of an intervention<sup>(140)</sup>. Interviews allow for more in-depth discussion and have the advantage of being able to clarify the respondent's exact meaning. Interviews however, can be time-consuming and in a group setting such as a focus-group, not all respondents may respond. Self-report surveys or questionnaires are the most appropriate method for assessing acceptability due to the subjective concept of intervention acceptability<sup>(140)</sup>. Sidani and Braden<sup>(140)</sup> describe how an intervention's acceptability can be defined by:

- 1) Appropriateness – the perception of the extent to which the intervention is helpful, or how helpful the intervention is in managing the problem.
- 2) Effectiveness – perceptions of the intervention's overall reasonableness and the extent to which the intervention is helpful in managing the presenting problem,
- 3) Adherence – Extent to which participants are willing to follow or adhere to the intervention
- 4) Convenience – how easy the intervention is applied in daily life, how long it takes to implement it and how suitable it is to the individual's lifestyle.
- 5) Risks or adverse reactions – level of severity of the intervention's adverse reactions/side effects

### Chapter summary

Participation in regular physical activity after stroke has multiple health benefits however, levels of physical activity are low after stroke. The best way to promote physical activity to community dwelling stroke survivors, including the optimum duration and delivery method are not yet known. Interventions utilising activity trackers may be of benefit but these should be theory based, and incorporate behavioural change techniques. The behaviour change techniques that have been identified as beneficial for increasing physical activity are barrier identification, goal setting, action planning, feedback, self-monitoring and providing information about the consequences of the behaviour. Activity trackers may help facilitate

behaviour change as they encourage users to self-monitor their physical activity, give tailored feedback on behaviour and facilitate goal setting<sup>(23, 144, 145)</sup> which closely matches recommendations from the SCT.

## Chapter 3: Methodology

This chapter outlines the study design, recruitment of participants, the intervention and outcome measures used, and the method of data analysis. This research study had two main purposes. First, to evaluate if an eight-week, individualised walking programme using a commercially available activity tracker, and behavioural change components, could increase daily step counts in people living with stroke. Second, to investigate the acceptability of the intervention to those who participated in the walking programme. The study was conducted with a sample of community dwelling, chronic stroke survivors. The intervention contained weekly face-to-face consultations for the initial four weeks, to establish a progressive walking programme and promote exercise self-efficacy by incorporating strategies such as barrier identification, problem-solving, goal setting, self-monitoring and action planning. During the following four weeks, participants continued the walking programme independently.

### Study design

This study used a mixed methods design using an embedded approach with an experimental design<sup>(146)</sup>. The quantitative method was quasi-experimental using a single group, pre-test, post-test design. Qualitative data was gathered from the participants via a survey utilising open-ended questions and text boxes at the completion of the intervention. The purpose of using a mixed-methods design and collecting qualitative data was to investigate the acceptability of the intervention, and to provide context to the quantitative data. A survey was chosen due to the ease of administration and to reduce response bias by allowing participants to remain anonymous.

### Participants and recruitment

Participants randomised to the control group of the 'Walking to Better Health After Stroke' project undertaken at the University of Otago, were invited at completion, to participate in the current study. The 'Walking to Better Health After Stroke' study was a feasibility RCT that aimed to determine if regular walking could improve the health and wellbeing of people following stroke (trial registration on Australian New Zealand Clinical Trials Registry: ACTRN12616001733460). The 12-week walking intervention was delivered and monitored by a physiotherapist. The results of the 'Walking to Better Health After Stroke' are yet to be published. The inclusion criteria (for the current study) were: community dwelling adults > 18 years who had suffered a stroke and were able to walk ten metres without assistance.

Participants were able to use a walking aid but needed to be able to walk independently with the aid. Participants were excluded if they scored less than twenty-five points on the Mini-Mental State Examination<sup>(147)</sup> and/or did not receive medical clearance from their general practitioner to participate in a walking programme. The research physiotherapist contacted each potential participant by phone or email after which all interested individuals were mailed an information sheet (Appendix A). Participant flow through the study is illustrated in Figure 2.

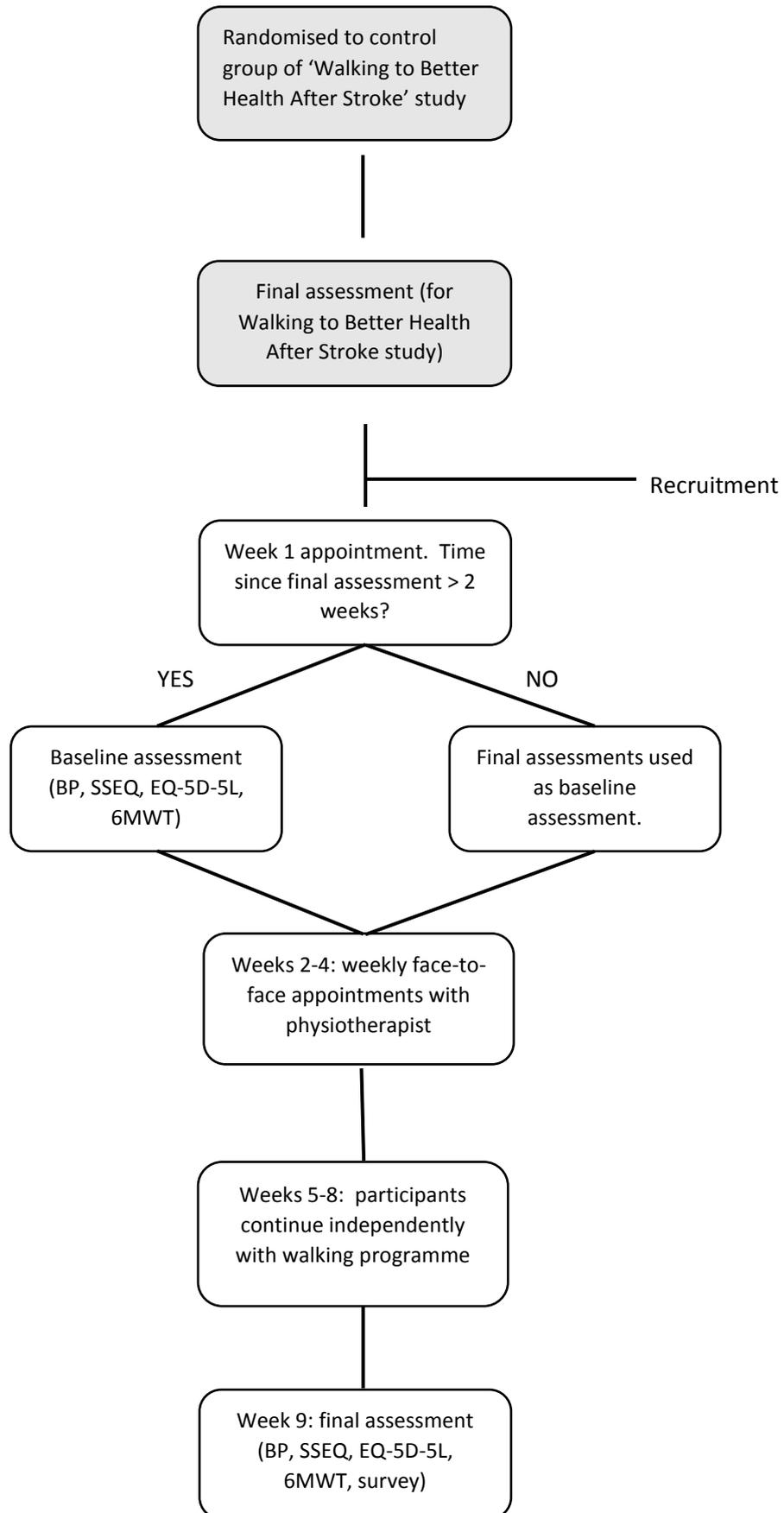


Figure 2: Participant flow through study

## Ethical considerations

Ethical approval for this study was obtained from the Health and Disability Ethics Committee (16/NTA/243) under the Walking to Better Health After Stroke application (Appendix B). All participants received an information sheet (Appendix A) and had an opportunity to ask questions prior to participating in the study. All participants signed a consent form (Appendix C) and it was clearly explained that they could withdraw from the study at any time. The main ethical issues were the risk of people falling during the walking programme and that people may experience delayed muscle soreness and/or fatigue, if unaccustomed to regular exercise. The risk of falling was minimised by allowing each individual participant to choose when and where to walk, and allowing the support of walking aids. An individualised, gradual walking programme was used to reduce the risk of delayed muscle soreness and fatigue by tailoring the programme to each individual.

## Sample size

No sample size calculation was completed due to the exploratory nature of this study. All participants who were randomised to the control group of the 'Walking to Better Health After Stroke' study were invited to participate.

## Instruments

The Fitbit™ Zip (Fitbit Inc. USA) is a commercially available, small device (measuring 27.9mm x 9.7mm x 35.6mm) that contains a tri-axial accelerometer and can be clipped to clothing or placed in a pocket (refer Figure 3). The Fitbit™ Zip (FBZ) was chosen due to its simple design, inexpensive cost and its ability to provide immediate feedback to the user. A device that was simple to use was chosen due to the potential cognitive and physical limitations that stroke survivors may present with. The FBZ has a touch screen and resets the daily step count to zero automatically each night at midnight. The FBZ is powered by a replaceable 3V CR2025 lithium battery which lasts up to six months under normal use conditions<sup>(148)</sup>. Manufacturers of the FBZ claim it is 95-97% accurate in step counting<sup>(149)</sup> and this has been confirmed in studies investigating the validity of the FBZ in counting steps in healthy adults<sup>(150-154)</sup>. The FBZ has also demonstrated excellent reliability (ICC=0.974) and accuracy (error rate= 4.2%) in people with stroke who walk at speeds greater than 0.35m<sup>s</sup>-1<sup>(155)</sup>. While slower walking speeds were associated with greater undercounting of steps, it is suggested that the FBZ is sufficiently accurate to provide individuals with feedback needed to set goals

and monitor progress and that it an appropriate tool to use in research studies in which the key outcome is step counts<sup>(156)</sup>.



Figure 3: Image of the Fitbit Zip™ activity tracker

Samsung J1 galaxy smartphones were offered to each participant to allow access to the Fitbit™ mobile application (app). The FBZ synchronises with the Fitbit™ app using wireless internet and Bluetooth™ technology. The interactive app allows tracking of daily steps, goal setting and presents activity over the past 30 days, in a graphical format viewable either on a computer or mobile device. Figure 4 shows a screenshot of the information provided in the Fitbit™ app. Use of the Fitbit™ app was optional and required participants to have access to a wireless internet connection or a mobile data account. Funding for the FBZ activity trackers and the Samsung smartphones was available via a University of Otago research grant.



Figure 4: Example of information provided in Fitbit™ app

### Intervention

This study involved an eight-week intervention which aimed to increase daily physical activity as measured by steps taken each day. Participants completed an individually tailored, eight-week walking programme. Participants were provided with a FBZ activity tracker to enable them to self-monitor their walking. The intervention was based on the social cognition theory and incorporated principles from the Bridges self-management programme as discussed in chapter two.

The intervention contained weekly face-to-face appointments for the initial four weeks, to establish a progressive walking programme and to promote exercise self-efficacy by incorporating strategies such as barrier identification, problem-solving, goal setting, self-monitoring and action planning. Each participant chose whether to attend the appointments at the School of Physiotherapy (University of Otago) or at their own home. All face-to-face appointments were conducted by the principal investigator, a New Zealand registered physiotherapist with fourteen years clinical experience, including five years working in a community setting with stroke patients. The physiotherapist providing the intervention had also completed a Bridges self-management workshop (1.5 days) in 2017.

During weeks 5-8, each participant continued independently with their walking programme with no contact from the physiotherapist.

## Procedure

Refer to Table 2 for an outline of the intervention procedure.

Table 2: Outline of intervention procedure

<i>Week</i>	<i>Outline of session</i>	<i>Behavioural change interventions</i>
1	<ul style="list-style-type: none"> <li>a) Outline of intervention and gain written informed consent</li> <li>b) Build rapport with the participant; explore participants knowledge of physical activity, current ability and motivation/fears regarding participating in the study</li> <li>c) Identify meaningful end goal and record</li> <li>d) Identify potential barriers to achieving meaningful goal</li> <li>e) Provide with FBZ and explain/demonstrate use. Ask participant to wear FBZ daily but to continue with normal day-to-day activities in order to establish baseline activity.</li> <li>f) Provide with exercise diary and ask participants to record daily step counts.</li> </ul>	<p>Goal-setting</p> <p>Problem-solving</p> <p>Self-monitoring</p>
2	<ul style="list-style-type: none"> <li>a) Review step counts from previous week</li> <li>b) Review any issues using the FBZ</li> <li>c) Undertake self-efficacy walk</li> <li>d) Set step goal for coming week</li> <li>e) Identify potential barriers to achieving step goal and develop strategies to help achieve. Barriers recorded in exercise diary.</li> <li>f) Complete action/coping plan</li> </ul>	<p>Reflection</p> <p>Goal setting</p> <p>Problem-solving</p> <p>Taking action</p> <p>Knowledge</p>

	<ul style="list-style-type: none"> <li>g) Discuss benefits of physical activity after stroke and the recommended guidelines</li> <li>h) Introduce Fitbit app – provide with Smartphone device if necessary or assist to download on own device.</li> </ul>	Self-monitoring
3	<ul style="list-style-type: none"> <li>a) Reflect on past week and review step counts as well as barriers to achieving the set step goal</li> <li>b) Determine new step goal for coming week</li> <li>c) Review action/coping plan</li> <li>d) Introduce concept of intensity and discuss use of the BORG scale to measure intensity</li> <li>e) Discuss strategies to reduce sedentary time and document in action plan.</li> <li>f) Review any issues with use of FBZ and/or app</li> </ul>	<ul style="list-style-type: none"> <li>Reflection</li> <li>Goal setting</li> <li>Taking action</li> <li>Knowledge</li> </ul>
4	<ul style="list-style-type: none"> <li>a) Reflect on progress made over past 3 weeks</li> <li>b) Discuss strategies to maintain their walking routine over next 4 weeks and into the future</li> <li>c) Identify ways to increase exercise intensity – walking on slopes, steps, increasing speed for short intervals</li> </ul>	Reflection

### Week one

The aim of the initial appointment was to build rapport with the participant and explore the participants' motivation for signing up to the study and their beliefs and ideas regarding physical activity. Individualised, patient-centred goals were elicited by asking open ended style questions such as "what do you want to achieve over the next 8 weeks in regards to walking?" Barriers to achieving the identified end goal were investigated by asking the participant "what might make it difficult for you to achieve this goal?" or "what are the things stopping you at the moment?" Relevant information documented from the 'Walking to Better Health After Stroke' study was discussed with the participant specifically, medical history/conditions, current medications and any change in health status since the baseline

assessment was undertaken. This was to ensure there was no change in the participant's health as well as identifying any co-morbidities that may impact on their ability to complete a progressive walking programme. If the final assessment for the 'Walking to Better Health After Stroke' had occurred greater than two weeks prior, the measures were repeated at this first appointment.

