Walking Cadence: A Novel Strategy to Improve the Proportion of Inactive Older Adults who Reach the Canadian Physical Activity Guidelines

by

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Abstract

Problem: Only 13% of older adults reach the Canadian Physical Activity Guidelines (CPAG) aerobic activity recommendations. Walking cadence (steps per minute) is a strategy proposed to increase walking at the intensity recommended by the CPAG.

Methods: Inactive older adults (N = 51) were instructed to walk 150 minutes per week at no specified intensity during phase 1 (6 weeks). In phase 2 (6 weeks), duration was maintained but the group one (N = 23) received instructions on how to reach moderate intensity, using a pedometer and individualized walking cadence, while group two (N = 22) did not.

Results: During phase 1, MVPA time and MVPA in 10-minute bouts increased ($p \leq 0.05$), and in phase 2 group one continued to increase MVPA time and time in MVPA in 10-minute bouts ($p \leq 0.01$), while the group two significantly decreased ($p \leq 0.01$).

Discussion: Previously inactive older adults can improve time in MVPA in 10-minute bouts, as recommended by the CPAG, by using prescribed walking cadence, a pedometer to track moderate intensity, and practicing walking at this cadence.

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Abbreviations

ACSM – American College of Sports Medicine

BMI – body mass index

BPM – beats per minute

CEP – Certified Exercise Specialist

CPAG – Canadian Physical Activity Guidelines

CRF – cardiorespiratory fitness

CSEP – Canadian Society for Exercise Physiology

HR – heart rate

HR max – maximum heart rate

HRR – heart rate reserve

MET – metabolic equivalent of tasks

MVPA – moderate to vigorous physical activity

RER – respiratory exchange ratio

RPE – rate of perceived exertion

VO_2 – volume of oxygen

VO_2 max – maximum oxygen consumption

VO_2 peak – peak oxygen consumption

VO_2R – volume of oxygen reserve

WHO – World Health Organization

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CHAPTER 1: INTRODUCTION

Multiple chronic conditions such as cardiovascular disease, diabetes, certain cancers, hypertension, and simply overall health are negatively impacted by physical inactivity [1, 2]. The World Health Organization (WHO) recognizes physical inactivity as the fourth leading cause of death [3]. Although many older adults are aware of the health benefits related to physical activity, they still fail to exercise regularly. This statement is supported by the most recent national data, using objective measures of physical activity, which shows that only 13% of older adults are reaching the Canadian Physical Activity Guidelines (CPAG) [4]. The primary goal of the CPAG for older adults is to improve or maintain their physical capacity [5]. Having the physical capacity to safely and independently carry out daily living activities, known as functional fitness, or physical capacity [6], allows individuals to maintain their independence [7], and has a positive impact on healthcare system costs [8]. The CPAG outline the amount of physical activity required to optimize physical capacity, and therefore increasing the likelihood of maintaining functional independence. The most recent recommendation for aerobic activity is to cumulate a minimum of 150 minutes per week of moderate to vigorous intensity aerobic physical activity in bouts of 10 minutes or more [9].

In order to *consciously* achieve the recommendation for aerobic activity, the knowledge of how to identify exercise intensity is required. This seems to be an important problem for many Canadians, including older adults, because they report themselves as being active, but very few are successfully reaching the CPAG [10]. In fact, based on self-reported analysis, 65% of older adults in Canada would reach the CPAG [11, 12] when really only 13% are achieving it when based on an objective measure [4]. In addition, many older adults overestimate the amount of physical activity they do and are unable to accurately identify exercise intensity [13], potentially leading to the observed difference between self-reported and objectively measured physical activity levels in the literature. Although the CPAG are one of the most popular documents downloaded from the Health Canada website [10], only one older adult out of seven knows the specific recommendations such as time, intensity or mode of exercise recommended [14]. One way to help older adults to consciously reap the benefits of meeting the CPAG is to be made aware of the information, understand how to achieve the recommendations, and increase their ability to identify exercise intensity.

Older adults are a sub-group of the population that need particular attention because they represent the lowest proportion of individuals being regularly active [4]. In addition, this sub-group could benefit enormously from any increase in time spent in moderate to vigorous intensity; not only physiologically, but also socially [15], and psychologically [16-19]. As age increases there are higher occurrences of low cardiorespiratory fitness (CRF), low functional capacity, and increased chronic conditions [20]. These factors impact health care costs because older adults use the health care system more frequently than younger adults [21]. Fortunately, reaching the CPAG by accumulating 150 minutes of moderate intensity aerobic physical activity per week can help reduce the impact of aging. It is also known that it is feasible for older adults to reach moderate to vigorous intensity, as the average time spent at this intensity was about 119 minutes per week for older men, and 84 minutes per week for older women in the last national evaluation of physical activity levels [4]. However, even if the total time spent at moderate to vigorous intensity is reaching a minimum of 79% and 56% of the weekly recommendation for men and women respectively, the challenge seems to be to maintain that intensity for bouts of

10 minutes or more. As mentioned earlier, most older adults, 60–79 years of age, are not reaching the CPAG with only 13.7% of men and 12.6% of women achieving the minimum requirements of 150 minutes of moderate to vigorous intensity aerobic activities in 10-minute bouts per week [4].

Walking cadence is usually measured as the number of steps taken per minute and can be used to identify intensity when walking. Most studies to date have determined that the general public recommendation for walking cadence to reach moderate intensity in adults aged 55 or lower is 100 steps per minute [22-25]. Studies done more recently with older adults show that cadences higher than 100 steps per minute are commonly chosen as a comfortable walking cadence in clinical settings [26-28], suggesting that older adults are able to achieve the cadence necessary to reach moderate intensity or that they need more steps per minute to achieve moderate intensity. Although it has been found that older adults can walk at cadences ≥100 steps per minute and achieve moderate intensity [26-28], Tudor-Locke et al. [28] recently reported, based on accelerometer wear for one week, this cadence was only achieved for an average of eight minutes per day, and this was mostly done in bouts shorter than 10 minutes. Since walking is the most common form of exercise for older adults [29], it is imperative to determine how fast they need to walk in order to reach moderate intensity, and identify strategies to teach them how to walk at that cadence and hopefully reach the CPAG in order to gain optimal health and functional benefits.

Currently, we are aware of only two studies that have aimed to increase time spent doing moderate to vigorous intensity while using a pedometer [13, 30]. The study done by Bouchard et al. [13] did not result in significant increases in time in moderate to vigorous physical activity (MVPA), but did provide positive information about the pedometer being an appropriate tool for older adults. Marshall et al. [30] also used a pedometer as the intervention tool and found that among three groups with different interventions (self-selected pace, 10,000 steps per day, or 100 steps per minute), the group that was prescribed a walking cadence (i.e., 100 steps /minute) had the greatest increase in moderate to vigorous time spent in 10-minute bouts. This study is encouraging in trying to identify a strategy to help older adults know how fast to walk, but also to encourage a duration of at least 10 minutes to have them reach the CPAG and obtain the optimal health and functional benefits. However, the literature is suggesting that cadences greater than 100 steps per minute might be more desirable older adults [26, 27].

The proposed study will implement a 12-week walking intervention where participants will be randomly assigned to group one or group two at week six. Fifty older adults (≥ 65 years) who self-report doing less then 150 minutes of physical activity per week will be recruited for this study. In order to be eligible they had to be willing to use walking as their primary form of exercise, able to walk without assistance, available for the 12 consecutive weeks and able to come to the University of Manitoba for 10 visits during this time. After collecting one week of baseline data for participants with the pedometer and accelerometer, those who were surpassing the CPAG were excluded from the study. The aim for the first six weeks of the study is to have all participants gradually increase the time they spend walking, and during the last six weeks both groups will be directed to continue accumulating this walking time at a moderate to vigorous intensity in bouts of 10 minutes or more, but the intervention group will also be receiving an individualized cadence (steps per minute) to inform them how fast they need to walk in order to reach moderate intensity. All participants will be wearing a pedometer for the entire duration of the study, but at week six participants in group two will have their pedometers locked shut so that they cannot receive any visual feedback, while participants in group one will be shown how the pedometer can help them achieve the appropriate walking cadence as it is able to display time spent at MVPA and the number of 10-minute bouts accumulated in moderate to vigorous intensity each day, based on walking [31].

The information gathered in this study could lead to a novel way to help older adults increase their time in MVPA in 10-minute bouts and their total time in MVPA, helping them to potentially reach the CPAG. The main objectives of this study are to have all participants increase total time in MVPA and 10-minute bouts in MVPA from baseline to week six (phase 1), and most importantly to see an increase in the intervention group in 10-minute bouts of MVPA and total MVPA based on using the pedometer and individualized cadence prescription, from week six to twelve (phase 2). The hypotheses that accompany the main objective are that all participants will see an increase in total MVPA and 10-minute bouts of MVPA from baseline to week six (phase 1), and that group one will see a significant increase in 10-minute bouts of MVPA and total MVPA based on using the pedometer and individualized cadence prescription, from week six to twelve (phase 2), and group two will not.