Participants were provided with a FBZ activity tracker, familiarised with its use and given the opportunity to practise using the device. Written information about the FBZ such as how to wear it and how to read the display was also provided (Appendix D). Participants were advised that the FBZ activity tracker could be worn clipped to clothing such as a waistband or bra strap, or placed in a pocket. Participants undertook a 2-3 minute indoor walk at a self-selected pace, to determine that the FBZ activity tracker was working and that they were able to read the display. Participants were instructed to continue with normal daily activities over the next seven days in order to establish their baseline number of steps taken per day. Participants were provided with a walking diary (Appendix D) to record daily step counts and instructed to wear the FBZ continuously during waking hours. Contact details for the physiotherapist were provided.

#### Week two

The aim of this appointment was to work collaboratively with the participant to determine a realistic starting daily step target for their individualised, progressive walking programme. The participant's daily step counts from the previous week were reviewed and the participant and physiotherapist discussed any patterns that emerged. This included identifying the days with the highest and lowest step counts and discussing what helped or hindered their walking. Participants completed a self-efficacy walk<sup>(157)</sup> alongside the physiotherapist. The purpose of the self-efficacy walk was to demonstrate their ability to increase the number of steps taken in a short 5-10 minute walk. The self-efficacy walk was completed at the participant's self-selected speed and the duration was determined by the participant.

Working collaboratively with the participant, a daily step goal for the following week was determined, taking in to consideration the mean daily step count from the previous week's walking, as well as the number of steps taken during the self-efficacy walk. Step goals were determined on an individual basis rather than by increasing by a fixed number of steps or a percentage based amount. Potential barriers to achieving the proposed daily step count

were identified and participants were supported to problem solve solutions to overcome these barriers and to contemplate strategies to increase daily step counts. The strategies to increase daily step counts, potential barriers and solutions were documented in an action/coping plan. The action/coping plan detailed agreed solutions regarding how, when and where to walk in order to achieve their daily step goal. As part of the goal-setting process, the participant was asked “on a scale of 0-10, how confident do you feel that you can achieve this goal?” If the reply was less than eight, the goal was adjusted. The daily step goal was documented in the participant’s exercise diary as a target for the following week. Participants were encouraged to continue recording daily steps in their exercise diary.

Any issues the participant encountered with using the FBZ activity tracker were discussed. The physiotherapist also discussed and provided information regarding the benefits of physical activity after stroke and the New Zealand Ministry of Health guidelines on physical activity<sup>(78)</sup>. Information discussed/provided was tailored to the individual’s knowledge base. Participants were encouraged to utilise the Fitbit™ app as another method to self-monitor their daily walking. The app was either downloaded to a device provided by the participant or the participant was provided with a Samsung J1 smartphone. Use of the Fitbit™ app was demonstrated and written information provided (Appendix E). Participants were advised that the research physiotherapist would be able to view the step counts once synched to the Fitbit™ app.

### Week three

The aim of this appointment was to introduce the concept of intensity and to discuss the benefits of moderate intensity exercise. The participant was given a copy of the Borg Rate of Perceived Exertion (RPE) scale<sup>(80)</sup> and encouraged to increase the intensity of their walking by aiming for an RPE of 11-14 which represents moderate exertion and is recommended for stroke survivors to increase cardiovascular fitness<sup>(16)</sup>. Suggestions to increase walking intensity included walking on hills or steps or walking at a faster pace. The RPE scale has been used widely in both research and clinical settings to measure exercise intensity despite concerns that it may not accurately reflect exercise intensity due to it being an indirect measure of exercise intensity<sup>(158)</sup>.

Step counts from the previous week were reviewed and collaboratively, a new daily step count determined for the coming week. The action/coping plan was reviewed and participants were encouraged to reflect on the past week and independently problem solve

any difficulties that had arisen or may arise over the next week. Participants were also encouraged to think about the amount of time spent sedentary each day and encouraged to think of strategies to reduce time spent sedentary.

#### Week four

The aim of this final appointment was to ensure each participant was able to self-manage their progressive walking programme by independently setting a realistic step goal and problem-solving perceived barriers to achieving the goal. Participants were encouraged to reflect on what they had already achieved. For example, any increase in steps taken over the past four weeks and participants were also reminded of their long-term end goal set in week one. Participants were encouraged to think about how they would maintain their walking routine without having weekly contact with the physiotherapist.

#### Weeks five-eight

During weeks five through eight, participants did not meet face-to-face with the physiotherapist but were encouraged to continue using the FBZ to self-monitor and record their daily walking activity, increasing their step count by continuing to set weekly goals, and problem-solving when barriers arose. The physiotherapist did not initiate contact with the participants over these four weeks, but they did agree to respond to phone calls and/or emails should problems arise. The physiotherapist was able to monitor participants daily step counts via the Fitbit™ app but did not provide any support/intervention.

#### Assessments

##### Baseline assessment

Demographic information (age, gender, time since stroke, body mass index (BMI), medical history and medications) was available from the 'Walking to Better Health After Stroke' study. As participants had just exited the aforementioned study, their results from the stroke self-efficacy questionnaire (SSEQ), the six-minute walk test (6MWT), and the Euro-Qol health survey (EQ-5D-5L) were used as baseline measures. However, if the time since the final assessment data from the 'Walking to Better Health After Stroke' study was greater than two weeks, participants completed the SSEQ, 6MWT and EQ-5D-5L at the first appointment. Resting blood pressure was measured using a manual sphygmomanometer for all participants at the first appointment.

### Final assessment

At the completion of the study participants attended an appointment at the School of Physiotherapy to return the FBZ and smartphone along with their completed walking diary. The following measures were assessed: resting blood pressure, SSEQ, 6MWT and EQ-5D-5L. Prior to the final assessment, an open-ended evaluation survey exploring acceptability of the intervention (Appendix F) was posted to each participant and they were requested to complete the survey and bring the completed survey to the scheduled appointment. The measures were completed in the following order for all participants: SSEQ, EQ-5D-5L, resting blood pressure, 6MWT. The SSEQ and EQ-5D-5L were self-administered and the blood pressure and 6MWT were conducted by the physiotherapist who delivered the intervention.

### Primary outcome

The study's primary outcome was change in mean daily step count measured by the FBZ activity tracker. Each participant recorded their daily step count as measured by the FBZ, in an exercise diary and/or using the online Fitbit™ app to record daily steps taken. The mean daily step count at the end of week one was calculated as the baseline step count. The mean daily step count at the end of week eight was calculated as the final step count.

### Secondary outcomes

Secondary outcomes measured at week nine were: resting systolic and diastolic blood pressure, stroke related self-efficacy, walking endurance, health-related quality of life, adherence and acceptability of the intervention.

### Blood pressure

Resting systolic and diastolic blood pressure was measured using a manual sphygmomanometer. Three measurements were taken on the non-hemiparetic arm with the participant seated and the arm elevated and supported at the level of the heart. Blood pressure was measured after participants had completed the self-administered outcome measures to ensure they had been seated, and resting for five minutes without talking as per the ACSM guidelines<sup>(159)</sup>. Blood pressure was classified as normal, elevated, stage one or stage two hypertension as outlined in Table 3<sup>(160)</sup>.

Table 3: Classification of blood pressure

Blood pressure category	Systolic blood pressure		Diastolic blood pressure
Normal	<120mmHg	and	<80mmHg
Elevated	120-129mmHg	and	<80mmHg
Stage 1 hypertension	130-139mmHg	or	80-89mmHg
Stage 2 hypertension	>140mmHg	or	>90mmHg

#### Stroke related self-efficacy

Stroke related self-efficacy was measured using the Stroke Self-Efficacy Questionnaire (SSEQ). The SSEQ (Appendix G) is a 13-item self-report questionnaire that asks the individual to rate their confidence in completing various tasks in specific domains of functioning post stroke, including walking indoors and outdoors<sup>(161)</sup>. Individuals rate their belief in their ability to achieve each of the 13-tasks on a 10-point visual analogue scale where 0 = not at all confident and 10 = very confident. The SSEQ has demonstrated good internal consistency (Cronbach alpha=0.90) and criterion validity ( $r=0.803$ ) against the Falls Efficacy Scale (FES)<sup>(161)</sup>.

#### Walking endurance

Walking endurance was measured using the six-minute walk test (6MWT). The 6MWT was conducted as per the American Thoracic Society guidelines<sup>(162)</sup> however, due to space limitations, the walkway used was 15 metres in length. Standardised feedback was given throughout the test and participants were able to use a walking aid to complete the test if required. The 6MWT is a self-paced, sub-maximal exercise test and has good criterion validity ( $r=0.66$ ) and excellent test-retest reliability ( $ICC_{2,1}=0.96$ ) in people with chronic stroke (time since stroke > 1 year)<sup>(163)</sup>. The minimal clinically important difference (MCID) for the 6MWT in people with chronic stroke is a change of greater than 13%<sup>(164)</sup>.

#### Health related quality of life

Health related quality of life was measured using the EuroQoL health survey (EQ-5D-5L). Permission to use the paper version of the EQ-5D-5L (Appendix H) was granted after registering the study with the EuroQoL Research Foundation (registration number 21280). The EQ-5D-5L is a two-part, self-reported questionnaire that captures general health status. In the first part, participants rate their health over five domains (mobility, self-care, usual

activities, pain/discomfort and anxiety/depression). Each domain is scored on a five-point scale with level 1 corresponding to 'no problems' and level 5 corresponding to 'extreme problems/unable to do'. The responses from each domain can be converted into a single number called an utility score with numbers closer to 1.0 representing better health status<sup>(165)</sup>. The second part of the survey asks the participant to rate their perceived health on a visual analogue scale from 0-100 with higher levels representing better levels of health. The EQ-5D-5L has been validated for use in assessing quality of life in individuals living with stroke<sup>(166, 167)</sup>. The MCID of the EQ-5D-5L utility index is 0.100<sup>(168)</sup>. The MCID for the EQ-5D-VAS is 8.61 points<sup>(168)</sup>.

### Adherence

Adherence is defined as the extent to which a person's behaviour corresponds to the recommendations of a healthcare provider<sup>(169)</sup>. Therefore, adherence in this study is defined as meeting the agreed step goal. Adherence to the intervention was calculated by visual inspection of each participant's exercise diary. Adherence was determined by counting how many days the participant met their daily step goal and dividing this number by the total days in the intervention period. Adherence data is presented as a percentage.

### Acceptability of intervention

Acceptability is defined as the extent to which participants express favourable attitudes towards the intervention<sup>(140)</sup>. The acceptability of the intervention was determined using qualitative data collected by a self-administered survey. The survey was developed by the research physiotherapist and consisted of open-ended questions and was completed at the conclusion of the intervention (Appendix F). The questions utilised in the survey were developed to incorporate the five categories outlined by Sidani and Braden<sup>(140)</sup>.

### Data analysis

#### Quantitative results

Statistical data analysis was performed using Microsoft Office Excel 2016. Descriptive analysis of the demographic data provided information on the median and inter-quartile range for age, body mass index and time since stroke in order to describe the sample population. Gender is reported as the number of male and female participants. Ethnicity is reported as the number of participants identifying with each ethnic group. Mean change

scores were calculated for each outcome measure. The increase in daily step counts for each individual is reported and the percentage change calculated. The mean daily step count data was collected from the participants' exercise diaries. Any missing entries from the exercise diary were managed by using the last recorded observation carried forward<sup>(170)</sup>. Paired t-tests were used for the outcomes where data was normally distributed. Wilcoxin-signed rank tests were used for the outcomes where the data was not normally distributed. Normality was determined by visual inspection of the data. A test of normality was not used due to the lack of power due to the small sample size. P-values of <0.05 were considered statistically significant.

### Qualitative results

The data collected from the open-ended survey questions was analysed by qualitative content analysis. Qualitative content analysis is a method for the subjective interpretation of text data through a systematic classification process of coding and identifying themes<sup>(171)</sup>. The responses to the self-report survey were entered in a Microsoft Office Word 2016 document and were read multiple times by the principal investigator in order to enable familiarisation with the content. A directed approach<sup>(171)</sup> was used as the key concepts of acceptability had already been determined based on the categories of acceptability outlined by Sidani and Braden<sup>(140)</sup>: appropriateness of the intervention, effectiveness of the intervention, adherence, convenience and adverse events. The survey responses were coded under each category and preliminary themes identified using key words or quotes. The findings from the directed content analysis are also described by the frequency of codes in each category<sup>(171)</sup>. As the survey involved open-text sections, any responses that did not fit the pre-determined categories were identified and given a new code. The new codes were sorted into themes and analysed using an inductive approach as described by Braun and Clarke<sup>(172)</sup>. The identified themes were reviewed and then further defined and named.

## Chapter 4: Results

This chapter describes the quantitative and qualitative findings of the study. The statistical analysis was exploratory in nature due to the small number of participants.

### Quantitative results

#### Participants

Ten stroke survivors were invited to participate in the study with eight individuals providing informed consent and completing the study intervention (6 female, 2 male). One person expressed an interest but was unable to find time to attend appointments due to work commitments. It is unknown why the other stroke survivor declined to participate. Table 4 displays the demographics of each participant at baseline. The median age of the participants was 67 years (IQR=11.25). All participants experienced their stroke over six months prior to the study (median = 13.5 months; IQR = 16.8). The median BMI was 34.8kg/m<sup>2</sup> (IQR =3.3) with only one participant categorised in the healthy weight range. Six participants had a BMI classifying them as obese. BMI was classified as: <18.5 underweight; 18.5-24.9 normal weight; 25.0-29.9 overweight; 30.0-34.9 class I obesity; 35.0-39.9 class II obesity; >40.0 class III obesity

There was a high prevalence of co-morbidities with five of the eight participants having more than one co-morbidity. The most common co-morbidities were musculoskeletal conditions (n=5). All participants were taking more than one prescription medication. Six of the participants mobilised without an assistive device. Seven of the eight participants attended all scheduled appointments at the School of Physiotherapy, University of Otago.

Appointments with the remaining participant were conducted at her home as she was unable to attend the School of Physiotherapy on a weekly basis due to transport difficulties. All eight participants completed the final assessment at the School of Physiotherapy.

Table 4: Participant demographics at baseline

Participant	Ethnicity	Gender	Age (years)	Time since stroke (months)	BMI (kg/m <sup>2</sup> )	Walking aid	Co-morbidities	Medications
1	NZ-European	Female	68	18	24.5	No	Bipolar disorder	Olanzapine, Citalopram
2	NZ-European	Female	71	48	33.2	Walking stick outdoors	Asthma, chronic back pain	Clopidogrel, Atherostatin, Cilazapril, Furosemide, Omeprazole, Symbicort, Ventolin
3	NZ-European	Female	59	6	35.5	No	Asthma, knee pain, type 2 diabetes, breast cancer	Cilazapril, Omeprazole, Clopidogrel, Seretide
4	NZ-European	Female	66	12	35.3	No	Depression	Paracetamol, Seratide, Bisoprolol Fumarate, Furosemide, Warfarin sodium, Omeprazole, Atorvastatin, Cholecalciferol
5	NZ-European	Male	65	9	29.7	No	Epilepsy, total knee replacement, chronic back pain	Aspirin, Allopurinol, Omeprazole, Atorvastatin, Cilazapril, Felodipine, Diclofenac sodium, Dipyridamole, Levetiracetam, Morphine, Amitriptyline, Cholecalciferol, Zopiclone, Pulmicort
6	Scottish	Male	77	146	34.2	Walking stick	Hypertension, osteoarthritis hip	Metoprolol, Cilazapril, Aspirin
7	NZ-European	Female	69	8	41.2	No	Total hip replacement, bilateral total knee replacements, type 2 diabetes, gout	Candesartan, Levothyroxine, Amlodipine, Aspirin, Simvastatin, Loperamide, Allopurinol
8	NZ-European	Female	50	15	36.1	No	Depression	Omeprazole, Amitriptyline, Fluoxetine, Atorvastatin, Aspirin
<b>Median (IQR)</b>			67 (6)	13.5 (16.8)	34.8 (3.3)			

### Primary outcome: daily step count

The group mean daily step count as recorded on the Fitbit™ Zip activity tracker increased by 1343 steps (SD = 2467) which was not statistically significant ( $p = 0.161$ ). The group mean percentage change was 51.75% ( $p=0.079$ ). Table 5 displays the mean steps taken per day for each participant at the two assessment time points. At baseline, six participants recorded less than 5000 steps/day, one participant recorded between 5000-7500 and one participant recorded greater than 7500 steps/day. At the completion of the intervention, four people recorded less than 5000steps/day, one participant between 5000-7500 steps/day and three participants recorded greater than 7500steps/day. Two participants failed to increase their daily step counts over the intervention period. There was large variation in baseline daily step counts ranging from 1134 steps/day to 8983 steps/day. The mean percentage change also varied with one participant increasing their step count by 136% and another participant reducing their mean daily step count by 50%. The group data is presented graphically in Figure 5 and individual changes are presented in Figure 6. Most participants did not increase their step counts in a linear manner.

Table 5: Individual changes in mean daily step counts

<b>Participant</b>	<b>Mean daily steps at baseline</b>	<b>Mean daily steps at final assessment</b>	<b>Mean percentage change</b>
<b>1</b>	8983	7547	-16
<b>2</b>	2673	4990	87
<b>3</b>	2402	6105	154
<b>4</b>	3149	7431	136
<b>5</b>	3190	4448	39
<b>6</b>	1134	1280	13
<b>7</b>	4877	2435	-50
<b>8</b>	5761	8679	51
<b>Mean (SD)</b>	4021 (2467)	5364 (2586)	51.75 (71.11)

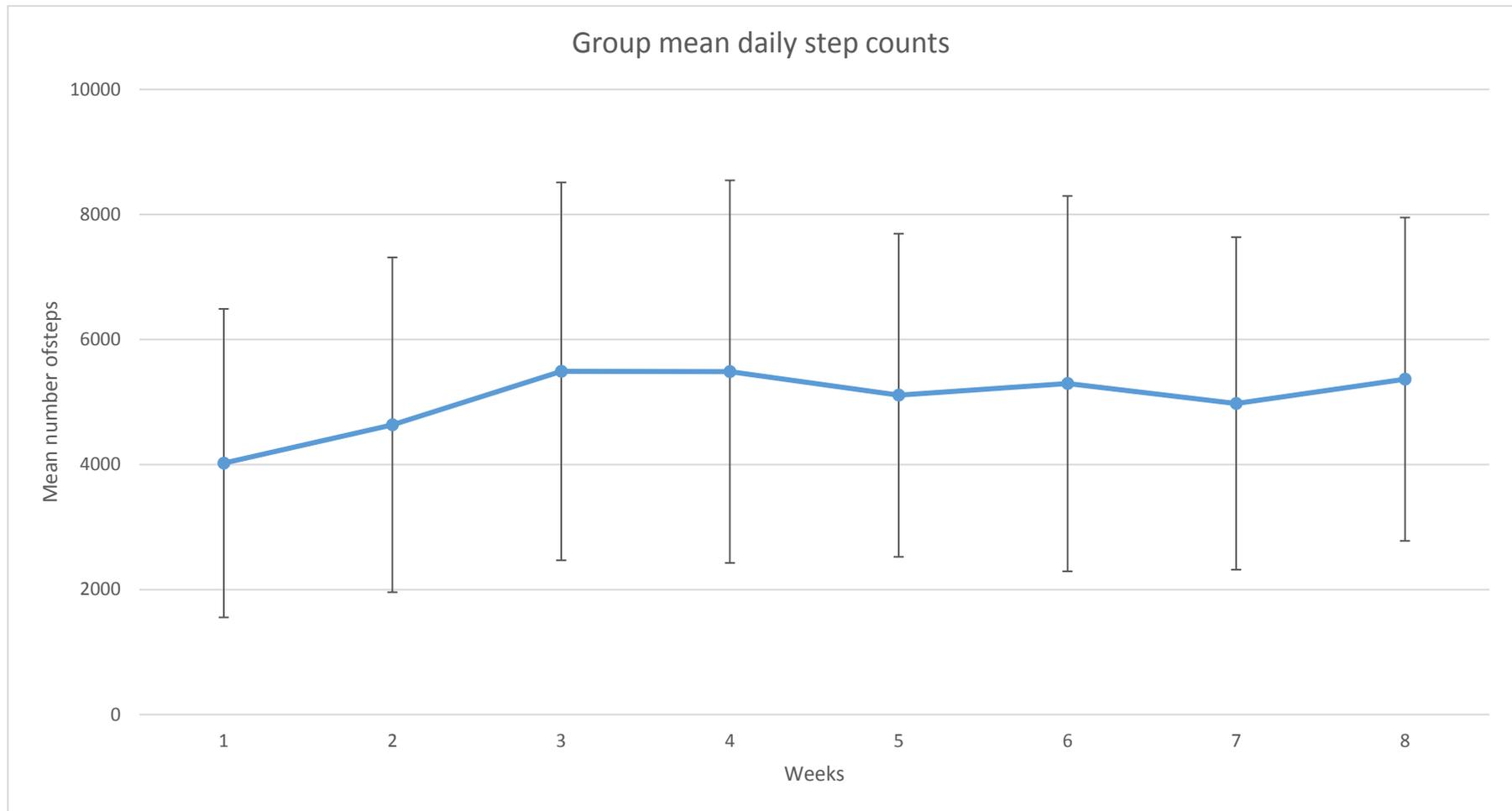


Figure 5: Graph of group mean daily step count at each week of the intervention

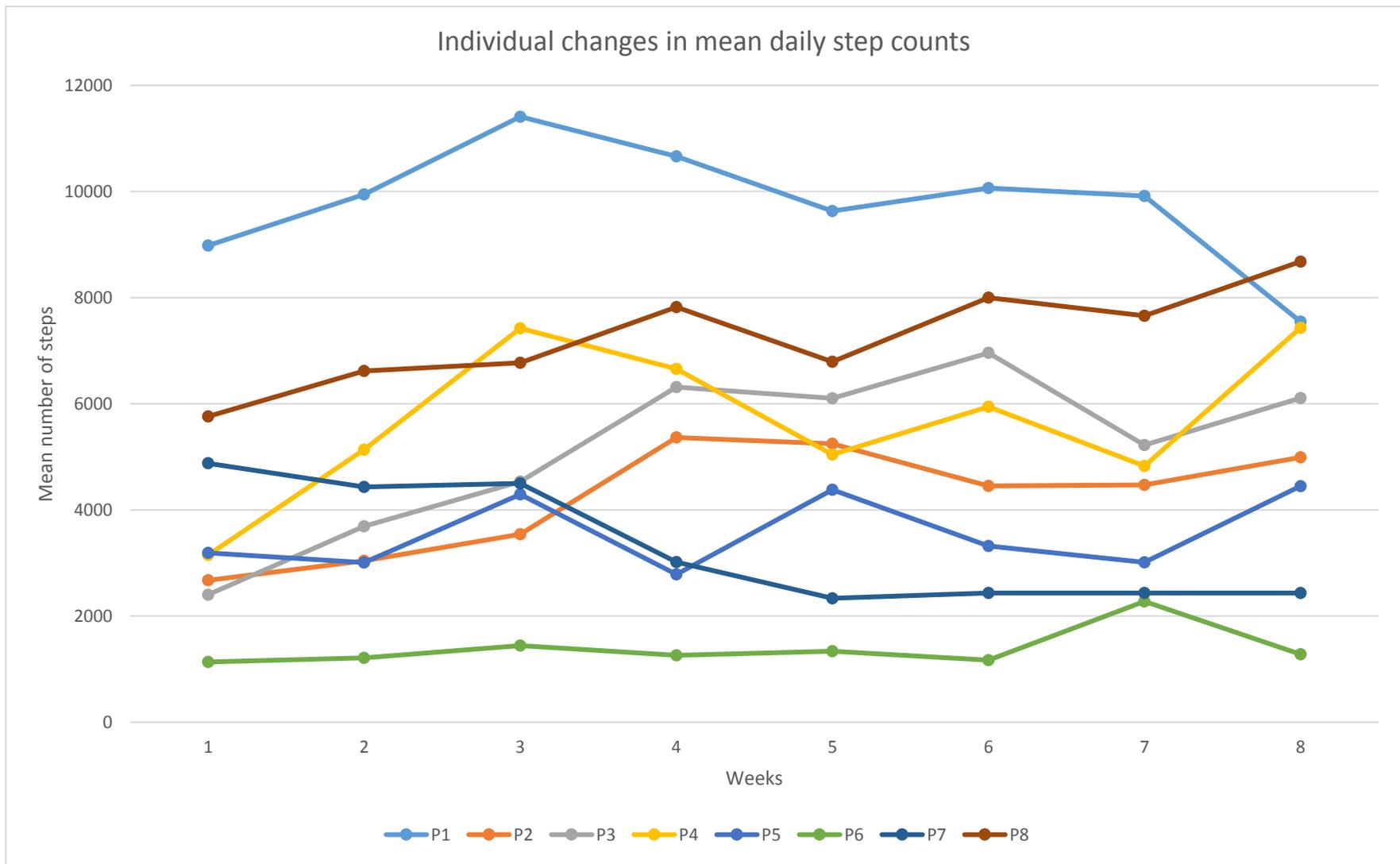


Figure 6: Graph of individual changes in mean daily step counts at each week of the intervention

## Secondary outcomes

Table 6 displays results for the secondary outcome measures.

Table 6: Secondary outcome measure results (mean and SD)

Outcome	Baseline	Final	Mean change	p-value
BP systolic (mmHg)	132 (24)	130 (17)	-2 (16.2)	0.675*
BP diastolic (mmHg)	78 (10)	78 (11)	0 (10.5)	0.948*
SSEQ	7.88 (1.87)	7.97 (1.87)	0.09 (1.14)	0.270*
6MWT (m)	366.18 (119.31)	393.75 (122.63)	27.57 (41.7)	0.103*
EQ-5D-5L	0.584 (0.342)	0.697 (0.258)	0.113(0.183)	0.126 <sup>+</sup>
EQ-5D VAS	54.00 (27.35)	68.00 (21.03)	14.00 (13.00)	<b>0.022*</b>

\*Wilcoxon signed-rank test; <sup>+</sup>student paired t-test; p <0.05 in bold

### Resting blood pressure

There was a mean reduction of 2mmHg in systolic blood pressure and no change in diastolic blood pressure. The reduction in systolic blood pressure was not statistically significant (p=0.675). At baseline, the number of participants in each classification of blood pressure were normal (n=2), elevated (n=1), stage 1 hypertension (n=2), stage 2 hypertension (n=3). At final assessment, the number of participants in each classification changed to normal (n=2), elevated (n=0), stage 1 hypertension (n=3), and stage 2 hypertension (n=3). Four participants reduced their systolic blood pressure by greater than 5mmHg, a clinically significant reduction that decreases the risk of recurrent stroke<sup>(52, 173)</sup>.

### Stroke specific self-efficacy

Stroke specific self-efficacy showed an upward trend with the mean self-efficacy score increasing from 7.88 (SD=2.62) to 7.97 (SD=1.88) over the intervention period. However, this was not statistically significant (p=0.270). The MCID for the SSEQ is unknown.

### *Walking endurance*

The distance walked on the 6MWT increased by a mean of 27.57m (SD=41.7) which was not statistically significant ( $p = 0.105$ ). Seven of the eight participants increased their distance from baseline. The mean percentage change was 7.7% with only one participant increasing the distance walked by more than the MCID of 13%<sup>(164)</sup>.

### *Health related quality of life*

The mean utility score on the EQ-5D-5L increased by 0.113 points (SD=0.183). This increase in the utility score was not statistically significant however, was greater than the MCID of 0.100<sup>(168)</sup>. Changes in health-related quality of life were seen across all five dimensions. The mobility, pain and anxiety/depression dimensions showed improvements. At baseline the number of participants reporting no problems in each dimension were: mobility (n=3), pain (n=1), anxiety/depression (n=3). At the final assessment, the number of participants reporting no problems in each dimension were: mobility (n=5), pain (n=5), anxiety/depression (n=4). The self-care and usual activities dimensions showed deterioration with more people reporting 'some/moderate problems' at final assessment. At baseline, one participant reported 'some/moderate problems' with self-care and this increased to two participants at final assessment. In the usual activities dimension, four participants reported 'some/moderate problems' at baseline and this increased to six participants at final assessment. The mean EQ-5D 5L VAS score showed a statistically significant increase of 14 percentage points (SD=13.7) over the intervention period ( $p < 0.05$ ) indicating an increase in self-perceived health related quality of life. Three participants exceeded the MCID of 8.61 points<sup>(168)</sup>.

## Adherence

All participants recorded daily step counts in exercise diaries and five participants also used the Fitbit™ app to record daily step counts. The mean adherence, that is, the percentage of days in which each participant met their daily step goal was 62% (SD=21.2). Adherence decreased across the intervention period (Figure 7) with a mean adherence rate of 68% in the first four weeks compared to 58% during weeks five-eight. Adherence was measured from week two as participants were not given a step goal in week 1.