Defining Terms

Physical Activity

Physical activity is body movement that is produced by the skeletal muscles which causes an increase in energy expenditure [32]. There are many different levels of physical activity but according to the CPAG, in order to be adequately aerobically physically active, adults need to partake in at least 150 minutes of moderate to vigorous intensity aerobic activity in bouts of 10 minutes or longer each week [9, 33]. The purpose of these guidelines is to provide information on the minimum amount of physical activity required in order to gain optimal physical capacity and independence in older adults [33].

Physically Inactive

It is important to distinguish the difference between being physically inactive and being sedentary. Physical inactivity is defined as participating in less then 150 minutes of aerobic MVPA per week, which directly reflects the CPAG [9, 33], while sedentary activity can be defined by activities done in a rested state such as sleeping, sitting, and watching television, and the metabolic equivalent of these tasks (MET) is equal to about 1-1.5 METs [34].

Older Adults

There are different cut-points to determine what is defines an older adult. In Canada, when it comes to physical activity level, older adults are usually classified as being 65 years of age or older, in accordance with the CPAG [9, 33].

Certified Exercise Physiologist (CEP)

A CEP is the highest Canadian certification in the health and fitness industry. A four-year University degree in the field of exercise science is the starting requirement, and once certified these individuals are able to work with a large portion of the population including healthy individuals, and those with medical conditions, functional limitations or disabilities. These specialists are certified through the Canadian Society for Exercise Physiology (CSEP) [35].

Aerobic Moderate Intensity

Moderate intensity is the minimum intensity recommended by many international and national agencies in order to optimize health and functional benefits when achieving regular aerobic physical activity [9, 33, 36, 37]. The CSEP defines moderate intensity as breathing a bit harder and sweating a little bit [9]. Brisk walking is used as an example for a moderate intensity activity [9]. Exercise intensity can be measured both subjectively (e.g., rate of perceived exertion scale), and objectively (e.g., heart rate). There are many different methods that can be used to evaluate exercise intensity, but according to the American College of Sports Medicine (ACSM), the most accurate way to calculate an individual's moderate intensity is by using 40 to 59% of maximal oxygen capacity when considering baseline values, commonly called VO_2 reserve (VO_2R) [38].

Oxygen Consumption (VO_2)

Oxygen consumption is the volume of oxygen a person is able to consume while performing a task. Maximal oxygen consumption (VO_2 max) is the product of cardiac output, which is how much blood the heart pumps in a minute, and arteriovenous oxygen difference, which is the difference in O_2 between arterial and venous blood at exhaustion [39]. Maximal oxygen consumption is an objective way to assess cardiorespiratory endurance and functional aerobic capacity [40] by measuring the rate at which oxygen can be transported during aerobic activity [41]. The most accurate measure of oxygen consumption is done through gas analysis during the completion of a maximal CRF test [40], but it can also be predicted without using gas analysis and relying on equations and a sub-maximal CRF tests [40]. Oxygen consumption can be represented as either an absolute or relative value. Absolute VO_2 is measured in L/min and does not factor in body size, therefore these values cannot be used for comparison among individuals of different body weight [40]. Relative VO_2 is more commonly used as this is measured in mL/min/kg accounting for differences in body weight [40].

Walking Cadence

Walking cadence is defined as the number of steps taken in a fixed period of time (e.g., minute). Walking cadence has been suggested as a method to identify walking intensity, and the recommendation for adults is to reach at least 100 steps per minute in order to achieve moderate intensity [22-25]. In older adults, preliminary research suggests that older adults are capable of reaching a cadence higher than 100 steps per minute which result in them reaching moderate intensity [26-28], however no specified recommendation for older adults exists.

CHAPTER 2: REVIEW OF LITERATURE

Prevalence of physical inactivity

Physical inactivity has become a growing concern in North America [2]. Common methods of transportation and communication, while providing convenience, have contributed to increasing inactivity [42]. Physical inactivity has been recognized as the fourth leading cause of death [3], and according to data from Statistics Canada only about 15% of Canadian adults are meeting the new physical activity guidelines, and that proportion is even lower in older adults [43]. In addition to not meeting the CPAG, almost half of Canadians (47%) cumulate less than 30 minutes of MVPA per week, and the average time that Canadian adults spend in a sedentary state (e.g., sitting) while awake is 9.7 hours per day [4].

Physical inactivity has a negative impact on many different chronic conditions and on overall health [1]. It can lead to an increased risk of heart disease, diabetes, and different types of cancer [3], and it contributes to poor CRF which is linked to mortality [44-48]. Aging is associated with poor balance and less muscle strength, leading to an increased risk for falls [49, 50], therefore reducing the chances of regular physical activity. There is a linear relationship between health status and volume of exercise [51], therefore any increase in physical activity is associated with health improvements [41], but the main focus of the current CPAG are on reaching moderate to vigorous intensity for different reasons. It has been proven that higher intensity activities elicit greater health benefits including greater increases in CRF [52-54] and increases in functional capacity [55]. Although research supports that vigorous or high intensity activity has the greatest effect on increasing CRF [54], this intensity can be intimidating, and it has been shown that moderate intensity activity is better tolerated, especially in older adults or obese population [56]. Moderate intensity is a preferable recommendation as this intensity has a lower chance of injury when compared to higher intensities for older adults [57], and moderate intensity has been identified as the preferred exercise intensity for older adults compared to vigorous intensity [58].

Barriers to physical activity

There are a variety of barriers that people face when it comes to getting or staying active. Having the knowledge of barriers that people face prior to engagement in physical activity is ideal in order to help them overcome these barriers and more successfully adhere to a physically active lifestyle. One barrier that many older adults face is believing that they already get enough physical activity in their daily lives [59] by overestimating the amount of physical activity they do [4]. They also struggle to properly identify exercise intensity [13], which may help explain why only 13% of older adults are reaching the CPAG when objectively measured [4] and why they tend to overestimate their physical activity levels. Another possible reason for the small percentage of older adults reaching the CPAG could be based on the evidence that many are not aware of the CPAG [14]. In 2011 Plotnikoff et al. [14] found that only 27% of Canadians were aware of the CPAG, and only 16% knew the specific recommendations. Without knowledge of the specific recommendations of the CPAG and knowing what types of activity can achieve the intensity required by the CPAG, it is no surprise that so many older Canadians are not achieving the CPAG.

Weather has also been shown as a barrier to being physically active and reaching the optimal intensity. For example, it has been reported that warm temperatures affect walking pace [27] and many studies have found that weather has been reported as a perceived barrier to physical activity [60-63]. Tu et al. [63] found in a population of older women, that non-attendance to group fitness was associated with multiple weather factors including temperatures above 32^{o} Celsius, wind-chill below minus 6^{o} Celsius, overcast skies, and snowfall. In a systematic review by Tucker et al. [64], 73% of the reviewed articles reported weather having a significant impact on physical activity participation.

As summarized by Humpel et al. [65], many studies have shown that access to nearby walking paths or accessible facilities, otherwise known as the walkability of a neighborhood, is associated with the likelihood of being physically active [66-69]. Increased walkability of neighborhoods decreases the use of vehicles for transportation and increases the number of people walking or biking for transportation [70]. The association between a walkable environment is not only associated with walking more for transportation [71], but also with more total physical activity time when compared to suburban neighborhood designs which are designated as being less walkable [72, 73]. This relationship also carries over to health outcomes because many studies have shown that there is an increased chance of being overweight or obese when living in a less walkable neighborhood [71, 74-77].

Lack of self-efficacy, which refers to the perception of being capable of doing a task, is another common barrier, but as Grembowski et al. [78] explains, increased self-efficacy is associated with better health in older adults. Therefore improving self-efficacy could improve the likelihood of being active and have an impact on health status. Based on the socio-cognitive theory, an individual's self-efficacy can influence their behavior based on the four sources; i) mastery experiences, ii) vicarious experiences, iii) verbal persuasion and iv) physiological and affective states [79], therefore it is important to structure physical activity programs to encompass these factors with the intention to increase self-efficacy and therefore adherence to physical activity and overall health [78, 80].

Benefits of physical activity

Regular physical activity has been proven to provide a wide range of health benefits including being able to prevent and treat many chronic diseases (e.g., cardiovascular diseases, diabetes, cancer, hypertension, depression and osteoporosis) [3, 41]. Reaching the CPAG has been proven as enough activity to optimize health and functional benefits, but even if the guidelines are not being met, any amount of physical activity is better than none as there is not only a positive linear relationship between physical activity level and health status. However, the greatest improvements in health are seen in the initial stages when inactive individuals become active [81, 82]. Although light to moderate intensity activity provides benefits to those just starting out [83], as an individual becomes more fit an increase in exercise intensity may be required in order to provide additional health benefits, and higher intensities are associated with lower mortality rates [84]. Regular aerobic physical activity can provide many benefits including decreasing risks associated with cardiovascular disease (e.g., high blood pressure, obesity, type 2 diabetes) [20, 85-88]. Although increasing maximal oxygen consumption is beneficial, some studies have shown that the decrease in risk factors associated with increasing physical activity levels will take place even if the maximal oxygen consumption level is not increased [85-87]. Regular aerobic activity helps minimize the age related decrease in maximal oxygen consumption that inadvertently occurs with age [89]. It can also help in controlling or maintaining bodyweight, and decreasing the accumulation of adipose tissue [90] which reduces the likelihood of metabolic disorders [57]. This is important because in adults between 30 and 74 years old, body mass index (BMI) and body fat have been associated with an increased risk for all-cause mortality and cardiovascular disease, and unfortunately both bodyweight and fat tend to increase with age [91]. Another factor that can be impacted by regular physical activity is one's lipid profile, which can be a major risk factor for coronary heart disease [92]. Adults can improve their lipid profile by increasing high density lipoprotein-cholesterol levels through incorporating regular physical activity into their lifestyle [86, 93]. Arterial blood pressure increases with age and this increase contributes to a larger risk for many cardiovascular disorders [94]. Research has shown that not only can arterial blood pressure be controlled with regular exercise [95], but that resting blood pressure can also be decreased in individuals with initially high rates through regular aerobic activity [95-97]. Specifically in older adults, physical activity can help to decrease the age related decline in maximal aerobic capacity [89] which is associated with maintaining physical capacity [55], preserve bone mass [20], and improve mobility and balance resulting in increased confidence to exercise [20].