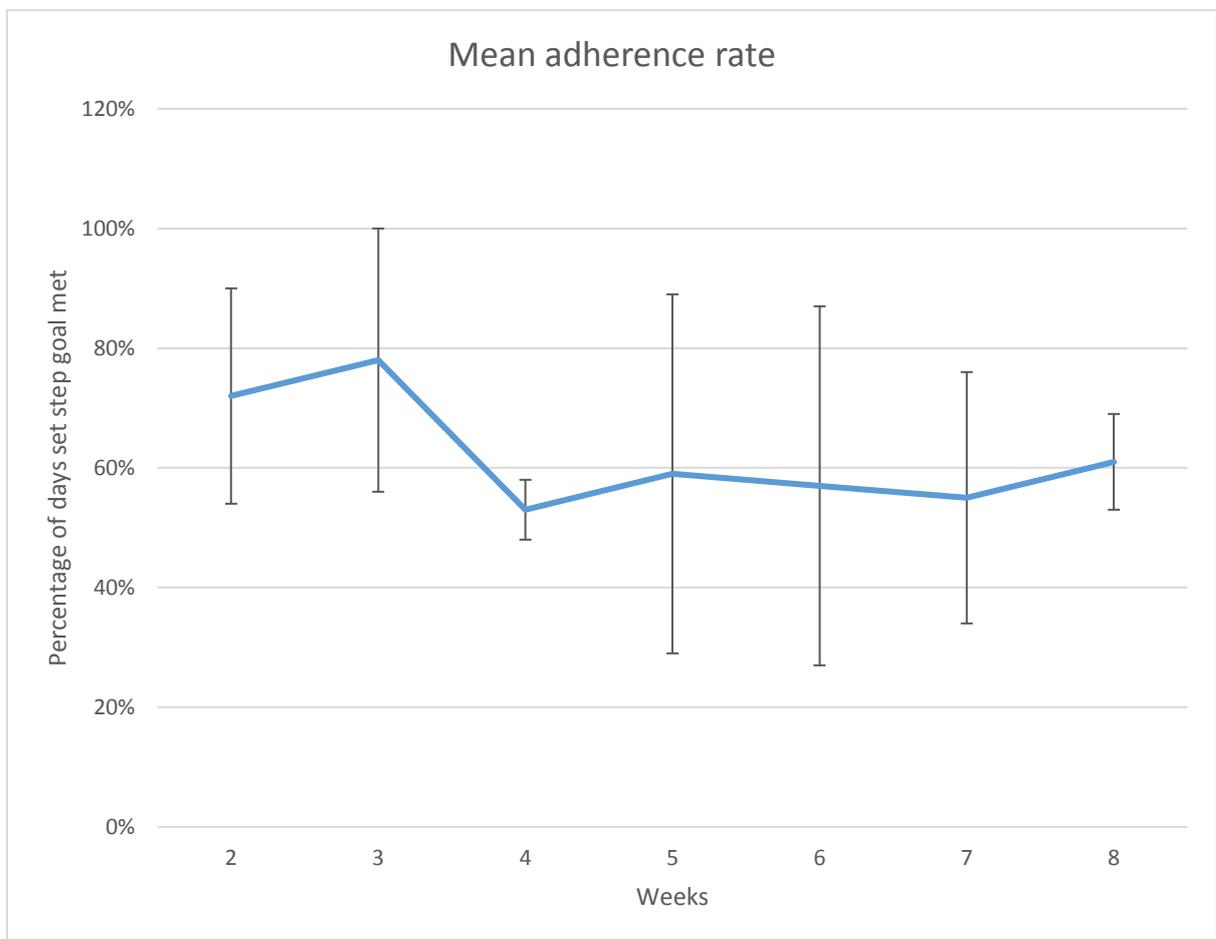


Figure 7: Graph of the mean group adherence rate at each week of the intervention

## Qualitative results

### Acceptability

Overall, participants were positive about their experience completing the walking programme although responses to the open-text survey questions were brief and of varying quality. Refer to Appendix J for examples of responses to the survey. Using directed content analysis, the text responses were sorted into the following categories: appropriateness, effectiveness, adherence and convenience and emerging themes identified. As part of this process, a new theme emerged, motivation, that did not fit into the existing framework.

### Appropriateness

Two themes emerged regarding the appropriateness of the intervention. The first included reasons why participants chose to volunteer for the study. The second theme referred to the number of face-face appointments with the physiotherapist. Participants reported volunteering for this study as they hoped it would improve their walking or fitness.

*“To see if it would help my walking.” (P6)*

*“To get my walking back up to scratch” (P4)*

*“I want to get as much fitness back as possible” (P3)*

Participants had mixed opinions on the whether the number of face-to-face appointments with the physiotherapist during the intervention was appropriate. Five participants felt the weekly contact during the first four weeks provided enough support to enable them to feel confident setting their own weekly step goals, and to allow them to continue independently with the programme.

*“I felt confident. I knew what to do and how to do it.” (P2)*

*“no problems – 4 weeks was enough” (P6)*

Three participants felt more contact would have been better even if the latter appointments did not occur on a weekly basis.

*“More contact to keep me on track.... maybe every fortnight” (P8)*

*“It was worthwhile but just need more monitoring” (P7)*

*“it was good to meet weekly with a professional.... maybe spread out appointments e.g. fortnightly/monthly” (P6)*

### *Effectiveness*

Three themes relating to effectiveness were identified: positive effects on health, effective components of the intervention and planning for continuation of walking at the end of the intervention. The first theme relating to effectiveness was that the intervention had positive effects on participants' physical and mental health.

*“I found it relaxing – often left the house stressed but relaxed once got in the rhythm of it” (P2)*

*“My anxiety and depression are much better” (P1)*

*“My legs feel a lot stronger and I'm not as reliant on my stick” (P2)*

The second theme was identification of components of the intervention that participants reported as effective. Having a goal and being able to self-monitor their own walking were valued by the participants

*“It was good having a set goal rather than just being told to walk more.” (P8)*

*“Having the Fitbit. To actually know how much you were doing.” (P8)*

*“it was good using the phone to monitor steps during the day.” (P6)*

A third theme relating to effectiveness was planning for continuation of the walking programme with all participants indicating that they planned to continue walking regularly at the conclusion of the study. Three participants reported that they had purchased their own activity tracker and another participant had downloaded a step counting application to his phone.

*“maybe get a Fitbit.... or I think my phone has an app that counts steps.” (P5)*

*“I bought a Fitbit and I'm going to aim for 9000 steps a day” (P1)*

*“keep walking as much as I can. I know how far to walk to get 1000 steps” (P6)*

There was a lack of negative feedback regarding the effectiveness of the intervention although one participant reported that they would have liked to have somebody to walk with.

*“would have been nice to have someone to walk with” (P4)*

## Adherence

The main theme that emerged regarding adherence was the barriers or challenges participants identified that prevented them from completing the walking programme as planned. A summary of barriers identified as challenges to achieving the weekly step goal are displayed in Table 7. The most commonly reported barriers to walking regularly were unfavourable weather and general health concerns. Barriers related to overall health and fatigue were the most commonly cited health-related barriers to completing the walking programme.

*“Probably didn’t do as much as I should have. My energy levels and my health stopped me doing more.” (P7)*

*“my health stopped me doing more” (P5)*

*“I did my best but some days I was so tired” (P3)*

Environmental factors such as uneven footpaths, living on a hill and bad weather also hindered participants from fully completing the walking programme. In particular, these environmental factors hindered where participants were able to walk on a daily basis.

*“the weather made it difficult” (P2)*

*“Except on wet days and I didn’t include hills” (P4)*

*‘cold days and bad pavements’ (P7)*

Table 7: Barriers to achieving set step goals

Barriers to achieving step goal
Unfavourable weather (n=5)
Other health issues (n=5)
Lack of motivation (n=4)
Environment – living on a hill, uneven footpaths, loose gravel at park (n=4)
Fear of falling (n=3)
Fatigue (n=3)
Lack of time (n=2)
Pain (n=2)

### *Convenience*

Two themes emerged regarding the convenience of the intervention. The first theme was the time commitment required to complete the intervention.

*“it took up a lot of time” (P1)*

*“was hard to fit in on busy days” (P4).*

*“it was difficult at the weekends when I like to blob out” (P3)*

However, the intervention was convenient in that participants were able to fit it in around their normal activities of daily living by walking in their neighbourhood, walking to undertake errands, taking the stairs and getting on and off buses at further away stops. Two participants reported specifically travelling to recreation areas/local trails to complete their walking.

*“around my local area but avoiding the hills” (P7)*

*“tried to take the stairs” (P8)*

*“I walked every morning. I also got off the bus earlier so I had to walk” (P1)*

The second theme was the use of technology and related to the FBZ and associated mobile app. A summary of technical issues relating to use of the activity tracker are listed in Table 8. No participants reported difficulties using the FBZ activity tracker although two people required the FBZ to be replaced due to losing it during the intervention period, and another participant reported that he worried about losing the FBZ due to its small size. Three participants required the battery to be replaced during the intervention period.

*“no problems except when flat battery, and phone battery when not charged” (P5)*

*“I lost it – fell off clip/rubber stretched. But no technical difficulties” (P8)*

*“really easy to synch to phone. The battery did go flat” (P2)*

The FBZ did not record steps for one participant when worn as suggested by the manufacturer. Two participants did not have access to the internet and were unable to use the Fitbit app, and one participant chose not to use the app due to a dislike for technology. None of the participants who used the Fitbit app reported difficulties using the mobile technology. Two participants preferred the online record of steps taken in the app to the exercise diary.

*“the diary was hard to remember what I had done” (P5)*

Table 8: Technical issues associated with use of activity tracker

Technical issues associated with use of activity tracker
Lost FBZ (n=2)
FBZ did not record steps when worn as directed (n=1)
Flat battery (n=3)
No access to internet (n=2)

#### *Motivation – inductive theme*

Motivation emerged as a theme that did not fit under the pre-determined categories. Participants reported that both the intervention and the activity tracker device itself were motivating. It appeared that participants were looking for motivation to increase their walking with three participants citing motivation as a reason to participate in the study.

*“This seemed a good opportunity to motivate myself.” (P4)*

*“It helps to do things when externally motivated.” (P2)*

*“I want to get as much fitness back as possible and need the incentive.” (P3)*

It was difficult to distinguish from the survey responses whether it was the support from the physiotherapist that was motivating or the activity tracker device.

*“need more monitoring to keep the person motivated” (P7)*

*“the Fitbit was a good motivator” (P8)*

*“it was good. It motivated me to get up and do something” (P7)*

#### *Chapter summary*

Eight participants completed the study. The primary outcome of interest was change in daily step counts and the mean group daily step count increased by 1343 steps (SD=2467) which equates to a mean change of 52% compared to baseline steps. There was no statistically significant change in the secondary outcome measures except for health-related quality of life measured on the EQ-5D-5L VAS which increased by a mean of 14 points (SD=13.7). Participants were positive about the intervention and it appeared acceptable although,

many barriers to completing the intervention were reported. Common barriers identified were lack of motivation, lack of time, fatigue, pain and environmental barriers such as unfavourable weather. There were no difficulties reported in regards to using the Fitbit™ Zip activity tracker.

## Chapter 5: Discussion

This study used a mixed methods design to evaluate an eight-week, individualised walking programme using a commercially available activity tracker, incorporating an initial four-week, face-to-face behavioural change intervention in people with chronic stroke. The behavioural change intervention involved barrier identification, problem solving, goal setting, self-monitoring and action planning. The primary outcome of interest was change in mean daily step counts and the mean group daily step count increased by 1343 steps (SD=2467) which equates to a mean change of 52% compared to baseline steps. Six of the eight participants were able to increase their mean daily step counts over the intervention period. A secondary objective of the study was to investigate the acceptability of the intervention. Acceptability was determined by evaluating the appropriateness, effectiveness, convenience and adherence of the intervention. Qualitative findings suggest the intervention was acceptable to community dwelling stroke survivors and no adverse events occurred.

The increase in mean daily step counts is promising. The mean number of daily steps taken by the participants at baseline of 4021 (SD=2467) represented a sedentary lifestyle (<5000 steps/day)<sup>(76)</sup>, whilst at the final assessment the mean number of steps/day of 5364 (SD=2586) classified as 'low active'<sup>(76)</sup>, and approached the 6000 steps/day recommended for older adults and people living with long-term health conditions<sup>(85)</sup>. The increase in mean daily step counts is comparable to other studies that have investigated walking to increase daily step counts in people with chronic stroke<sup>(94, 95)</sup>. Danks et al<sup>(94)</sup> reported a mean increase of 1167 steps/day after a four week intervention and Paul et al<sup>(174)</sup> reported an increase of 1633 steps/day after a six week intervention. However, the mean percentage change in daily step count of 52% was much greater than the 22% change reported by Danks et al<sup>(94)</sup> and 39% reported by Paul et al<sup>(95)</sup>. The large increase in the current study could be explained by the fact the sample started at a lower step count so, therefore had more potential to increase. The mean daily step count at baseline in the study by Danks et al<sup>(94)</sup> was 5205 (SD=2571), however the mean daily step count at baseline of 4148 (SD=2550) in Paul et al<sup>(95)</sup> was very similar. In the current study, there were two participants who increased their baseline steps by 154% and 134% respectively which may have skewed the results.

The percentage by which each participant increased their mean daily step counts was highly variable. Strategies utilised to increase step counts were individualised to each participant. The most inactive participants at baseline accumulated steps by reducing sedentary time whereas the more active participants were encouraged to plan structured walking into their week. Frequent, short bouts of low intensity physical activity can reduce systolic blood pressure in stroke survivors and may have other health benefits<sup>(91)</sup>. Physiotherapists should put greater emphasis on the benefits associated with short bouts of low intensity physical activity compared to remaining sedentary. For inactive individuals, increasing physical activity through short bouts of activity may be more acceptable than walking for 30 minutes at a time as recommended in physical activity guidelines<sup>(78)</sup>.

In the current study, the largest increases in individual step counts occurred in the first four weeks compared to weeks five-eight, and most participants did not increase their weekly step count in a linear fashion. This is unsurprising as during the first four weeks, participants met weekly with the physiotherapist. Meeting weekly is likely to have kept the individual accountable especially as part of the meeting involved reviewing the individual's step counts as recorded in the walking diary from the previous week. While the mean increase in daily step counts slowed after the cessation of the face-to-face appointments, it is promising that participants did continue to increase step counts albeit at a slower rate. A slow and steady rate of increasing daily step counts may in fact be more sustainable in the long term rather than a large increase during the intervention which returns to baseline at the conclusion of the intervention. There are no current studies focusing on increasing walking in stroke survivors that have followed up participants using objective measures greater than one year. Preston et al<sup>(96)</sup> delivered a self-management programme over three months involving five face-to-face sessions. The aim of the self-management programme was to increase physical activity and participants were followed up at three and six months. The mean number of steps per day increased from baseline by 20% at the conclusion of the three month intervention but had decreased to 3.6% from baseline at the six month follow up<sup>(96)</sup>. More longitudinal studies are warranted to determine the long-term effects of walking interventions in stroke survivors.

The plateau in step counts after week four, is reflected in the adherence rate which decreased over the course of the intervention. The mean adherence rate was 68% in the first four weeks when the face-to-face appointments occurred and decreased to 58% during

weeks five-eight. In the current study adherence rates varied from 39 – 78%. Interestingly, on an anecdotal note, there did not appear to be any association between adherence rate and daily step counts. That is, some people with low adherence (<50%) still had a large increase in step counts over the intervention period. This may be a result of the most adherent participants not progressively increasing their step goals across the intervention, whereas other participants set very high step goals that they were unable to achieve on a regular basis. The reason some participants had high adherence yet small increases in step counts may be related to self-efficacy. Higher self-efficacy is linked to setting harder goals and being more resilient to challenges such as failing to meet the set step goal<sup>(130)</sup>. In the current study, individuals with higher self-efficacy may have set higher step goals for themselves than the individuals with lower self-efficacy. Daily step goals were set by the participants with support from the physiotherapist and if participants reported being less than 8/10 confident of achieving the goal, it was suggested the goal was re-defined. Adherence was calculated from the exercise diary of each participant as the percentage of days the step goal was achieved. Therefore, individuals who regularly achieved the set daily target had higher adherence than those who increased their physical activity by accumulating steps on less days across the week. Some participants structured their week by planning to undertake three planned walks a week and on those days, they far exceeded the step goal. One participant consistently met his daily step goal but did not progressively increase his goal over the intervention period (mean change in daily step count 12.8%). It is difficult to compare the adherence rate to other studies due to inconsistencies relating to how adherence is reported<sup>(175)</sup>.

Although adherence across the study was highly variable, four of the eight participants reported that they completed the walking programme fully and all participants reported that they intended to continue walking regularly at the conclusion of the study. In fact, four participants purchased their own activity trackers or downloaded a mobile phone app to ensure they could continue monitoring step counts. This supports the qualitative data that the intervention was acceptable and proposes that behaviour change did occur for some participants. It is a promising finding that participants intended to continue walking and monitoring step counts and ultimately reduce their risk of recurrent stroke.

The qualitative data explained the variability in the adherence rate in part. Participants reported how reaching their daily step goal was often challenging and identified a number of

barriers to achieving this goal. Participants who voiced that they thought more contact time with the physiotherapist would be beneficial, appeared to want the external motivation “to keep them on track”. While it is likely that each individual may require differing amounts of support to increase and maintain regular walking, future research should consider extending the amount of support provided to individuals struggling to meet their daily step goal, as more support may have resulted in further increases in mean daily step counts.

Adherence may be improved by providing external support as the plateau in step counts in the current study suggest that more ongoing contact/support is needed in order to sustain the behaviour change. External support does not have to be provided face-to-face and methods such as telephone, email, text messaging or internet platforms could be explored. However, the evidence for using telephone coaching, email, text or internet platforms to deliver walking interventions to stroke survivors is limited. A small (n=22) feasibility study delivered an eight week self-management programme via telephone and email to people with acquired brain injury<sup>(176)</sup>. The focus of the self-management programme was to increase physical activity. Ninety-five percent of participants were satisfied with the programme however, there were no statistically significant changes in the amount of sedentary time, mean daily steps taken or time spent in moderate to vigorous activity per day at the end of the eight-week intervention or at three month follow-up<sup>(176)</sup>. Similarly, Damush et al<sup>(177)</sup> investigated a self-management programme for stroke survivors delivered by a combination of face-to-face appointments and telephone calls. The duration of the intervention was six months and the purpose of the telephone calls was predominantly to help with goal setting. Participants in the intervention group showed an increase in self-efficacy and an increase in self-reported physical activity although this was not statistically significant and not measured objectively<sup>(177)</sup>.

Text messaging to encourage physical activity has been used in acute stroke survivors following discharge from hospital<sup>(178)</sup> and has been shown to be feasible in this population. The text messages used by Taylor et al<sup>(178)</sup> were automated and not individualised. Text messaging has also been used in older adults to increase physical activity<sup>(179, 180)</sup>. Parker et al<sup>(179)</sup> sent morning and evening automated text messages on three days a week to prompt study participants (n=28) to complete physical activity. Parker et al<sup>(179)</sup> reported an increase in physical activity in the intervention group who received the text messages however, physical activity was measured using a self-report measure and the study participants were

described as 'active' at baseline. Müller et al<sup>(180)</sup> evaluated the use of text messages to promote physical activity in a sample of sedentary older adults. Participants received 60 text messages over the 12-week intervention period. Text messages were not personalised to the individual but each participant received an unique text each day. Participants in the intervention group increased their self-reported physical activity over the intervention period but physical activity levels decreased significantly once the text messages ceased<sup>(180)</sup>. This further supports the need for ongoing external support for maintenance of physical activity.

The Fitbit™ app allows for remote monitoring of participants and this could be supported by text messaging both as reminders to complete daily planned walking and as positive encouragement after meeting goal steps for the day. The features available in the Fitbit™ app were not completely utilised in this study and warrant further investigation especially regarding the features available to create virtual friend networks. Virtual friend networks could provide the external motivation and support that stroke survivors require to maintain their daily walking without requiring professional support. Motivation to exercise has been reported to decrease over time in long-term stroke survivors without ongoing external facilitation<sup>(181)</sup> and stroke survivors report a tendency to relapse to low levels of physical activity without continued external support<sup>(181)</sup>. In the STARFISH App developed by Paul et al<sup>(95)</sup> individuals work together in groups of four to create a virtual network of social support/competition with the goal of increasing physical activity. Each group member is represented by a fish avatar and individual and group rewards are provided for achieving goals. In a focus group of older adults who used the STARFISH app, participants reported that they valued the social comparison the app allowed and that this motivated them to do more physical activity<sup>(174)</sup> Social support is an important construct of the SCT which allows for vicarious experiences and has been identified as an important motivator for uptake and maintenance of physical activity in long term stroke survivors<sup>(133, 182, 183)</sup>. Only one participant in the current study mentioned they would have liked formal social support such as somebody to walk with. However, most participants reported having informal support networks that encouraged them with their walking. It is possible that providing structured support networks such as a weekly walking group may keep people accountable and reduce the need for ongoing professional support. Further research should continue to investigate

the optimal amount of support and new ways to provide this support, that encourages long term participation while also enabling participants to self-manage their physical activity.

As well as an increase in daily step count, seven of the eight participants increased their walking endurance when measured by the 6MWT. All but one participant had base line 6MWT scores below those of healthy, age matched peers<sup>(184)</sup> supporting previous studies which have found stroke survivors to have low levels of cardiovascular fitness<sup>(14, 36)</sup> The mean increase of 27.5m represented a mean change of 7.7%. Flansbjer et al<sup>(164)</sup> has suggested that a change greater than 13% represents a clinically meaningful change in chronic stroke survivors. The small mean change seen in 6MWT results in the current study could be due to a number of factors:

- i) Different walkway lengths have been found to significantly affect the distance walked in the 6MWT<sup>(185)</sup> so not using the full 30m walkway as recommended in the ATS guidelines due to space limitations may have under-estimated distance. Individuals had to complete more turns in the current study. Turning can be difficult for people with stroke and may require more time to complete.
- ii) Individuals walk at a self-selected pace which may not truly reflect how far they are able to walk in six minutes.
- iii) Final assessments in the current study were undertaken after nine weeks. It is possible that the intervention period was too short for changes in walking endurance to occur. However, the increase of 27.5m was greater than the increase reported by Sullivan et al<sup>(69)</sup> where only five of eleven participants improved the distance walked on the 6MWT after a six week intervention to increase step counts in a chronic stroke population. The mean increase reported by Sullivan was -25m, that is, walking endurance actually decreased at follow up. In contrast, Preston et al<sup>(96)</sup> reported much larger increases of 43m at three months and 61m at six months. These increases were in acute stroke survivors with a mean time since stroke of 16 days at baseline, which may not be comparable and Preston et al<sup>(96)</sup> had longer follow up. It is also likely that acute stroke survivors have less deconditioning and therefore it may be easier for them to increase their walking endurance over a shorter time period.

Interventions to improve walking after stroke need to be task-specific<sup>(186)</sup>. Therefore, to increase walking endurance, individuals need to increase time spent walking in a single session. Walking at moderate intensity may also be important for improving walking endurance. In the current study, participants were educated about moderate intensity and encouraged to monitor the intensity of their walking using the Borg rate of perceived exertion scale however, intensity was not formally measured. The lack of statistically significant change seen in the 6MWT results may be due to participants not undertaking steps at a high enough intensity during the walking intervention to impact walking endurance. An observational study investigating how stroke survivors accumulate steps across the day found that 75% of steps taken were across short bouts of activity<sup>(187)</sup>. Short distance bouts of activity were defined as less than 40 steps<sup>(187)</sup>. This is comparable to Danks et al<sup>(94)</sup> who found that even after an intervention to increase daily step counts, more than 50% of steps accumulated were taken during short bouts of activity<sup>(94)</sup>. Encouraging individuals to take longer bouts of activity may be a simple way to increase steps and influence walking endurance in future studies.

Walking has been shown to increase quality of life after stroke<sup>(53)</sup> and in the current study there was a statistically significant change in health related quality of life (QOL) when measured on the EQ-5D 5L VAS. The group mean change in the EQ-5D-5L utility index exceeded the MCID<sup>(168)</sup>. The qualitative data also supported this increase in health-related QOL with three participants reporting improved mood after walking. While this is unsurprising given that daily physical activity has been shown to have a positive effect on QOL in stroke survivors<sup>(188)</sup>, it is promising that such a modest increase in steps (1343) can lead to a meaningful clinical change in health related QOL. This increase in health-related QOL is comparable to Preston et al<sup>(96)</sup> who reported an increase of 15 points on the EQ-5D-5L VAS after five sessions of self-management over three months. It is interesting that the change in EQ-5D-5L VAS in the current study was similar to that found by Preston et al<sup>(96)</sup> as the study populations were quite different in regards to time since stroke. The median time since stroke in the current study was 13.5 months compared to Preston et al<sup>(96)</sup> where mean time after stroke was just 16 days. QOL may be more amenable to change in acute stroke survivors due to stroke being a sudden event. A sudden change in health status may make people more likely to initiate positive health behaviours acutely after stroke rather than in

the chronic phase. QOL is also likely to change rapidly during the acute time period due to improvements in motor skill and function which can occur on a daily basis.

Stroke self-efficacy scores showed minimal change at the final assessment. This is a somewhat unexpected finding as the intervention aimed to improve self-efficacy. Self-efficacy is closely linked to behaviour change and the increase in step counts would suggest that behaviour change did occur to some extent. The lack of meaningful change seen could be due to a lack of sensitivity of the outcome measure used or that the SSEQ measure had ceiling effects. Participants already scored highly on the stroke related self-efficacy scale at baseline with the mean score on the SSEQ at baseline 7.88 out of maximum 10 points. While the SSEQ is specific to the stroke population it does have a number of items not related to walking. The psychometric properties of SSEQ need more research including determining what represents a meaningful change. For future research, it would be worth investigating a different scale that may be more sensitive to change in a more active population. An alternative scale that has been used to measure self-efficacy in people with stroke is the self-efficacy for exercise scale<sup>(189)</sup>. The self-efficacy for exercise scale is a simple measure where an individual rates their confidence in completing exercise under nine different conditions<sup>(57)</sup>. However, the self-efficacy for exercise scale also has limitations as it was developed in older, sedentary adults and subsequently lacks sufficient validation in the stroke population.

### Acceptability

A novel part of this study was the qualitative component which explored the acceptability of the intervention which has not been reported in previous research using pedometers or activity trackers in chronic stroke survivors. Previous studies have tended to focus on the efficacy of interventions, and the few studies which have used qualitative methods, have investigated feasibility alone, rather than acceptability. For example, both Sullivan et al<sup>(69)</sup> and Carroll et al<sup>(70)</sup> used a pedometer satisfaction survey however, the survey consisted of questions regarding the ease of use of the pedometer device such as ability to read steps and don/doff the device, rather than the participants perception of the intervention. The current study aimed to explore the participants experience of the intervention and it was hoped that in doing so, would add context to the quantitative data. Overall, the intervention appeared acceptable and there was a lack of negative feedback regarding the intervention.

The intervention was appropriate in that the purpose of the walking programme was to increase daily step counts in people living with stroke and participants reported volunteering for the study to improve their fitness and walking. Some participants reported that they were looking for motivation to walk more and that they needed an 'incentive' or external motivation to enable this to happen. Participants reported the increase in step count had positive changes in other aspects of health including increased leg strength, decreased anxiety and better mood due to walking

Goal setting and self-monitoring appeared to be the most important components of the intervention and the qualitative data provided insight that participants liked knowing what to do, having a set daily step goal to work towards and being able to self-monitor their daily step counts. Participants were able to self-monitor the steps taken by checking the FBZ throughout the day, completing the exercise diary or accessing the dashboard of Fitbit™ app. There were two participants who did not record their steps in the paper exercise diary and used only the app on their phone. An aspect of the intervention that was potentially under-utilised was the action and coping plans. The action plans were completed in collaboration during the face-to-face meetings however after this time, no participants added to them. It is possible that it is the process of talking through the action plan that is important rather than the document itself.

The barriers to increasing physical activity identified by the participants in this study, are consistent with previous findings<sup>(43, 44, 133)</sup> and include both personal and environmental factors. Personal factors identified were a lack of motivation to walk, making time to walk, lack of confidence walking outdoors, general health concerns, fatigue and pain.

Environmental factors identified were unfavourable weather conditions, uneven footpaths, slopes and accessibility of public parks. Lack of motivation is commonly cited as a barrier to physical activity in stroke survivors<sup>(133)</sup>. However, as the participants in the current study were volunteers who chose to take part in a walking programme, it was somewhat unexpected that they reported feeling unmotivated to walk. Consequently, the qualitative data revealed that many of the participants were looking for motivation to walk more and was the main reason they volunteered for the study. The inductive theme of 'motivation' identified in the qualitative data of my study supports how motivation was a key aspect of the intervention and how participants were aware that they required external motivation either from the physiotherapist or the activity tracker device itself to maintain their walking.

The current study was based on the SCT. Another model of health behaviour change is the Trans-Theoretical Model of change<sup>(190)</sup> which proposes behaviour change occurs through a series of stages. The six stages are: precontemplation, contemplation, action, maintenance, relapse, termination<sup>(190)</sup>. Completing a stages of change assessment at baseline may also have helped identify those not ready to make a change rather than assuming volunteers for a study were ready to take action. An individual's level of readiness to change at the beginning of an intervention to increase exercise has been shown to predict compliance and outcomes of the intervention<sup>(191)</sup>. Garner and Page<sup>(192)</sup> used the Stages of Change Questionnaire<sup>(191)</sup> in a sample of stroke survivors and demonstrated that a higher stage of readiness to change was associated with a higher level of participation in exercise. Future research into walking programmes using activity trackers could use the Stages of Change Questionnaire<sup>(191)</sup>. Knowing the individual's stage of readiness to change would allow for more specific tailoring of the intervention and enable health care providers to determine who is most likely to successfully increase their physical activity using an activity tracker based intervention.

Lack of time or time required to reach the daily step goal was a common barrier and participants disliked the time commitment involved with the walking programme. Only one participant in the current study was employed and it appeared difficult for this participant to increase their daily step counts. Three participants reported fear of falling and another two voiced not feeling confident walking alone. This fear/lack of confidence limited their ability to self-manage their walking as they were reliant on family to either walk with them or to provide transport to a suitable location to walk. Despite the mild physical impairments present in the study population there were three falls reported during the intervention period suggesting falls self-efficacy is an important aspect to address in all stroke survivors when increasing physical activity. Falls self-efficacy has been found to be closely associated with participation<sup>(193)</sup>. Future research should include a measure of balance self-efficacy and a tailored intervention to address this.

General health concerns were prevalent in the study sample with seven of the eight participants reporting co-morbidities. The most commonly reported health concerns that impacted on walking were musculoskeletal pain and fatigue. Musculoskeletal pain is common and reported by up to 30% of stroke survivors at six months after stroke<sup>(194, 195)</sup> and in older adults living in NZ, it is estimated 67% have some form of musculoskeletal pain<sup>(196)</sup>.

Fatigue is also highly prevalent in people with chronic stroke<sup>(197)</sup>. Targeted education regarding how exercise can improve pain and fatigue should be incorporated into future studies.

Inclement weather was consistently reported as a barrier to increasing step count even though the majority of participants completed the walking programme during spring/summer. Participants all lived in the city of Dunedin, in southern New Zealand. Dunedin has a mean temperature of 15 degrees Celsius and frequent rainfall. Developing a local resource and suggesting strategies to target common barriers to increasing physical activity may be beneficial for future walking interventions. Dunedin is also a hilly city and many of the participants were unable to walk outside their houses due to steep streets and uneven footpaths. A recent review of 21 parks within New Zealand found that none met the national standards for accessibility and usability<sup>(198)</sup>. Physiotherapists need to continue to advocate for accessible spaces for people with disabilities in order to reduce environmental barriers to physical activity.