Aside from the physical benefits that physical activity can provide, there are also psychological and social benefits. Both physical activity and social interaction have been shown to slow the decline in functional capacity in an older population [98]. When self-reporting physical activity items such as high physical activity compared to peers, high physical activity compared to one year ago and frequency of walking one mile, they were significantly associated ($p < 0.0005$) with slower functional decline [98]. As for social factors, seeing friends in the past two weeks, social events in the past two weeks, and church/temple attendance were also associated ($p < 0.05$) with slower functional decline in these older adults [98]. Studies have shown that mild to moderate depression and anxiety can be prevented or improved with physical activity [17-19, 99]. Other factors that are impacted by regular physical activity are perceived stress [16], enhanced quality of life [100], improvements in total well-being (e.g., mood, stress levels, ability to cope) [101], decreased depression [16], and life satisfaction when activities were perceived as being enjoyable [102]. McAuley et al. [15] found that regular physical activity was associated with life satisfaction and social support. The same study found that both aerobic and anaerobic activities reduced loneliness [15]. Another social factor that can influence physical activity level is having a supportive spouse, family, or friend as this is associated with higher levels of physical activity [68, 103]. A study concluded that social support influences an individual's self-efficacy which in turn has an impact on physical behavior as adherence to physical activity is higher with increased support and self-efficacy [104].

Studies have shown that both sleep quality and quality of life can be impacted by physical activity. With regards to sleep quality, Edinger et al. [105] explored whether health status (fit or sedentary), in generally healthy older men with no sleep complaints, impacted their sleeping continuity and depth. After monitoring participants sleep for two nights it was found that the aerobically fit men had deeper sleeps, less wake time and more continuous sleeps, compared to the sedentary men [105]. A randomized control trial on sedentary older adults with moderate sleep complaints explored whether sleep quality could be impacted through exercise [106]. After a 16 week intervention that gradually increased exercise intensity to 60 to 75% heart rate reserve (HRR), and promoted aerobic exercise for 30 to 40 minutes four times per week, participants in the group that received the exercise intervention had significant improvements ($P < 0.001$) in their sleep quality compared to the control group [106].

Quality of life when measured with a questionnaire developed by the World Health Organization encompassed physical and psychological health, along with social relationships and environmental issues [107]. As a whole quality of life addresses physical, mental and social well-being [108], and physical activity has been proven to impact these factors, particularly in older adults [109]. Some of the more specific psychological and social factors that are positively influenced by physical activity are summarized by Fox [110] and include improved mood, more resilience to stress, improved self-esteem, and decreased anxiety. There are many questionnaires that have been developed to measure quality of life, but one that has been validated as a good measure for older adults in the Older People's Quality of Life Questionnaire [111].

Canadian Physical Activity Guidelines for older adults

The CPAG provide recommended guidelines for Canadians on the minimum amount of exercise required in order to optimize health and functional benefits [9]. These guidelines are developed through a systematic review and synthesis of all of the relevant literature to date, and then translated into terms and messages that are accessible for all Canadians [112]. These guidelines have been accessible since 1996, but were most recently revised in 2011 [33]. The process to develop these guidelines is rigorous [112]. The CSEP and Public Health Agency of Canada methodically evaluated the current literature regarding the CPAG and developed five systematic reviews, which were then reviewed independently by an international panel of experts. Once consensus was reached among the panel another document containing the updated recommendations along with rationalization for each one was created [112]. The current recommendation is a minimum of 150 minutes of aerobic physical activity per week at moderate to vigorous intensity, in bouts of 10 minutes or more, and at least two days per week of resistance training. The primary goal of the CPAG for older adults is to identify the minimum dose of aerobic activity required in order to improve or maintain physical capacity and functional independence [9]. For older adults, in addition to the aerobic exercise and the resistance training recommendations, it is recommended to do exercises to improve flexibility and mobility if needed [9]. Physical capacity is the ability to carry out daily living activities, in turn favoring independence, so it becomes increasingly important to improve this as age increases [7]. Having the physical capacity to be able to accomplish activities of daily living without undue fatigue or struggle is important for older adults in order to maintain their independence as having challenges with these is a factor related to nursing home admission [113, 114]. Emphasis on the older population is important because 15.3% of Canadians are already 65 years or older, and the number of older adults in the coming years is expected to continue growing [115]. In Canada this population is expected to continue growing until 2025 based on the fact that Canada had such a strong baby boomer population in the 1950's and 1960's [21]. This older population in Canada is expected to increase by about 10% over the span of 33 years, which is faster than most other countries, excluding Japan, this increase is expected to take 50 years in the United States of America and even longer in most other countries [21]. Based on this increase, it is hypothesized that the cost of the health care system will increase until 2025 [21]. If simple strategies like becoming regularly active can help to improve older adults health and functional capacity, this may help to minimize the health care system costs that are expected based on older population growth.

Both aerobic and resistance training guidelines are included in the CPAG, but the aerobic guidelines are more specific with information on duration and intensity. The reason that the aerobic guidelines receive more focus compared to resistance training in the media is because aerobic activity is strongly associated with decreasing all-cause mortality and cardiovascular disease mortality [20, 85-88, 116-118] and it is an accessible form of activity for everyone. Training aerobically also increases aerobic capacity, and it has been proven in men with and without cardiovascular disease, that peak aerobic capacity is the strongest predictor of mortality [55].

The CPAG emphasize activity duration, exercising in bouts of at least ten minutes, and intensity, reaching at least moderate intensity for aerobic activity because these two factors provide optimal functional benefits [81, 119]. These guidelines were updated in 2011, and one of the modifications made was on frequency. The number of days per week someone should be active is no longer emphasized, instead the focus is on accumulating 150 minutes in at least 10-minute bouts throughout the week [9]. The duration of a single bout, frequency and mode of physical activity have become less important as the focus has shifted to the total amount of activity cumulated per week [57, 120]. This flexibility may be beneficial because people have the opportunity to incorporate shorter bouts into daily life instead of setting aside large periods of time for physical activity.

Mode of Exercise

Of all aerobic activities, walking is the preferred activity as 71% of Canadians 12 years of age and older report walking as their most common leisure activity [29]. When reported by older adults, walking remains the most common form of activity [121, 122]. One important fact is that the majority of older adults are able to achieve moderate intensity while walking, which can result in optimizing both physiological and psychological benefits [53, 122-125]. It has been proven that greater health benefits occur with greater intensity [45, 126, 127], and that most older adults can reach moderate intensity by walking [26-28, 122]. Walking is an ideal aerobic activity as it requires movement of large muscles, elicits cardiorespiratory benefits, can increase functional capacity which leads to increased independence in older adults, and has a low risk for adverse effects [121]. In addition, walking is an inexpensive and accessible form of physical activity [121].

Besides, physiological benefits, walking is associated with the psychological benefits including the prevention and improvement of mild to moderate depression and anxiety, [16-19, 99], decreases in tension and anxiety [128], decreases in perceived stress [16], enhanced quality of life [100], and improvements in total well-being [101]. With walking being the most favored mode of exercise [29, 121, 122], life satisfaction can be expected to increase since it has been proven to increase when activities are perceived as being enjoyable [102]. Social well-being can be positively influenced by both aerobic and anaerobic activity [15], and physical activity interventions can decrease the feeling of loneliness which is a main factor that effects social well-being [15]. Having a supportive social network has been associated with higher levels of physical activity [68, 103], and having a partner to walk with has also been shown to increase the chances of reaching the physical activity guidelines [129].

Adherence to physical activity

Although there is some controversy on whether group based programs or home based programs are more beneficial for adherence, both types of interventions lead to increased physical activity in the short term [130, 131]. However, some studies have shown that long-term adherence to the program was better among the home-based groups programs

[58, 130, 132]. In women 40 years or older, 64% of them preferred to exercise on their own compared to an instructor led group program [133]. Even if some programs start in a group based setting, it has been recognized that the integration into a home-based program is a necessary step in order to develop skills and habits that will be maintained when the intervention is over [130].

Self-efficacy level can also play a role in adherence to physical activity as it has been shown that low self-efficacy leads to decreased attendance in group sessions, but self-efficacy can be increased through individual contact during the intervention [80]. In a walking study done by Lombard et al. [134] there were a variety of groups comparing different levels of contact and structures; high contact/high structure, high contact/low structure, low contact/high structure, low contact/low structure, and control. High contact was classified as being contacted via telephone three times per week, low contact was only once a week, high structure received supportive feedback on the walking completed and plans for future walking including frequency, time and duration, and low structure received a simple check with no specific feedback [134]. An interesting finding from this study was that the two groups that received the high contact portion of the intervention, regardless of high or low structure, saw the greatest effect in participation in walking [134]. This study supports the notion that some contact with participants might lead to a greater adherence to physical activity.