From the interventionists point of view, developing a rapport with each participant appeared to be a vital part of whether or not the participant engaged with the intervention. Those individuals who shared the most about their motivations to change appeared to respond best to the intervention. A common perception amongst researchers regarding behaviour change is the importance of a collaborative or therapeutic relationship between the patient and the health care provider<sup>(199, 200)</sup>. A therapeutic relationship refers to the rapport established between the therapist and client through collaboration, communication, therapist empathy and mutual understanding and respect<sup>(201)</sup>. Patient satisfaction has been shown to be associated with the quality of the therapeutic relationship<sup>(202)</sup>. There is emerging research in the physiotherapy arena that suggests the important ways to develop a therapeutic relationship involve being present, receptive, genuine and committed<sup>(200)</sup>. These conditions are important for both the physiotherapist and the person for whom they are engaging in the clinical interaction. Working collaboratively with individuals is an important component of the Bridges framework discussed in chapter two and was the approach utilised by the researcher in this intervention.

From the interventionist's perspective, it was challenging to work with some participants who appeared less able to problem-solve and were looking to myself, as the physiotherapist for solutions. Problem solving may be challenging for those after stroke due to the loss of

executive functioning<sup>(203)</sup>. Although the Mini Mental State Examination<sup>(147)</sup> was used to exclude participants with cognitive impairment, executive function changes may be more subtle and affect the ability to problem solve. Unfortunately, there is currently limited research regarding the best techniques to use to improve executive functioning and problem solving in people with stroke<sup>(204)</sup>.

### Technical challenges

The current study used the commercially available FBZ activity tracker. Overall, there were no difficulties reported by participants regarding don and doffing the device or reading the step count display. Some participants raised concerns about the small size of the device and two activity tracker devices needed to be replaced during the intervention period due to being lost. The FBZ was chosen for use in the current study due to the advertised long battery life (4-6months) and to eliminate the need for regular charging of the device as it was assumed this may be difficult if participants had upper limb impairments following stroke. However, three participants required the battery to be replaced during the course of the intervention. Battery life appeared to be related to the frequency of synching the FBZ to the smartphone as the batteries lasted longer in the participants not using the mobile app. In hindsight, the participants in the current study had mild physical impairments and would have managed to use a rechargeable device. It is probable that any activity tracker that provides feedback to allow self-monitoring could be considered and that the increase in mean daily steps counts is not unique to the activity tracker chosen for this study. The FBZ was unable to record steps when worn as directed for one participant. This problem was solved by attaching the FBZ to the participant's shoe and using the Fitbit app to allow him to self-monitor his steps. This participant walked very slowly, completing only 109m in the 6MWT at baseline. The inability of activity tracker devices to detect steps at slow walking speeds and with asymmetrical gait patterns has been previously identified<sup>(74, 155)</sup> and discussed in chapter 2. The FBZ was unable to measure sedentary behaviour or intensity of physical activity. Future studies could use an activity tracker device that is able to capture these outcomes alongside daily step counts. Three of the participants did not use the Fitbit™ app. The main reason that participants did not use the app was due to lack of internet access. When developing remote/internet based interventions, researchers need to be cognisant that not all people have internet access or the desire to utilise technology.

### Study strengths and limitations

A strength of this study is that all appointments during the intervention period, were conducted by the same physiotherapist which standardised the delivery of the intervention. However, lack of a comparison group and lack of blinding of the assessor and participants are threats to internal validity. Baseline measurement of daily step counts was conducted in week one of the intervention after providing participants with the FBZ activity tracker. Participants were instructed to undertake their normal daily activity to gain the baseline measurement however, it is possible that giving someone a novel device may encourage them to be more active than normal. Therefore, the baseline daily step counts may actually have been lower than reported. Further to this, daily step counts were measured using the FBZ activity tracker which although reliable at slow walking speeds<sup>(155)</sup>, has yet to be validated in people with stroke. The FBZ was unable to measure all elements of physical activity such as time spent in sedentary behaviour and intensity of physical activity.

There are a number of limitations to this study. A major limitation was the small sample size which in turn meant the study was under-powered and therefore not able to demonstrate statistically significant results. The small sample size was a reflection of the methodology used whereby recruitment was dependent on participants being recruited to the initial “Walking to Better Health After Stroke” study. The inability of the “Walking to Better Health After Stroke” study to recruit the proposed number of control participants, reduced the pool of participants available to participate in this study. The difficulty with recruitment and time constraints of this project resulted in a small sample size which means the results may lack generalisability to the wider population. The participants recruited were predominantly female and lack ethnic diversity with all but one identifying as New Zealand European. While the participants were also heterogenous in regards to time since stroke (time since stroke ranged from 6-146 months) and varied in their walking endurance (6MWT ranged from 109.5-488m at baseline), this heterogeneity is likely to be representative of any cohort of community dwelling stroke survivors. Acceptability of the intervention was measured using a self-administered survey. The process of returning the survey and the small number of participants, meant it was not possible to totally anonymise the responses. Bias may have occurred if participants felt unable to record negative comments. A limitation of the survey design was that most questions were answered with short responses. Conducting individual semi-structured interviews with each participant may have elicited more detailed qualitative data.

### Future research

Further research with larger samples, a comparison group and longer follow up time is warranted to determine whether the increase in daily step count can be maintained. Future research could deliver the same intervention using the four face-face appointments but expand the remote monitoring aspect of the intervention. Using the Fitbit™ app to monitor participants daily step counts and supporting this by text messages to provide feedback to the individual may be an easy way to extend the support given and provide the motivation some participants reported was lacking in the current study. Text reminders to complete daily walking may also be advantageous. More research is also warranted to identify those individuals who will need more support to undertake and sustain increased physical activity.

### Conclusion

This study used a low-cost commercially available activity tracker device alongside a behavioural change intervention delivered by a physiotherapist. The behavioural change intervention involved barrier identification, problem solving, goal setting, self-monitoring and action planning and was delivered over four face-to-face appointments. The findings suggest that it is possible to increase daily step counts in a population of chronic stroke participants. More research with larger sample sizes, a comparison group and longer follow up is required however, ultimately this was an acceptable intervention to increase daily step counts in community dwelling, chronic stroke survivors.

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# Participant Information Sheet

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## A pedometer-based walking programme for people with stroke

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### Introduction

Thank you for showing an interest in this project. Please read this information sheet carefully. Take time to consider and, if you wish, talk with relatives or friends, before deciding whether or not to participate. If you decide to participate, we thank you. If you decide not to take part, it will not affect your usual care (now or in the future) and we thank you for considering our request.

### What is the aim of this research project?

The aim of this research project is to determine whether an 8-week goal-directed walking programme, facilitated by a physiotherapist, can improve physical activity in people with stroke, and to determine what factors impact on adherence to the walking programme. This project is being undertaken as part of a Masters of Physiotherapy degree.

### Who are we seeking to participate in the project?

Participants randomised to the control (usual care) group in the 'Walking to better health after stroke' study will be invited to participate in this project.

### If you participate, what will you be asked to do?

You will be asked to attend a 60-minute appointment at the School of Physiotherapy. Your physiotherapist will provide you with a pedometer (Fitbit™) to wear every day in order to monitor how many steps you take. This is a small device that can clip to a waistband or be carried in your pocket. You will be fully trained in how to use the Fitbit™ and given a walking diary in which to record the number of steps registering on the Fitbit™ each day. You and your physiotherapist will discuss how much walking you should aim to do and how you might be able to fit this into your daily routine.

For the next four weeks, you will meet weekly with the physiotherapist to review your step count and discuss any concerns. A daily step target for the following week will then be agreed and you and your physiotherapist will discuss how 'hard' you should walk and how best to fit this into your week. In this way, the walking programme will be tailored to suit your needs and progressed on a weekly basis.

During weeks 5-8, you will no longer receive weekly contact from the physiotherapist, however, you will have their contact details if any concerns arise. During this period, you will need to continue wearing the Fitbit™ on a daily basis and record steps taken in the walking diary. After 8 weeks, you will be asked to return to the School of Physiotherapy with your walking diary. You will also have your blood pressure measured, complete a six-minute

walking endurance test, and complete a quality of life questionnaire along with a short survey about your experiences using the Fitbit™.

### **Is there any risk of discomfort or harm from participation?**

There is a risk that you could fall whilst walking. All precautions will be taken to prevent this risk. You will be in charge of your walking programme and it is up to you where you walk, when you walk and whether you want to use a walking aid, handrail or the support of another person. You may experience some muscle discomfort from unaccustomed exercise; skin reaction from Fitbit™ contact (rare); or fatigue. You will be encouraged to discuss these issues and any others you experience, with your physiotherapist. If symptoms persist, or concern remains, advice will be given for you to attend an appropriate health practitioner and you can decide whether to continue with the programme or withdraw.

In the unlikely event an injury may occur, you would be eligible to apply for compensation from ACC, just as you would be if you were injured in an accident at work or at home. This does not mean that your claim will automatically be accepted. You will have to lodge a claim with ACC, which may take some time to assess. If your claim is accepted, you will receive funding to assist in your recovery.

If you have private health or life insurance, you may wish to check with your insurer that taking part in this study won't affect your cover.

### **What specimens, data or information will be collected, and how will they be used?**

Information will be collected on your age, gender, ethnicity and medical condition (including current medications) along with your responses to our questionnaires and measurements of blood pressure and walking endurance. Information relating to your daily step count will be collected from your walking diary for analysis, along with any information you provide regarding the programme. This information will be analysed to explore how practical the walking programme is for people with stroke, and the factors impacting on adherence to the programme. All information will be retained in secure storage for 10 years, as required by the University's research policy, after which it will be destroyed.

### **What about anonymity and confidentiality?**

A unique participant code number will be assigned to you at the start of the "Walking to better health after stroke" study and used on all records in this study instead of your name. The master list linking your name and number will be kept in a secure location and will be destroyed upon completion of the data collection period. Although we plan to publish the findings of this study and present at conferences, the data will be reported in group form, so that it will not be possible to identify individuals. The consent forms will be stored separately from the completed questionnaires so that it will not be possible to associate a name with any given set of responses. No information that discloses your identity will be released or published without your specific consent to the disclosure. A summary of the final results will be available to you on request.

### **If you agree to participate, can you withdraw later?**

You may withdraw from participation in the study at any time and without any disadvantage to yourself. Please make the primary investigator aware at any time if this is the case. Your participation in this study is voluntary and no aspect of any ongoing care will be affected should you either decline or agree to participate. Should you wish to participate, you will be asked to provide written consent. Unfortunately, we are unable to reimburse you for any expenses you may incur during the period of your participation.

### **Any questions?**

If you have any questions now or in the future, please feel free to contact the Principal Investigator:

<b>Dr Lynne Clay</b> , Centre for Health, Activity and Rehabilitation Research, School of Physiotherapy, <a href="mailto:lynne.clay@otago.ac.nz">lynne.clay@otago.ac.nz</a>	Contact phone number: 03 479 5235/ 0800 687489
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*This study has been approved by the Health and Disability Ethics Committee (HDEC) Number 16/NTA/243/AM02. If you have any concerns about the ethical conduct of the research you may contact the Committee by phone on 0800 4 38442 (0800 4 Ethic) or email [hdecs@moh.govt.nz](mailto:hdecs@moh.govt.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome*

## Appendix B: Ethics approval



### Health and Disability Ethics Committees

Ministry of Health  
133 Molesworth Street  
PO Box 5013  
Wellington  
6011

0800 4 ETHICS  
hdec@moh.govt.nz

15 February 2017

Dr Lynne Clay  
School of Physiotherapy  
325 Great King St  
Dunedin 9016

Dear Dr Clay

Re:	<b>Ethics ref:</b>	<b>16/NTA/243</b>
	Study title:	Feasibility study to evaluate a goal-directed, physiotherapy-facilitated walking programme to enhance health and wellbeing in people after stroke

I am pleased to advise that this application has been approved by the Northern A Health and Disability Ethics Committee. This decision was made through the HDEC-Expedited Review pathway.

#### Conditions of HDEC approval

HDEC approval for this study is subject to the following conditions being met prior to the commencement of the study in New Zealand. It is your responsibility, and that of the study's sponsor, to ensure that these conditions are met. No further review by the Northern A Health and Disability Ethics Committee is required.

Standard conditions:

1. Before the study commences at *any* locality in New Zealand, all relevant regulatory approvals must be obtained.
2. Before the study commences at *any* locality in New Zealand, it must be registered in a clinical trials registry. This should be a WHO-approved (such as the Australia New Zealand Clinical Trials Registry, [www.anzctr.org.au](http://www.anzctr.org.au)). However <https://clinicaltrials.gov/> is acceptable provided registration occurs prior to the study commencing at *any* locality in New Zealand.
3. Before the study commences at a *given* locality in New Zealand, it must be authorised by that locality in Online Forms. Locality authorisation confirms that the locality is suitable for the safe and effective conduct of the study, and that local research governance issues have been addressed.

After HDEC review

Please refer to the *Standard Operating Procedures for Health and Disability Ethics Committees* (available on [www.ethics.health.govt.nz](http://www.ethics.health.govt.nz)) for HDEC requirements relating to amendments and other post-approval processes.

Your **next progress report** is due by **14 February 2018**.

Participant access to ACC

The Northern A Health and Disability Ethics Committee is satisfied that your study is not a clinical trial that is to be conducted principally for the benefit of the manufacturer or distributor of the medicine or item being trialled. Participants injured as a result of treatment received as part of your study may therefore be eligible for publicly-funded compensation through the Accident Compensation Corporation (ACC).

Please don't hesitate to contact the HDEC secretariat for further information. We wish you all the best for your study.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'B J Fergus', with a horizontal line underneath.

Dr Brian Fergus  
Chairperson  
Northern A Health and Disability Ethics Committee



Health and Disability Ethics Committees  
Ministry of Health  
133 Molesworth Street  
PO Box 5013  
Wellington  
6011

0800 4 ETHICS  
hdecs@moh.govt.nz

21 July 2017

Dr Lynne Clay  
School of Physiotherapy  
325 Great King St  
Dunedin 9016

Dear Dr Clay

Re:	<b>Ethics ref:</b>	<b>16/NTA/243/AM02</b>
	Study title:	Feasibility study to evaluate a goal-directed, physiotherapy-facilitated walking programme to enhance health and wellbeing in people after stroke

I am pleased to advise that this amendment has been approved by the Northern A Health and Disability Ethics Committee. This decision was made through the HDEC Expedited Review pathway.

Please don't hesitate to contact the HDEC secretariat for further information. We wish you all the best for your study.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'B J Fergus'.

Dr Brian Fergus  
Chairperson  
Northern A Health and Disability Ethics Committee

## Appendix C: Consent form for participants



### A pedometer-based walking programme for people with stroke

*Principal Investigator: Dr Lynne Clay, [lynne.clay@otago.ac.nz](mailto:lynne.clay@otago.ac.nz), 03 479 5235*

## CONSENT FORM

Following signature and return to the research team this form will be stored in a secure place for ten years.

Name of participant: .....

1. I have read the Information Sheet concerning this study and understand the aims of this research project.
2. I have had sufficient time to talk with other people of my choice about participating in the study.
3. I confirm that I meet the criteria for participation which are explained in the Information Sheet.
4. All my questions about the project have been answered to my satisfaction, and I understand that I am free to request further information at any stage.
5. I know that my participation in the project is entirely voluntary, and that I am free to withdraw from the project at any time without disadvantage.
6. I know that as a participant I will:
  - a. attend the School of Physiotherapy on two occasions 8 weeks apart
  - b. be provided with a pedometer for the course of the study and asked to record my daily step count
7. I understand the nature and size of the risks of discomfort or harm which are explained in the Information Sheet.
8. I know that when the project is completed all personal identifying information will be removed from the paper records and electronic files which represent the data from the project, and that these will be placed in secure storage and kept for at least ten years.
9. I understand that the results of the project may be published in a medical journal or presented at a medical conference. I agree that any personal identifying information will not appear in any spoken or written report of the
10. I know that there is no remuneration offered for this study, and that no commercial use will be made of the data.

Signature of participant: \_\_\_\_\_

Date: \_\_\_\_\_

## Participant Diary

Participant ID \_\_\_\_\_

Please do not write your name in the diary

When completed, please return to School of Physiotherapy

This diary is to help you record your step count each day. The step count is shown on your Fitbit™ Zip **HERE**



Just tap the screen here until you see the footsteps



### How to wear the Fitbit™ Zip

The Fitbit™ Zip can be worn in many different ways. We advise one of the following:

- Attach to your belt/waistband using the clip
- Clip it on to your trouser / shorts / skirt pocket
- Clip it to your bra strap
- Place it in a pocket



### **Fitbit™ App**

- The Fitbit™ App can be downloaded to a smartphone, tablet or computer so that you can track your step count over the week.
- Ask your physiotherapist for more information on the Fitbit™ App if you would like to use it.

### **How to use the Step Diary**

- At the start of each week, record your daily step 'goal' in the diary. This will be calculated by you in conjunction with your physiotherapist at each appointment
- Wear the Fitbit™ every day for 12 weeks & each night record the number of steps you took during that day
- See how many days you reached your step goal
- 

### **What if the battery needs replacing or I break/lose the Fitbit™?**

- Please contact your physiotherapist as soon as possible to arrange a replacement.

### **What happens after 8 weeks?**

- At the end of the 8<sup>th</sup> week, an appointment will be arranged for you at the University of Otago, School of Physiotherapy. You will complete the study questionnaires and assessments you did at the start of the research. You will also complete a short survey designed to understand how you found the walking programme – what worked well, what was problematic etc. At the same time, you will return the step diary and Fitbit™ to the research team.

Shown below is an example of how to fill in the diary

Week	Step goal
Two	4100

Write your daily step goal  
HERE (calculated between  
you and your physiotherapist

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total
Date	12.1.15	13.1.15	14.1.15	15.1.15	16.1.15	17.1.15	18.1.15	
No of steps	3850	4110	3760	4320	4125	4340	4457	28962
Planned walking		Walk to shop		Use treadmill at UMove for 10 mins			Walk grandson to school	
Actual walking	Walked up and down garden path 3 times	As planned		15 mins on treadmill plus UMove stairs x2 RPE =13			As planned	
Comment			Forgot to wear between 8am and 11am					Average daily steps 4137

RPE = rate of perceived exertion.  
See page 17 for more information

Each day record the number of steps you have taken HERE. If you miss a day leave blank and make a note in the comment box

Record any walking you planned over and above your normal day-to-day activity.

Use the comment box if for any reason you are unable to record your daily step count on a particular day or part of a day

You can add up total steps for whole week H

You can work out your average number of steps HERE. Divide the total number of steps for the week by the number of days you wore your Fitbit™

<b>Week</b>
<b>One</b>

	<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>	<b>Day 5</b>	<b>Day 6</b>	<b>Day 7</b>	<b>Total</b>
<b>Date</b>								
<b>No of steps</b>								
<b>Comment</b>								<b>Average daily steps</b>

If you have any problems with the Fitbit™ write them down here and discuss with your physiotherapist when you see her next

<b>Week</b>	<b>Step goal</b>
<b>Two</b>	

	<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>	<b>Day 5</b>	<b>Day 6</b>	<b>Day 7</b>	<b>Total</b>
<b>Date</b>								
<b>No of steps</b>								
<b>Planned walking</b>								
<b>Actual walking</b>								
<b>Comment</b>								
								<b>Average daily steps</b>

<b>Week</b>	<b>Step goal</b>
<b>Three</b>	

	<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>	<b>Day 5</b>	<b>Day 6</b>	<b>Day 7</b>	<b>Total</b>
<b>Date</b>								
<b>No of steps</b>								
<b>Planned walking</b>								
<b>Actual walking</b>								
<b>Comment</b>								
								<b>Average daily steps</b>

<b>Week</b>	<b>Step goal</b>
<b>Four</b>	

	<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>	<b>Day 5</b>	<b>Day 6</b>	<b>Day 7</b>	<b>Total</b>
<b>Date</b>								
<b>No of steps</b>								
<b>Planned walking</b>								
<b>Actual walking</b>								
<b>Comment</b>								
								<b>Average daily steps</b>

<b>Week</b>	<b>Step goal</b>
<b>Five</b>	

	<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>	<b>Day 5</b>	<b>Day 6</b>	<b>Day 7</b>	<b>Total</b>
<b>Date</b>								
<b>No of steps</b>								
<b>Planned walking</b>								
<b>Actual walking</b>								
<b>Comment</b>								
								<b>Average daily steps</b>

<b>Week</b>	<b>Step goal</b>
<b>Six</b>	

	<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>	<b>Day 5</b>	<b>Day 6</b>	<b>Day 7</b>	<b>Total</b>
<b>Date</b>								
<b>No of steps</b>								
<b>Planned walking</b>								
<b>Actual walking</b>								
<b>Comment</b>								
								<b>Average daily steps</b>

<b>Week</b>	<b>Step goal</b>
<b>Seven</b>	

	<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>	<b>Day 5</b>	<b>Day 6</b>	<b>Day 7</b>	<b>Total</b>
<b>Date</b>								
<b>No of steps</b>								
<b>Planned walking</b>								
<b>Actual walking</b>								
<b>Comment</b>								

<b>Week</b>	<b>Step goal</b>
<b>Eight</b>	

	<b>Day 1</b>	<b>Day 2</b>	<b>Day 3</b>	<b>Day 4</b>	<b>Day 5</b>	<b>Day 6</b>	<b>Day 7</b>	<b>Total</b>
<b>Date</b>								
<b>No of steps</b>								
<b>Planned walking</b>								
<b>Actual walking</b>								
<b>Comment</b>								
								<b>Average daily steps</b>

## **The Borg Scale of Perceived Exertion (RPE)**

One way to gauge how hard you are walking is to use the Borg Scale of Perceived Exertion. The Borg Scale takes into account your fitness level: It matches how hard you feel you are working with numbers from 6 to 20; thus, it is a “relative” scale. The scale starts with “no feeling of exertion,” which rates a 6, and ends with “very, very hard,” which rates a 20. Moderate activities register 11 to 14 on the Borg scale (“fairly light” to “somewhat hard”), while vigorous activities usually rate a 15 or higher (“hard” to “very, very hard”). Dr. Gunnar Borg, who created the scale, set it to run from 6 to 20 as a simple way to estimate heart rate – multiplying the Borg score by 10 gives an approximate heart rate for a particular level of activity. Your physiotherapist will discuss this scale with you and may ask you to record how hard you are walking during your planned walks.

<b>How you might describe your exertion</b>	<b>Borg rating of your exertion (RPE)</b>	<b>Examples</b>
None	<b>6</b>	Reading a book, watching television
Very, very light	<b>7</b>	Tying shoes
	<b>8</b>	
Very light	<b>9</b>	Chores like folding clothes that seem to take little effort
	<b>10</b>	
Fairly light	<b>11</b>	Walking to the grocery store or other activities that require some effort but not enough to speed up your breathing
	<b>12</b>	
Somewhat hard	<b>13</b>	Brisk walking or other activities that require moderate effort and speed your heart rate and breathing but don't make you out of breath
	<b>14</b>	
Hard	<b>15</b>	Walking briskly uphill, running, bicycling, swimming, or other activities that take vigorous effort and get the heart pounding and make breathing very fast
	<b>16</b>	
Very hard	<b>17</b>	The highest level of activity you can sustain
	<b>18</b>	
Very, very hard	<b>19</b>	A finishing kick in a race or other burst of activity that you can't maintain for long
	<b>20</b>	

## Action and Coping Plan

If.....	Then.....

**Action and Coping Plan cont.**

If.....	Then.....

**Fitbit Number**

---

---

**Smartphone Number**

**Fitbit Name**

---

**Fitbit Email**

---

**Fitbit Password**

---

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**Physiotherapist Name**    Claire Hargest

**Contact details**

You can leave a message by contacting the School of Physiotherapy Clinics on:

Phone: **(03) 479 5757**

Email: [claire.hargest@otago.ac.nz](mailto:claire.hargest@otago.ac.nz)

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## Appendix E: Information sheet regarding use of the Fitbit App

### Using the Fitbit App/online dashboard

The Fitbit App allows you to record how many steps you take each day. You will need an internet connection and Bluetooth technology on your phone to use the Fitbit App. You need to use the log in details printed on the back of your walking diary.



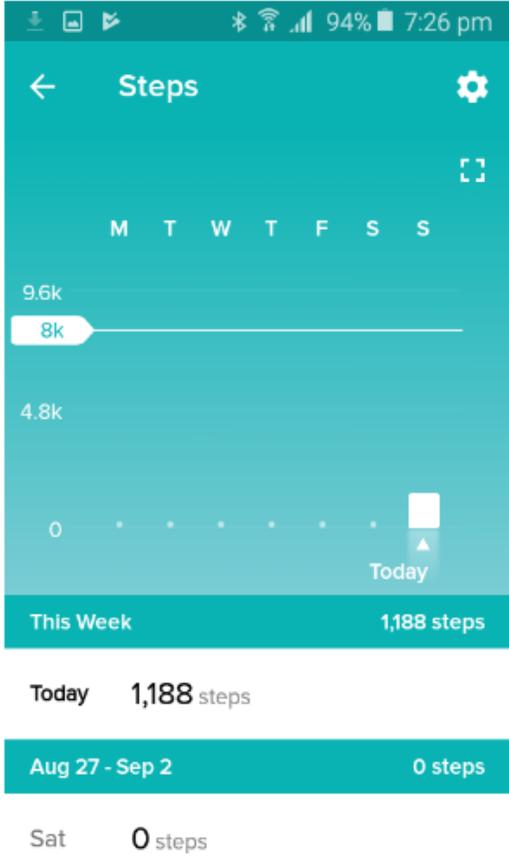
The image shows the Fitbit app dashboard. At the top left is the 'fitbit' logo. In the center, a large circular progress indicator shows 'Today' with a blue arc and a picture of feet, with '1,188 steps' below it. To the right of the progress indicator is a small icon of a Fitbit Zip device with a green battery indicator. Below the progress indicator are three smaller circular icons: a location pin for '0.86 km', a flame for '1,312 cals', and a lightning bolt for '0 minutes'. At the bottom is a navigation bar with icons for 'Dashboard', 'Challenges', 'Guidance', 'Friends', and 'Account'. A red dashed arrow points from the Fitbit Zip icon to the 'How to synch the Fitbit with the phone?' text box. Another red dashed arrow points from the '1,188 steps' text to the 'Weekly activity' text box.

**How to synch the Fitbit with the phone?**

The Fitbit Zip should synch automatically with the phone when it is placed within one metre of the phone. If this doesn't happen, touch the picture of the Fitbit Zip in the top right hand corner of screen. Make sure Bluetooth is switched on.

**Weekly activity**

Clicking on the steps icon (picture of feet) will take you to the screen shown on right and allow you to see how many steps you have taken over the past week.



The image shows the 'Steps' screen in the Fitbit app. At the top, there's a status bar with icons for Bluetooth, Wi-Fi, signal strength, 94% battery, and 7:26 pm. Below that is a teal header with a back arrow, the word 'Steps', and a gear icon. A progress bar shows '8k' steps out of a goal of '9.6k'. Below the progress bar is a weekly activity chart with days of the week (M, T, W, T, F, S, S) and a bar for 'Today' showing '1,188 steps'. At the bottom, there's a summary for 'This Week' showing '1,188 steps' and a bar for 'Today' showing '1,188 steps'. Below that is a bar for 'Aug 27 - Sep 2' showing '0 steps' and a bar for 'Sat' showing '0 steps'.

## Appendix F: Acceptability survey

### **A pedometer-based walking programme for people with stroke**

Thank you for taking part in this research study.

This survey will ask about your experiences with the walking programme and using the Fitbit™ Zip.

1. Why did you choose to participate in this study?

2. What did you like most about the walking programme?

3. What did you like least about the walking programme?

4. Do you feel you followed the walking programme fully? Please explain why/why not.

5. When and where did you walk?

6. What was the most challenging thing about meeting the daily step targets?

7. How do you intend to maintain your increased level of physical activity?

8. Please explain your experience (including any difficulties) using the Fitbit and/or App.

9. Any other comments?

## Appendix G: Stroke self-efficacy questionnaire (SSEQ)

Stroke self-efficacy questionnaire (SSEQ)

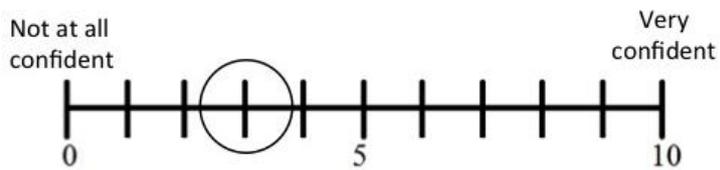
Participant #

---

These questions are about your confidence in doing tasks that may have been difficult for you since your stroke.

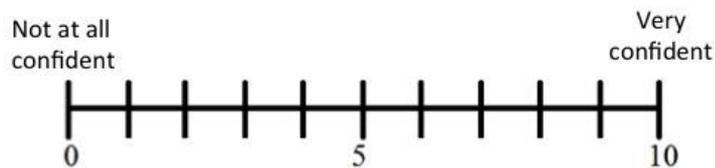
For each of the following tasks, please circle a point on the scale that shows how confident you are that you can do the tasks now in spite of your stroke, where 0 = *not at all confident* and 10 = *very confident*.

Eg.