Previously, it has been found that only about 50% that started an exercise program continued with it after three months [135], but as recognized by King et al. [130] when reviewing interventions with older adults, participation rates were about 75%, implying that older adults may be more inclined to adhere to a physical activity intervention, compared with younger adults. Another factor that can influence adherence is the type of program. For example, two studies that implemented a 12-week high intensity resistance training program had dropout rates of 12% [136] and 18% [137], but two 12-week studies that implemented a walking intervention had only a 5% dropout rate in both studies [30, 138].

Importance of moderate intensity and 10-minute bouts

Even though some activity is better than none [41], studies show that reaching at least moderate intensity while being active is associated with greater health and functional benefits [45, 126, 127]. For example, Schnohr et al. [126] showed that exercise intensity had a greater impact on mortality risk than the total duration of walking, which is most likely due to increases in CRF, which is strongly associated with mortality [45]. Reaching at least moderate intensity is emphasized in the current CPAG, and it is recommended that each activity should be accumulated in bouts of at least 10 minutes for a minimum of 150 minutes per week [9]. The reason that 10-minute bouts are encouraged is because it has been proven that many of the factors that influence cardiovascular fitness can be effectively improved with these shorter bouts as compared to the former longer durations suggested [128, 139-141]. The accumulation of 10-minute bouts has been proven just as effective at influencing risk factors such as CRF [128, 139-141], lipid profiles [128, 139], blood pressure [141], fasting plasma insulin [139] and weight control [140] as the longer durations. Although there is a greater increase in CRF with higher intensities [54], Perri et al. [142] found that adherence to moderate intensity activity was significantly better than adherence to vigorous intensity ($p = 0.02$), and that increasing the frequency of moderate activity did not decrease adherence, but an increase in intensity resulted in a decrease in adherence, therefore leading to less total physical activity. The

CPAG provide the opportunity to find ways to incorporate short bouts of exercise into daily living, instead of having to set aside a prolonged period for exercise, potentially making the guidelines more achievable.

Methods to assess exercise intensity

Exercise intensity can be measured in a variety of different ways, but the measure is either subjective (e.g., rate of perceived exertion) or objective (e.g., heart rate monitor). Objective measures are favorable because they are not influenced by personal bias or assumptions, but they are often accompanied by a subjective measure that provides another layer of information. The benefit to objective measures is they are based on reliable and valid measures, they can detect small changes, and norms are usually available [143]. Objective measures use instruments to measure outcomes, and are expressed with numbers [144]. However, limitations to objective measures include high costs associated with the equipment needed, increased time, possibility of being limited to small groups, and increased resources to take the measures [144]. Represented below are some of the most common methods used to assess exercise intensity. These methods include a couple of subjective measures, but predominantly different objective measures and some of the advantages and disadvantages associated with them.

Subjective Measures

Talk Test

This test provides a subjective measure of exercise intensity while walking. The talk test is measured by the ability to carry on a conversation while exercising and when an increase in breathing is noticed, it indicates moderate intensity has been reached [145]. Even if this measure is subjective, it was validated in the past against heart rate (HR) and

VO_2 [145-147].

Borg Scale

The Rate of Perceived Exertion (RPE) scale, otherwise known as the Borg Scale, categorizes different intensities into a numeric scale (6 to 20 or 0 to 10), the higher the number the more intense the activity is perceived as being [148]. This scale also incorporates some key words that correlate with the numeric values in order to help people understand the scale. For example, moderate intensity can be identified as a value of 12 to 13 and the corresponding definition of this intensity is somewhat hard [149].

Objective Measures

Metabolic Equivalent of Tasks (MET)

METs are a commonly used measurement for exercise intensity [22-25, 150-152], this method estimates the energy cost required to perform different activities [153]. It is assumed that one MET is the amount of oxygen consumed at rest, which is by convention is 3.5 mL O_2/kg/min [153]. If an activity were reported as requiring 3 METs, the default oxygen consumption would be 10.5 mL O_2/kg/min (3.5 mL O_2/kg/min x 3 METs = 10.5 mL O_2/kg/min). The common measure of METs for achieving moderate intensity is between 3 and 6 METs, leaving anything over 6 METs as vigorous intensity [38]. The use of METs as a general public message is useful, but when using it for an individual reference for exercise intensity no consideration is given to individual differences in fitness level or age. Since these vary from person to person, even if two people are achieving 3 METs they might be working out at two different percentages of their maximal aerobic capacity, and this would be even more prominent in young adults where the range of fitness levels varies more than in older adults.

Heart Rate Monitors

HR provides an objective and a practical measure of exercise intensity [51]. HR monitors usually consist of a chest strap and a watch that displays the current HR in beats per minute (bpm). Different intensities or goals can be achieved by prescribing different HR zones. First, a measure or estimation of either HR max or HRR must be done, and then HR can be prescribed based on different percentages of these. In order to reach moderate intensity either 64 to 76% of HR max or 40 to 60% of HRR is recommended [38]. Even though HR monitors can provide an accurate and valid measure of exercise intensity [154], they are sometimes impractical, especially for older adults because of cost and operational difficulties [13]. In addition, using HR as a prescription for intensity becomes more challenging and less accurate when older adults are taking medications that affect their HR, such as beta-blockers which cause the HR to be lower [155], or when it is taken into consideration that factors such as emotional stress can impact HR [156].

Oxygen Consumption

Maximum oxygen consumption can be measured through a maximal CRF test [40], but predictions can also be made using a sub-maximal CRF test [40]. When equations based on performing a sub-maximal test, such as the ACSM equation, are used to estimate VO_2 max in older adults, it can lead to an overestimation of aerobic capacity and this results in prescribing an intensity that may be too high [157]. If the equipment and qualified personnel are available it is preferable to do a maximal CRF test as it is considered to be the most valid measure of CRF [40]. Criteria used determine whether a person has reached their physiological maximum include, but is not limited to; i) reaching a plateau in oxygen consumption, this means that even when the workload is increased the consumption of oxygen does not increase by more than 150 ml/min [40], ii) failure of the HR to increase as the workload increases [40], iii) venous lactate concentration exceeding 8mmol/L [40], iv) respiratory exchange ratio (RER) ≥ 1.15 [40], v) RPE > 17 when using the Borg scale (6 to 20) [40]. The two most common criteria for determining if VO_2 max has been reached are criteria 1 and 4; when these criteria are not met, the highest value achieved during the test is referred to as a VO_2 peak [40]. Although reaching a maximum is ideal, obtaining a peak is more common for older adults and sedentary individuals [40], and the peak value, when attained from a maximal effort CRF test, has been proven as a valid index of maximal aerobic capacity [158] and thus preferable to a submaximal test as submaximal testing can present large variation and when an accurate assessment of VO_2 max is required, this method is not recommended [159]. The maximum value in VO_2 max expressed in ml/kg/minute can be used to determine VO_2R, which is the difference between maximal oxygen consumption and oxygen consumption at rest [40]. When oxygen consumption at rest is not measured, 3.5 ml/kg/min is used by default [22]. With this information moderate exercise intensity can be prescribed based on 40 to 60% of VO_2R [38, 51], which translates to the same proportion of HRR.

Pedometers

Pedometers are a great tool as they are simple to use, inexpensive, and provide instant visual feedback on either the total amount of steps, or more recently, the steps per minute, which is easy to understand [160]. Using pedometers to increase physical activity time has been proven as an effective method to increase physical activity levels, but long-term behavior change requires more than just the pedometer alone, as greater improvements are seen when education and goals are included in the intervention [30, 161, 162].

Previously, pedometers have only been able to quantify total steps per day, creating a reliance on setting step goals (e.g., 10,000 steps per day), and although step goals are a good starting point they are unable to address exercise intensity. It has been reported that having the goal of walking at least 10,000 steps per day could increase physical activity, but this was not necessarily associated with health benefits [123]. This prescription was based on reaching the guidelines at the time, which were to accumulate 30 minutes of moderate intensity activity on most days of the week. It was believed that walking 10,000 steps was equivalent to doing 30 minutes of aerobic exercise per day [163], considering that most people do about 6000 steps per day in their daily living activities [164-166]. Unfortunately reaching 10,000 steps per day may not be the best measure of physical activity as no minimal intensity is associated with this prescription, and bout length is left unaddressed [167]. There is also no guarantee that if 10,000 steps are achieved that the physical activity guidelines will be successfully reached [161, 168, 169]. Although Le-Masurier [168] found that participants who were walking more than 10,000 steps per day were spending more time in moderate intensity compared to the group not reaching 10,000 steps (62.1 ± 27.7 minutes vs. 38.8 ± 18.9; $p < 0.05$), , only 51% of participants that walked more than 10,000 steps met the CPAG in terms of aerobic activity. Another argument regarding whether reaching a step count is a good measure of physical activity level can be found in a systematic review by Tudor-Locke [170] which emphasizes the issue with prescribing 10,000 steps as a universal goal because there is variation among age groups and health status’. The main issue with a generalized step count prescription is that it does not provide the same effect for all individuals, it may be too high or too low [161], and the way that this recommendation has been advertised to the public has neglected to include intensity and bout length requirements which are critical components in order to reach the physical activity guidelines [168]. Walking cadence still relies on step count, but places the emphasis on the speed of the steps, therefore influencing the intensity.

Recently, pedometers that can track time at different intensities have been developed based on walking cadence, allowing a better chance to reach the CPAG. The Steps Count – Step Rx is a new pedometer that has recently been released [31]. This pedometer is able to record not only steps, but also time spent at a moderate to vigorous intensity [31] based on steps per minute. It has a walking cadence sensor to determine if one's walking at the threshold for moderate to vigorous intensity; 100 steps per minute by default. However, that threshold can be manually adjusted with five steps per minute intervals. It is preferable to individualize walking cadence because different factors can influence walking cadence, at least in adults aged 55 years old or younger, such as age [26, 27], height [24], leg length [24, 152], and stride length [24]. While using the Steps Count – Step Rx pedometer, individuals can see how many minutes of walking were completed at moderate intensity based on their individual walking cadence or the cadence set by default.

Walking Cadence

In 2005, Tudor Locke et al. [25] were the first to explore if walking cadence could be used to prescribe moderate intensity in apparently healthy adults. Since then the general public message has been to reach at least 100 steps per minute in order to achieve moderate intensity [22-25]. All these studies to date have used 3 METs as the threshold for moderate intensity to be achieved, and have identified the cadence associated with this [22-25, 30]. Although 100 steps per minute is known as the standard walking cadence to reach moderate intensity, there are some studies that support a more individualized approach to prescribing walking cadence for adults. For example, Rowe et al. [24] found that height can impact walking cadence by more than 20 steps per minute, and other measures such as stride length and leg length can also affect walking cadence [24, 152]. Although some factors have evidence to support individualization, one factor that does not seem to be individualized when prescribing walking cadence is resting metabolic rate [22]. Most of the studies done to determine walking cadence have been on a young, relatively healthy population [22-25, 152], and current public health recommendations may need to be modified for older adults [26] because there are unique factors that affect their walking cadence such as shorter steps [171] and slower walking speed [172].

Recently a few studies have investigated walking cadence in older adults and have found that older adults are capable of walking at a cadence more than 100 steps per minute [26-28] and their preferred pace is often higher than this threshold [26, 27]. In 2010, Taylor et al. [27] conducted a study on free-living walking pace in ten older adults aged 54 ± 8 years. There were two components to this study, a 150 meter timed trial at three speeds; i) slower than normal, ii) normal, iii) faster than normal, and a one kilometer pre-measured outdoor walk tracked by a global positioning system (GPS) where participants were asked to walk at their normal pace. To determine if participants were reaching moderate intensity, speed was measured, if they were walking at a speed between 1.34 and 1.79 meters/second they were classified as reaching moderate intensity as this corresponds with reaching 3–6 METs [173]. All participants achieved a speed of 1.34 meters/second while walking at their normal pace for the 150-meter trail, and the mean speed during the one-kilometer GPS walk was 1.52 ± 0.2 meters/second.

Another study supports the notion that older adults are capable of walking at cadences ≥ 100 steps per minute, and self-select this speed in a clinical environment [26]. This study recruited 29 healthy older women aged 71 ± 12 years and had them walk on a treadmill at three self-selected speeds; i) slow, ii) medium, iii) fast, while HR, oxygen consumption, RPE, and stride rate where recorded. The results of this study show that energy expenditure exceeded 3 METs at all self-selected speeds, and the mean stride rates associated with the self-selected speeds were; slow: 111 ± 12 steps per minute, medium: 118 ± 11 steps per minute, fast: 124 ± 12 steps per minute [26].

Tudor-Locke et al. [28] found older participants could walk at a pace ≥ 100 steps per minute, but it was also determined from a week of accelerometer and pedometer data that the likelihood of this walking cadence occurring during daily living was quite rare. The normal walking cadence chosen at testing for men was 104 ± 9 steps per minute, and they spent an average of 7.59 ± 8.01 minutes per day at a speed greater than or equal to this. Women chose a normal walking cadence of 111 ± 9 steps per minute, spending only 1.44 ± 1.96 minutes per day at this speed [28]. It is clear that more research needs to be done with this population in order to determine an accurate and achievable walking cadence goal. Developing an appropriate strategy to help older adults understand the necessary walking cadence and duration needed in order to reach a moderate to vigorous intensity is also important, and some studies have started to explore interventions targeting this.

Recently, two studies have carried out physical activity interventions with an outcome of increased time in MVPA [13, 30]. Bouchard et al. [13] evaluated whether different intensity monitoring devices would impact older adults time spent in MVPA and their ability to accurately identify moderate intensity. The different methods used to evaluate moderate intensity were, 40% HRR using manual pulse, 40% HRR using a HR monitor, or 100 steps per minute using total steps from the pedometer. Although no significant increases in time in MVPA were shown in this study, the two groups that used monitoring tools, not the manual pulse group, showed improvements in total activity time and increased daily step counts when compared to baseline. In this study the pedometer group had more success accurately identifying moderate intensity at the end of the intervention as compared to all other groups, suggesting that further research with this tool and walking cadence is needed [13]. Marshall et al. [30] also explored the effect of a walking intervention but used only pedometer based step goals to increase time in MVPA. In this study three groups with different daily step goals were compared; i) self-selected steps goal (control), ii) 10,000 steps, iii) 3000 steps in 30 minutes. Results showed that participants in both intervention groups spent significantly more time in MVPA compared to the control group, but only the walking cadence prescription group (3000 steps in 30 minutes) significantly increased time in MVPA in bouts of at least 10 minutes [30]. Accumulating MVPA time in 10-minute bouts is outlined in North American physical activity guidelines [9, 99] because accumulating activity in bouts of at least 10 minutes results in similar improvements in fitness as exercising at the same intensity for longer durations, as long as the total accumulated time is the same [47]. Both of these studies [13, 30], and an upcoming study by Tudor-Locke et al. [174], assign a walking cadence of 100 steps per minute in order to reach moderate intensity, but to determine their cadence participants have to track total steps and time spent walking, and then perform the calculation to determine walking cadence. There are now pedometers capable of tracking MVPA time using walking cadence as a threshold, making data collection more objective and less tedious for participants [31]. Another limitation to some of these studies is that walking cadence prescriptions were made with the pedometer, but outcome measures of MVPA time were based on accelerometer data [30, 174], and limited research has been done to compare pedometer and accelerometer intensities.

Accelerometers

Accelerometers are non-invasive, lightweight, portable devices that provide an objective assessment of physical activity, but they do not provide any instant feedback [175]. By measuring tri-axial accelerations caused by movements of the body, accelerometers are able to eliminate some bias that is associated with self-reported measures [176], and pedometers that only measure ambulatory activities. The values are represented as counts, and time as epochs, and these measures allow for interpretation of physical activity levels [177]. Currently, no standardized method has been developed to quantify accelerometer data, therefore the thresholds used to determine time spent in sedentary, light, moderate, and vigorous intensities can greatly impact the results, and with little consistency in thresholds used, comparison of results is challenging [178, 179]. Loprinzi et al. [179] showed that the threshold used can greatly influence estimates of time spent at different physical activity intensities, and therefore present controversial data on whether physical activity guidelines are being met (i.e., 4.5% to 99%). In addition, very few cut-off have been developed specifically with older adults [175, 180].

Although all accelerometer models report counts per minute, it is an arbitrary measure because making direct comparison between devices is practically impossible. In Canada, the Actical (Biolynx, Montreal) accelerometers have been popularized since the Canadian Health Measures Survey has validated and used it [4, 177]. Based on the literature that has used these accelerometers, three different cut points have been used with older adults [175, 177]. Hooker et al. [175] looked at MVPA thresholds to use with an older population and determined that in a population ≥ 65 years of age, 431 counts per minute was an accurate cut point, and 1065 counts per minute for a population ≥ 45 years of age. The third cut point is based on data from ages 9 to 59 years, but when classified as looking at ≥ 18 years, a MVPA threshold of 1535 counts per minute was determined [177]. This cut point has also been used on a population ≥ 65 years [4]. For accelerometer data to be considered valid the minimum number of valid days is at least four days [4]. A valid day requires a minimum of 10 hours of wear time [4] where non-wearing time is considered as any consecutive 60 minutes with no movement [4].

Summary of the review of the literature

It is obvious that a great deal of research has been done to show the importance of physical activity for health and functional capacity in older adults. However, where the literature lacks is in interventions that test strategies to increase the ability to identify moderate intensity to not only increase physical activity levels, but also physical activity at a moderate to vigorous intensity to optimize health benefits. Marshall et al. [30] and Bouchard et al. [13] have started to explore the possibility of this but have some limitations in their study designs. To name a few, one was done on middle-aged women with very low socio-economic status [30] and the other study only included contact with the research staff on one occasion [13]. The majority of the research on walking cadence has used an absolute measure of intensity to evaluate the walking cadence necessary to reach moderate intensity (e.g., 3 METs), which has been translated into 100 steps per minute, but this method may also have room for improvement in order to individualize walking cadence. The work that has been done on walking cadence in an older population suggests that they are capable of reaching moderate intensity through walking, but that it is not common during daily living [28]. Expanding the knowledge on walking cadence by using a pedometer that provides instant visual feedback about the exercise intensity represents an opportunity that could help increase the amount of time spent at moderate to vigorous intensity in 10-minute bouts, and consequently help individuals reach the aerobic component of the CPAG.