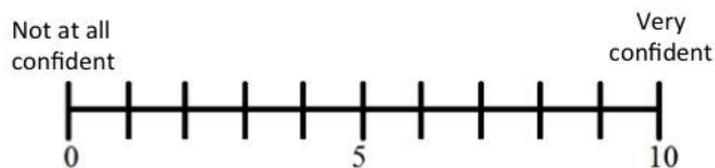


How confident are you now that you can:

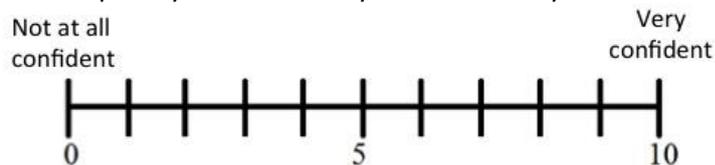
- 1) Get yourself comfortable in bed every night



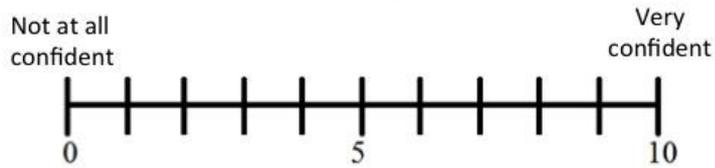
- 2) Get yourself out of bed on your own even when you feel tired



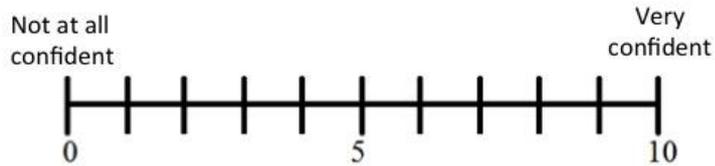
- 3) Walk a few steps on your own on any surface inside your house



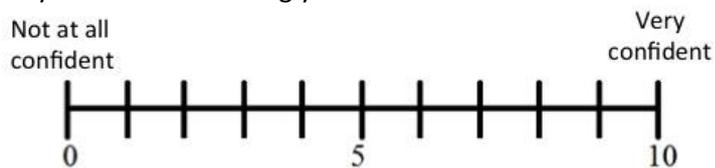
4) Walk about your house to do most things you want



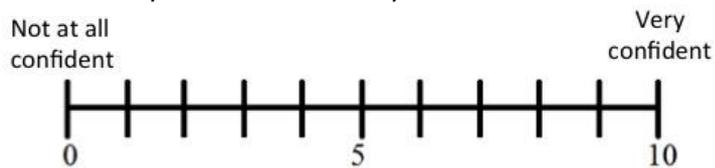
5) Walk safely outside on your own on any surface



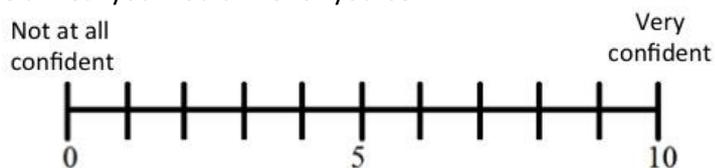
6) Use both your hands for eating your food



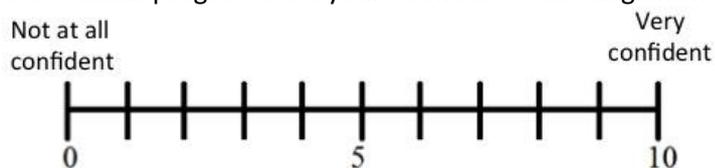
7) Dress and undress yourself even when you feel tired



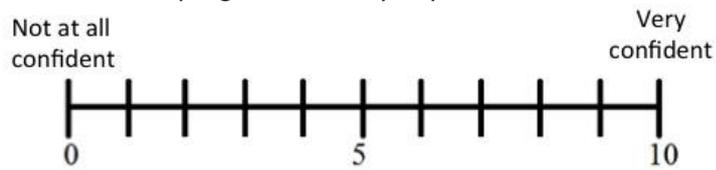
8) Prepare a meal you would like for yourself



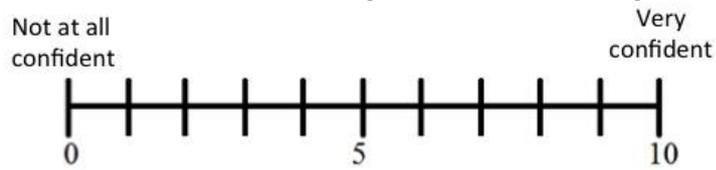
9) Persevere to make progress from your stroke after discharge from therapy



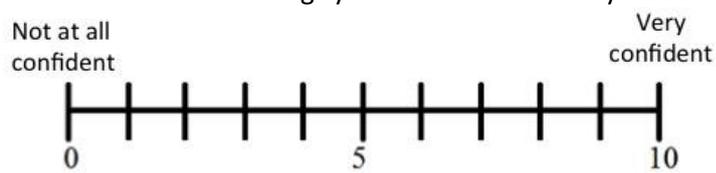
10) Do you own exercise programme every day



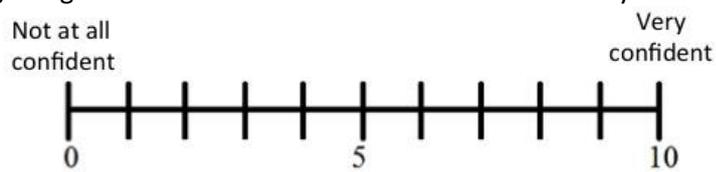
11) Cope with the frustration of not being able to do some things because of your stroke



12) Continue to do most of the things you liked to do before your stroke



13) Keep getting faster at the tasks that have been slow since your stroke





**Health Questionnaire**

**English version for New Zealand**

Under each heading, please tick the ONE box that best describes your health TODAY.

**MOBILITY**

- I have no problems in walking about
- I have slight problems in walking about
- I have moderate problems in walking about
- I have severe problems in walking about
- I am unable to walk about

**SELF-CARE**

- I have no problems washing or dressing myself
- I have slight problems washing or dressing myself
- I have moderate problems washing or dressing myself
- I have severe problems washing or dressing myself
- I am unable to wash or dress myself

**USUAL ACTIVITIES** (*e.g. work, study, housework, family or leisure activities*)

- I have no problems doing my usual activities
- I have slight problems doing my usual activities
- I have moderate problems doing my usual activities
- I have severe problems doing my usual activities
- I am unable to do my usual activities

**PAIN / DISCOMFORT**

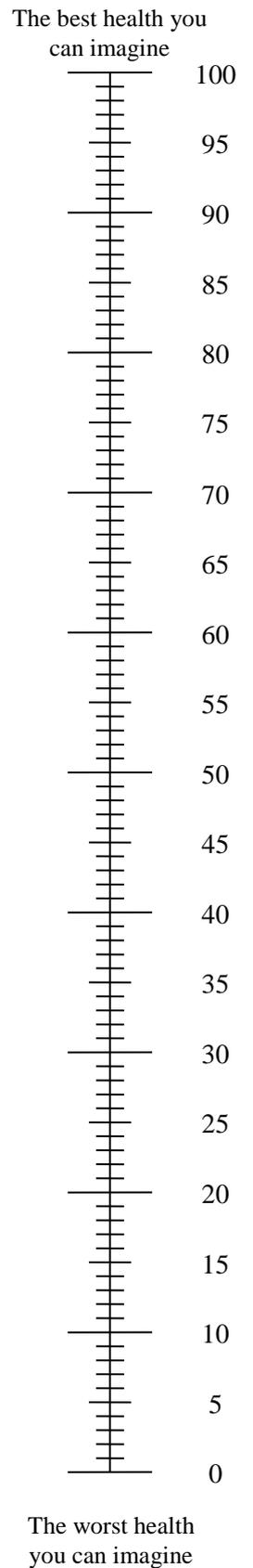
- I have no pain or discomfort
- I have slight pain or discomfort
- I have moderate pain or discomfort
- I have severe pain or discomfort
- I have extreme pain or discomfort

**ANXIETY / DEPRESSION**

- I am not anxious or depressed
- I am slightly anxious or depressed
- I am moderately anxious or depressed
- I am severely anxious or depressed
- I am extremely anxious or depressed

- We would like to know how good or bad your health is TODAY.
- This scale is numbered from 0 to 100.
- 100 means the best health you can imagine.  
0 means the worst health you can imagine.
- Mark an X on the scale to indicate how your health is TODAY.
- Now, please write the number you marked on the scale in the box below.

YOUR HEALTH TODAY =



## Appendix I: Individual changes in secondary outcome measures

Participant	SBP pre	SBP post	SBP change	DBP pre	DBP post	DBP change	SSEQ pre	SSEQ post	SSEQ change	6MWT pre	6MWT post	6MWT change (%)	EQ5D utility pre	EQ5D utility post	EQ5D change	EQ5D VAS pre	EQ5D VAS post	EQ5D change
1	93	106	13	61	71	10	8.84	7.62	-1.22	405	408	0.7	0.768	0.906	0.138	95	100	5
2	138	115	-23	90	69	-21	10.00	9.92	-0.08	416.5	429	3.0	0.768	1.000	0.232	95	100	5
3	160	137	-23	79	76	-3	9.38	9.69	0.31	488.5	461.5	-5.5	0.767	0.906	0.139	42	70	28
4	116	110	-6	77	82	5	8.00	9.30	1.30	371	401	8.1	0.627	0.654	0.027	50	50	0
5	129	142	13	81	90	9	5.07	6.23	1.16	360	476	32.0	0.001	0.340	0.339	5	40	35
6	120	135	15	68	62	-6	2.07	4.46	2.39	109.5	120	9.6	0.079	0.342	0.263	50	50	0
7	169	155	-14	85	81	-4	8.15	7.61	-0.54	307	340	10.7	0.836	0.592	-0.244	85	90	5
8	133	138	5	85	93	8	8.23	8.77	0.54	472	514.5	9.0	0.827	0.837	0.010	50	65	15

SBP = systolic blood pressure; DBP = diastolic blood pressure; 6MWT = six minute walk test

## Appendix J: Examples of responses for each category of acceptability

### Appropriateness

*"To see if it would help my walking." (P6)*

*"To get my walking back up to scratch."(P4)*

*"To get fitter - I want to be able to walk faster as that has really decreased since the stroke." (P5))*

*"I want to get as much fitness back as possible and need the incentive." (P3)*

*"I thought it would do me good." (P2)*

*"looking for something, anything to help me recover from the stroke" (P8)*

*"I felt confident. I knew what to do and how to do it." (P2)*

*"More contact to keep me on track....maybe every fortnight" (P8)*

*"I felt confident... but maybe a bit unrealistic" (P8)*

*"it was good to meet weekly with a professional....maybe spread out appointments eg fortnightly/monthly" (P8)*

*"no problems – 4 weeks was enough"(P6)*

*"would have been good to meet more often but generally was alright"(P4)*

*"It did make a difference....more contact to keep me on track. Maybe once a fortnight" (P7)*

*"It was worthwhile"(P7)*

*'I really enjoyed it' (P6)*

*'I enjoyed it immensely' (P1)*

*'I really enjoyed it' (P4)*

### Effectiveness

*"It made me think about my walking...like using the stairs or made me walk to the supermarket rather than driving." (P5)*

*"It gave me an idea of what I should be doing."(P2)*

*"Having the fitbit. To actually know how much you were doing." (P8)*

*"The Fitbit was a good motivator. It just made me more aware." (P8)*

*"It was good having a set goal rather than just being told to walk more."(P8)*

*"Seeing my progress and using the Fitbit" (P3)*

*"Monitoring how long I was walking for and seeing the number decrease" (P3) – decreasing time on regular walking routes*

*"it was good using the phone to monitor steps during the day." (P6)*

*"I found it relaxing – often left the house stressed but relaxed once got in the rhythm of it" (P2)*

*"My anxiety and depression are much better" (P1)*

*"My legs feel a lot stronger and I'm not as reliant on my stick" (P2)*

*"walking with a purpose" (P1)*

*"seeing how far I could go-measuring steps"(P4)*

*"getting out and about" (P4)*

*"the fitbit has become part of my life" (P3) – intends to purchase*

*"maybe get a fitbit.....or I think my phone has an app that counts steps" (P5)*

*"try and walk the dog twice a day" (P5)*

*"buy a fitbit"(P8)*

*"I bought a fitbit and I'm going to aim for 9000 steps a day" (P1)*

*"I'll keep walking every day and there's a group on Mondays that the stroke foundation has organised" (P1)*

*"keep walking as much as I can. I know how far to walk to get 1000 steps" (P6)*

*"get out and about more – like walking to shops and playing summer golf"(P2)*

*"need to find someone to walk with. I might join the stroke group. It has become part of my day/week. I'll miss the fitbit" (P4)*

*"I intend to do some walks. But its too cold now. And need to get my hip pain sorted" (P7)*

*"would have been nice to have someone to walk with" (P4)*

#### Adherence

*"I could of done better. It was difficult to fit in with my wife and I don't feel so confident walking by myself." (P5)*

*"No. Some of the planned walks didn't happen. I wasn't as vigilant as I could have been"(P8).*

*"Undertaking planned walks on tired days was a real battle"(P8)*

*"Yes. Except on wet days and I didn't include hills. I didn't increase the intensity." (P4)*

*"Probably didn't do as much as I should have. My energy levels and my health stopped me doing more." (P7)*

*"my health stopped me doing more" (P5)*

*"I did my best but some days I was so tired" (P3)*

*"doing it everyday can sometimes be a problem" (P3)*

*"Tried to achieve the goal each week'(P2)*

*"cold days" (P7)*

*"bad pavements" (P7)*

*"planned walking...if it was in my diary, felt pressured to get it done" (P8)*

*"as much as I could" (P6)*

*"tiredness from medications" (P5)*

*"Rain; other commitments" (P3)*

*"fatigue" (P8)*

*"hip pain" (P6)*

*"the weather made it difficult"(P2)*

*"when not feeling 100%"(P4)*

#### Convenience

*"All over – planned a walk 3-4 days a week eg. Ross creek, St Kilda beach, Sullivans Dam, Botanical gardens. Lunchtime during study days" (P3)*

*"started walking the dog twice a day now it's daylight savings" (P5)*

*"tried to take the stairs" (P8)*

*"I walked every morning. I also got off the bus earlier so I had to walk" (P1)*

*"Green Island parks and along the harbour" (P6)*

*"walked around the block...walking to do errands eg post office or to go to choir practice"(P2)*

*"walked around the block" (P4)*

*"around my local area but avoiding the hills"(P7)*

*"walking to the mailbox....I figured out how many trips I needed to do to make 1000 steps" (P6)*

*"the diary was hard to remember what I had done" (P5)*

*"worried about losing the Fitbit" (P5)*

*"it was fine" (P3)*

*"no problems except when flat battery, and phone battery when not charged" (P5)*

*"I lost it – fell off clip/rubber stretched. But no technical difficulties" (P8)*

*"No... made sure had a deep pocket" (P1)*

*"lost it" (P6)*

*"it was good using the phone to monitor steps during the day" (P6)*

*"really easy to synch to phone. The battery did go flat" (P2)*

*"No. It was very useful" (P4)*

*"no problems except the battery went flat"(P7)*

*"somedays I wasn't so enthusiastic, it took up a lot of time" (P1)*

*"it was difficult at the weekends when I like to blob out" (P3)*

*"it took up a lot of time" (P1)*

*"was hard to fit in on busy days" (P4).*

#### Motivation

*"I want to get as much fitness back as possible and need the incentive" (P3)*

*"helps to do things when externally motivated" (P2)*

*"good opportunity to motivate myself" (P4)*

*"but just need more monitoring to keep the person motivated." (P7)*

*"The Fitbit was a good motivator. It just made me more aware." (P8)*

*"It was motivating –'made me get up and go" (P5)*

*"It didn't force me to go out. I did it because I wanted to do it' (P4)*

*"it was good. It motivated me to get up and do something" (P7)*