Table 1. Assessing Moderate Intensity

Method	Moderate Intensity
MET	3 to 6 [38]
Heart Rate	64 to 76% HR max [38] 40 to 60% HRR [38]
Oxygen Consumption	46 to 64%VO_2 max [38] 40 to 60% VO_2R [38]
Pedometers	100 steps/minute [22, 23, 25]
Actical Accelerometer (counts per minute)	≥ 1535 (18 to 59 years) [177] ≥ 1065 (45 to 84 years) [175] ≥ 431 (≥ 65 years) [175]
RPE (scale from 6-20)	12 or 13 [148]

MET: Metabolic Equivalent of Tasks, ACSM: American College of Sports Medicine, RPE: Rate of Perceived Exertion, HRR: Heart Rate Reserve, VO_2max: Maximum Oxygen Consumption, VO_2R: Volume of Oxygen Reserve

CHAPTER 3: METHODS

Research methodology

This study used a randomized balance design, as all participants experienced the same intervention during the first phase (6 weeks) of the study and then they were randomly allocated to comparison groups one and two after that time period. The goal for the phase 1 was to walk a minimum of 150 minutes at no specific intensity. For phase 2, all participants aimed to walk at least 150 minutes per week, with the instruction of doing this in 10-minute bouts at moderate to vigorous intensity. This is all the information that group two received, but group one also received an individualized walking cadence prescription using a pedometer that provided instant visual feedback about whether their walking cadence was achieving moderate to vigorous intensity in 10-minute bouts.

Objectives:

Primary objectives

1. To study if only encouragement to be more active, in order to reach the CPAG in terms of aerobic exercise, significantly increased total time in MVPA and 10-minute bouts in MVPA in six weeks (phase 1).
2. To study if using a pedometer and an individualized cadence prescription to reach MVPA ($\geq$ 150 minutes/week) while walking for six weeks (phase 2: week 7 to week 12) increased total time in MVPA and 10-minute bouts in MVPA, once adjusted for confounders, compared with a group that did not receiving any specification on how to identify walking intensity.

Secondary objectives

1. Determine if there was a difference in baseline characteristics between the completers and non-completers in the study.
2. Evaluate if there was a significant change in clinical variables such as VO_2 peak, prescribed cadence, BMI, and physical capacity between week six and twelve.
3. See what covariates are most strongly associated with change in total MVPA time and MVPA in 10-minute bouts between weeks six and twelve.
4. Compare the results from the pedometer and the accelerometer from baseline to week twelve.

Hypotheses:

Primary hypotheses

1. Participants will significantly increase total MVPA time, but not time spent in 10-minute bouts of MVPA from baseline to week six (phase 1).
2. Compared with group two, group one will significantly increase total time in MVPA and time spent in 10-minute bouts of MVPA using a pedometer and an individualized cadence prescription to reach MVPA, from week six to twelve (phase 2).

Secondary hypotheses

1. There will be no significant differences in baseline characteristics of completers and non-completers.
2. Group one will see significant changes in their clinical variables such as VO_2 peak, prescribed cadence, BMI, and physical capacity between weeks six and twelve compared to group two.

3. Some baseline characteristics will be significantly associated with change in 10-minute bouts MVPA from week six to twelve.
4. No significant difference will be measured between MVPA time or MVPA time spent in 10-minute bouts between the pedometer and accelerometer from baseline to week twelve when using the individualized cut points for the accelerometer.

Conceptual Framework

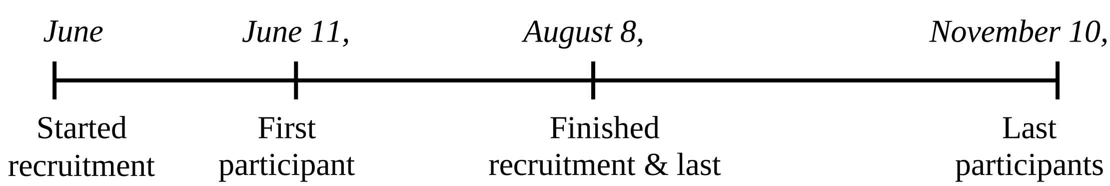
Adherence is a key factor to observe any expected outcomes in an intervention. Using a framework such as the self-efficacy theory may help increase adherence to the intervention [181, 182]. People's belief in their ability to engage in particular tasks necessary to create an outcome is referred to as self-efficacy [79]. This theory is based on the idea that an individual's self-efficacy is a key determinant of behavior, and it has practical application in preventing disease and promoting health in older adults [78]. Bandura [79], identifies four sources of self-efficacy; i) mastery experiences, ii) vicarious experiences, iii) verbal persuasion and iv) physiological and affective states. One goal of this intervention is to positively impact these sources, which should increase self-efficacy, and therefore encourage adherence to physical activity and the intervention.

Mastery experience is knowing that you can achieve something [79]. This was addressed through the intervention by gradually increasing walking duration, and after six weeks of adjusting to increased physical activity, only then was the focus turned to increasing intensity. This two-phase intervention aimed to be less intimidating and more achievable for participants. They also had one on one time spent walking with research staff in the first and second phase, which allowed research staff the opportunity to encourage participants and acknowledge the improvements that had been made. For the entire 12-week intervention, participants were asked to self-report their physical activity in an activity tracker, this provided the opportunity for them to reflect on total activity time completed compared to the CPAG, and to see the previous activity they have completed which could aid in keeping them motivated. The second source of self-efficacy theory is vicarious experience, this is when someone sees another person, similar to themselves, succeed at the task, the individual can draw confidence from this and can feel more inclined to do the task as well [79]. In this study participants are all in the same age category and starting from an inactive state (self-report < 150 minutes of physical activity per week), so seeing similar people stick with the intervention may have encouraged others to do the same. Verbal persuasion is simply sharing the message that the task they are being asked to do is feasible [79]. In order to administer this, research staff were positive and encouraging to the participants during their testing, walking appointments, and during any contact throughout the intervention. It was important to listen to the participants and help them address barriers they were facing in order to encourage adherence to the intervention. The final source of self-efficacy is physiological/affective states [79]. Since participants started from an inactive state, it is understandable that the changes the body goes through during MVPA may be overwhelming and potentially misunderstood. It was important to explain to participants what it feels like to exercise at this intensity, and what some of the normal physiological symptoms will be, such as an increase in body temperature, sweating, and an increase in breathing. Broadening their knowledge on this topic helped to decrease their anxiety about the exercise, had them gain a better understanding of what to expect and how to manage it, and made them less likely to take these physical symptoms as a sign that they cannot do the level of physical activity they are being asked to do.

Participants

Fifty men and women 65 years and older were recruited through newspaper advertisement (i.e., Lifestyle 55, Winnipeg Free Press, Senior Scope) and the Centre on Aging contact list. The Centre on Aging contact includes people who have agreed to be contacted for future studies at the University of Manitoba. In order to gain access to this list a copy of the study proposal and ethics approval had to be sent to the Centre on Aging. At this time the Centre on Aging determined that the list could be used to aid in recruitment. The list contained 57 names, out of which 52 were eligible. *The inclusion criteria for this study were*: i) Health screening to do physical activity based on the Physical Activity Readiness Questionnaire (PARQ+) [35], ii) Willingness and capacity to increase their walking level to a minimum of 150 minutes per week, iii) Available for a period of twelve consecutive weeks, iv) Accept walking as the primary mode of aerobic exercise during the intervention, v) Currently inactive (< 150 minutes of self-reported physical activity per week confirmed with the use of an accelerometer for seven days before starting the intervention). *The exclusion criteria were*: i) Previous participation in training on exercise intensity using a HR monitor (e.g., cardiac rehabilitation program), ii) Using a walking aid. Potential participants either contacted us by email or phone after seeing our advertisement (Appendix A), or were contacted by research staff from their information on the Centre on Aging contact list. Figure 1 outlines the timeline used to recruit participants.

Figure 1. Recruitment Timeline



Intervention

The intervention consisted of a twelve week walking program divided into two six-week phases. The first phase (6 weeks) was identical for all participants. The goal was to progressively walk at least 150 minutes per week with no indication for walking intensity. During this phase all participants were asked to wear a pedometer (Steps Count – StepRx, Ontario, Canada) at all times, aside from when they were sleeping or showering. For phase 1 participants were able to look at the pedometer if they wanted to as it was left unlocked. The pedometer was set on the screen that shows total steps accumulated each day, but no information regarding the pedometer was given other than asking them to wear it. After phase 1, participants were randomly assigned to group one (N=23) who received the intensity intervention, or group two (N=22) who did not receive the intensity intervention. Randomization was based on total MVPA time at baseline from accelerometer data. Time spent in 10-minute bouts was not criteria for randomization because many participants had 0 minute spent at moderate to vigorous intensity at baseline. Prior to the week six testing visit participants were they were randomized with a 2:2 allocation into one of the two groups. For example if four participants had a total MVPA time of 55, 70, 75 and 95 minutes at baseline during the week of evaluation, the participants with the lowest two values would be randomly assigned to either the control or intervention, and the same would be done for the participants with the highest two values. The goal of phase 2 (6 weeks) in group one was to walk 150 minutes per week, reaching at least moderate intensity, in bouts of at least 10 minutes, using the pedometer indicating the walking cadence needed to reach such intensity. Every time a participate was doing one bout of at least 10 minute at the minimum required intensity, a star was showing on the pedometer display. The intensity was individually determined upon completion of the CRF test at the end of phase 1. Participants maximal aerobic capacity achieved was used to determine moderate intensity based on 40% of VO_2R [38]. The goal of phase 2 (6 weeks) in group 2 was also to walk 150 minutes per week, in 10-minute bouts, at their perceived moderate intensity. However, they had no information regarding the appropriate cadence to do so. Participants in group two were asked to continue to wear their pedometer in order to quantify their walking times, but the pedometer was locked shut, so this group did not receive any visual feedback during phase 2, but the pedometer was set using the individualized cadence just like the intervention group.

All participants attended a total of 10 visits to the University of Manitoba's Fort Garry campus. During weeks 0, 6, and 12, the visits were for measurements. The additional visits (three walking sessions for the first week of each phase) were to complete their walking on-site to ensure participants understood the task and had the opportunity to ask the research staff questions. The final visit was to have a final walk with the research staff to talk about future plans for continuing their walking behavior. At this time participant in group two were also given their individualized walking cadence and shown how to use the pedometer to reach moderate intensity in the future. Finally, participants received personal feedback (Appendix B) regarding their testing throughout the study within two weeks of completing their final visit. In addition, a summary of the study findings will be sent to them once all data has been analyzed and interpreted.

During visits 2 to 4 and visits 6 to 8, participants were asked to walk with one of our research staff, either outside or on the flat indoor tracks at the University of Manitoba, in order to answer any questions and help participants understand the task. One of the first three visits was completed on a treadmill for familiarization so that participants felt more comfortable and confident at the week six visit when they performed the CRF test on the treadmill. During the twelve weeks of the study, all participants were asked to self-report the time they spend walking (Appendix C, D, E). Participants in group one were asked to record their time in MVPA each day along with the total number of 10-minute bouts accumulated (Appendix E). For visits 6 to 8, all participants were wearing their pedometers with their individualized cadence, but for group two the pedometers were locked shut. Participants in group one were shown how to reach moderate intensity based on their prescribed walking cadence. During these walks, the pedometer was checked after ten minutes of consecutive walking to ensure that the walking cadence was fast enough.

Prescribing moderate intensity

After the completion of the maximal CRF test participants completed a walking test, on a flat surface to determine their individualized walking cadence at 40% of their VO_2R, which is the minimum prescription required to reach moderate intensity according to the ACSM when individualizing the prescription [38]. The first step was to calculate their 40% VO_2R based on their maximal CRF test result, and the standard resting metabolic rate of 3.5 ml /kg/min [153]. For example if the maximal aerobic capacity was 25 ml/kg/min the calculation for 40% VO_2R was [(25 ml/kg/min – 3.5 ml/kg/min) x 0.4] + 3.5 ml/kg/min = 12.1 ml/kg/min. The second step was to identify the walking cadence needed to reach 40% VO_2R. Participants data (weight, height, and age) was entered into the validated portable metabolic cart (K4b^2 Cosmed, Chicago, USA) [183] which was calibrated before each visit. To determine the individualized prescription of walking cadence at moderate intensity, participants wore a mask attached to the portable metabolic cart. They were also asked to wear a watch and foot pod (Garmin FR60, Rome, Italy) in order to gather walking cadence simultaneously with gas analysis. Participants walked on level terrain at a self-selected speed, the research staff asked them to adjust their speed accordingly in order to reach 40% VO_2R. Once the intensity had been reached, the research staff had participants maintain this speed for two minutes and recorded the cadence from the foot pod, displayed on a watch. The cadence reached at moderate intensity, based on 40% of VO_2R, was identified as the individual walking cadence to reach moderate intensity. This individualized cadence is what was used to set the pedometers to the appropriate moderate intensity for each participant. Because the pedometer can only be set in increments of five steps per minute intervals, participants' cadence was rounded to the nearest value. For example if the individualized cadence was 100 to 102 steps per minute it was set at 100 steps per minute, and if the cadence was 103 to 105 steps per minute it was set at 105 steps.

Data collection

Before acquiring any information, the parameters of the study were explained and then the informed consent (Appendix F) was signed after making sure that the participant understood the content. Next, the PAR-Q+ [35] form that was filled out via phone was confirmed and signed. If participants had either a resting blood pressure > 144/94mmHg or a resting HR > 99 bpm they were sent to their physician to get clearance before being able to participate in the study. Throughout the duration of the 12-week intervention a variety of tests took place. Table 2 outlines all of the measures that were taken and it also displays a summary of the visits participants had at the University of Manitoba.

Table 2. Data Collection Schedule

	PHASE 1 (weeks 1-6)			PHASE 2 (weeks 7-12)		
Visits	**1** Baseline testing	**2 to 4** Walk at U of M	**5** Midpoint testing	**6 to 8** Walk at U of M	**9** Final testing	**10** Final
Physical activity level (pedometer & accelerometer)	**x**		**x**		**x**	
Consent form	**x**					
NEWS score	**x**					
Anthropometric measures	**x**		**x**		**x**	
Leg length	**x**					
Stride length	**x**					
Normal walking cadence	**x**				**x**	
Moderate intensity identification	**x**				**x**	
CRF test			**x**		**x**	
Individualized cadence			**x**		**x**	
Physical capacity	**x**		**x**		**x**	

NEWS: Neighborhood Environment Walkability Scale, CRF: Cardiorespiratory Fitness, U of M; University of Manitoba

Anthropometric Measures

These measures were taken in accordance to the CSEP protocols, as they are the Canadian reference [35]. Height was measured using a stadiometer. Participants were asked to stand tall with their feet together, arms by their side, and looking straight forward. The measurement was recorded during inhalation as recommended [35]. Body weight was measured using a digital scale (OMRON HBF-5186, Illinois, USA). Participants were asked to wear light clothing with no footwear when measuring weight. To measure waist circumference participants were asked to remove clothing at the abdominal area, stand with feet shoulder width apart, and place the arms across the chest. This measurement was taken twice at the superior edge of the iliac crest at the end of a natural expiration; measurements were rounded to the nearest 0.5 cm, as recommended [35]. If the difference between the two readings was more than 0.5 cm, a third reading was taken and the mean of the two closest readings was used. Leg length was measured as outlined by Hoyle et al. [184]. Participants were asked to lie on their back with their feet hip width apart. Measurements were taken from the anterior superior iliac spine to the medial malleolus, on the left side. This measurement was taken two times for accuracy and the mean of the two measurements was used.

Resting Heart Rate and Blood Pressure

Resting HR and blood pressure were measured using an automatic blood pressure cuff (OMRON HEM-432C, Illinois, USA). The CSEP protocol was followed [35]. Participants sat in a chair, with back support, for five minutes prior to taking the first reading. The cuff was wrapped around the upper portion of the left arm and lined up with the brachial artery. After the first reading, five minutes rest were given, and then a second reading was taken [35].

Physical Capacity

The Senior Fitness Tests (SFT) was used to measure participants' physical capacity. This protocol consists of many validated [185] tests, which assess agility, flexibility, endurance and strength [6]. Six of the SFT were used along with an additional test to assess balance from the CSEP protocol [9]. The balance test (unipedal stance test) was added because a decreased ability to stand on one limb, with the eyes opened or closed, is associated with increased age [186], and the ability to balance on one limb for ≥ 30 seconds decreases the risk of falling in an older population [187].

8 foot up and go

Participants started seated in a chair with their feet planted on the ground. Without using their hands to push them out of the chair they stood and walk as quickly as they could around a pylon positioned eight feet away from them and then returned to a seated position. This test assesses agility and dynamic balance and time to complete the task was recorded in seconds.

30 second chair stand

Starting in a seated position with feet on the ground, participants were asked to stand and sit as many times as they could on a chair without arm rests in 30 seconds with their arms across their chest. This test assesses lower body strength, and the number of completed repetitions was recorded.

Arm curl

This test was done from a seated position and begins with the arm fully extended towards to ground. Participants had 30 seconds to complete as many bicep curls as they could, men used an eight pound weight while women used a five pound weight. This tests upper body strength, and the number of completed repetitions in 30 seconds was recorded.

6 minute walk

This test had participants try to cover as much distance as they could during six minutes. They walked on a 20-meter course, and at the end of six minutes they were asked to stop so that the final measurement could be taken. This test aims to assess aerobic endurance.

Chair sit and reach

Sitting near the edge of the seat participants were asked to extend one leg and reach with both hands towards the toes, without bending their knee. The measurement was taken from the end of the fingers to the tip of the toe in centimeters. If the toes were not reached, the score was a negative value, and if the toes were passed it was a positive value. This assesses lower body flexibility.

Back scratch

From a standing position one hand reaches over the shoulder while the other reaches up the middle of the back, trying to move the middle fingers towards each other. The distance between the middle fingers was recorded as a negative value, or if there was overlap, it was a positive value. This assesses upper body flexibility.

Unipedal stance test (eyes opened and eyes closed)

This test was done a total of four times. The first two times were done with the eyes open, and the last two with the eyes closed. Participants stood on one foot with their arms across their chest and tried to hold their balance for up to 45 seconds. If the participant lost balance their time was stopped. For participants safety they were positioned close to a wall on one side, and had the back of a chair in front of them, creating the opportunity to grab something to prevent them from falling if they lost their balance.

Scoring of physical capacity

Instead of presenting all tests individually, we decided to combine all of them together using norms for each participant [6]. If the participants score was equal to or greater than the norm for their gender and age category they were given a value of one, if they did not meet the norm their value was zero. There were eight different physical capacity tests, and the final score was the sum of all the values whether the norm was met or not. The total score can range from zero to eight, and the higher the score is the best their physical capacity is, as this indicates that they reached the norms for more of the tests.

Cardiorespiratory Fitness Level

CRF level was measured at week six and week twelve visits through the completion of a CRF test by walking on a treadmill. This test was not performed at baseline. Intensity was not addressed in the first phase of the intervention, so there was no need to prescribe intensity based on CRF level. The aim of the test was to identify the peak aerobic capacity of each participant in order to individualize a moderate intensity exercise prescription by using 40% of VO_2R [38]. A maximal CRF test was used in order to elicit maximal exertion from participants, knowing based on the literature [40, 188], that only a proportion of participants would reach maximal capacity based on the traditional criteria [40]. Participants were contacted the week prior to their week six testing visit (visit #5) to remind them of their appointment, and also to inform them of the pre-testing procedure for the CRF test. They were asked to wear comfortable clothing and athletic footwear, avoid alcohol, caffeine, and food three hours before the test, and avoid strenuous activity the day of the test [38]. Resting HR and blood pressure were measured before the test to ensure that blood pressure was not too elevated for exercise, two readings were taken, with a five-minute break in between [35]. If blood pressure remained too high, > 144/94 mm Hg, or the resting HR was > 99 bpm, the CEP determined whether the CRF test was safe to perform [189], if the CEP did not consent for the individual to complete the test, the participant was referred to their physician for clearance.

The modified Bruce protocol was used for the CRF tests [40]. Although the modified Bruce protocol is suitable for older individuals [40], because we had a wide variety in participants health status, this protocol was too easy for some which would have led to a very long duration for the test. In accordance with the ACSM guidelines [38], the maximal CRF test should run between eight and twelve minutes in order to increase the odds of exerting a maximal effort. As a result, the modified Bruce protocol was individually adjusted for participants with the judgement of the CEP. All participants started at 1.7 miles per hour (mph) at a 0% grade for a two minute warm up. After, participants had either the speed or the grade increase every two minutes until they quit or reached maximal exertion. During the test the HR, walking cadence, and RPE on a scale from 6 to 20 [148] were recorded every minute. The test was stopped when participants felt they could not do any more or for safety reasons (e.g., systolic or diastolic blood pressure too high). The testing procedure used for each individual at the week six test was replicated at the week twelve test. As recommended, after each CRF test, blood pressure and resting HR were measured to ensure that they returned to pre-testing values [40]. We also calculated what the estimated VO_2 max for participants in this study would have been using a two-point estimation based on heart rate and VO_2 peak. This calculation allowed us to see if there were significant differences between the two methods and what the corresponding prescribed cadences would have been.

Measuring time spent at moderate intensity

Physical activity level was collected and evaluated with the pedometer data, which was also the main intervention tool. Data from the pedometers was collected for the first seven days (evaluation week), the 14 days prior to the week six visit, and the final 14 days of the intervention. The participants also wore an accelerometer during the evaluation week, and the last seven days of the intervention. This data was used as supplementary data to see if it aligns with the pedometer data.

Pedometer

Based on walking cadence data, the pedometer reports on many variables, but only total time spent in moderate to vigorous intensity and the total amount of time in MVPA in 10-minute bouts was kept for analysis.

The Step Rx pedometer (Steps Count – StepRx, Ontario, Canada) was used in this study. It collects and stores data for either the past 14 days, or the past 33 days, depending on the model. In our study we used the past 14 days for all participants. Cadence to reach moderate and vigorous intensity can be manually set in increments of five steps per minute (e.g., 95, 100, 105), which allowed us to individualize walking cadence according to the CRF result. At baseline, because individual cadence was not established, all pedometers were set at 100 steps per minute for moderate, and 120 steps per minute for vigorous, in accordance with current literature with adults and the apparatus default setting [25]. At week six, all pedometers were set to their individualized moderate intensity cadence based on 40% VO_2R, and vigorous intensity was set 20% higher than the determined moderate cadence. This allowed participants in the intervention group to receive instant visual feedback on if they were walking at the correct cadence to reach moderate intensity. The pedometer shows the number of 10-minute bouts done at MVPA by displaying stars. The pedometers count a 10-minute bout when the cadence for moderate intensity has been achieved for eight out of the ten continuous minutes; therefore to calculate time in MVPA in 10-minute bouts we multiplied the total number of bouts by nine minutes. Since the moderate and vigorous thresholds were not individualized at baseline, baseline data had to be adjusted to reflect an appropriate cadence for each individual in order to compare the data from phase 1. To do this, equations (Table 3) were used. At baseline, the pedometers were set at 100 steps per minute for moderate intensity and 120 steps per minute for vigorous intensity. Once the individual cadence was determined at week six, we were able to adjust the baseline pedometer information. For example, if one participant had an individualized walking cadence set at 115 steps per minute for moderate intensity, the number of minutes spent at MVPA for baseline was moderate intensity time X.25 + time spent at vigorous intensity.

Table 3. MVPA Adjustments for Baseline Threshold

Adjustment for Time at Baseline	Cadence equivalent to 40% of VO_2R
(Moderate x 1.5) + Vigorous	90
(Moderate x 1.25) + Vigorous	95
Moderate + Vigorous	100
(Moderate x 0.75) + Vigorous	105
(Moderate x 0.5) + Vigorous	110
(Moderate x 0.25) + Vigorous	115
Vigorous	$\geq$ 120

VO_2R: Volume of Oxygen Reserve

Accelerometer

The accelerometer was not the main tool used to measure exercise time and intensity for this study, but in order to validate the findings measured with the pedometer and compared our results to the literature, we added this measurement. The Actical accelerometer (Phillips – Respironics, Oregon, USA) was used in this study, and it provides extensive information. However, for the purpose of the study we kept the valid days, total time spent in MVPA and total time spent in MVPA in 10-minute bouts or more.

Participants were asked to wear the accelerometer for seven days during the evaluation week, and another seven days at the end of the study during. This data was used to assess whether the changes in total MVPA and time in MVPA in bouts ≥ 10 minutes from baseline to endpoint correlates with the pedometer data. Based on the literature the specific cut points to determine moderate to vigorous intensity in older adults is not clear for the Actical accelerometer as it vary from 431 counts per minute [175] to 1535 counts per minute [177]. We decided to use our own individualized cut point based on 40% VO_2R for data analysis.

The way this was done was by identifying the valid days worn for the accelerometer, only accelerometers worn for at least ten hours per day, with non-wear time considered as any consecutive 60 minutes with no movement, were considered valid [4]. Only the valid days from the Actical were used to compare with the pedometer data. From the pedometer data we measured the total number of minutes spent in MVPA based on their individualized threshold at 40% VO_2R. Based on this information, the raw accelerometer data was analyzed to see what activity count was associated with the same number of minutes in MVPA as the pedometer information. For example, if the participant had 20 minutes of time in MVPA based on the pedometer data, when analyzing the accelerometer data it was organized from highest to lowest activity counts, and then 20 minutes was counted, and the activity count at the last minute in MVPA was used as the cut point for reaching moderate intensity. In order to get the most accurate measure possible, all valid days of accelerometer wear were matched with the pedometer time and then the average cut point for all the valid days was used for each participant. With these individualized cut points the analysis was done separately for each participant, each time modifying the cut-point in order to determine the time they spent in MVPA based on the accelerometer. The median cut-point for MVPA based on the individualized cadence was 1679 (1040-2940) counts per minute.

Potential confounders

Data regarding neighborhood walkability and weather (i.e., temperature, humidity, humidex, and precipitation), and baseline characteristics (i.e., age, sex, education level, MVPA, BMI, and physical capacity) were considered as potential confounders to compare the two groups, during phase 2, on the change in time spent in 10-minute bouts of MVPA. Besides neighborhood walkability, weather, and education level, the method to measure the variables is presented above.

Neighborhood Walkability

Participants neighborhood walkability was evaluated with the Neighborhood Environment Walkability Scale [190]. This questionnaire measured nine different topics regarding the participants neighborhood; types of residences, stores and facilities, access to services, types of streets, neighborhood surroundings, safety from traffic, safety from crime, and neighborhood satisfaction. All questions were asked on a Likert scale from 1 to 5, and the total score for this questionnaire was calculated. A high score means a greater walkability in the neighborhood. The score range from 82 to 905.

Weather

Data regarding weather during the entire intervention was collected daily to determine if there was a significant difference between the control and intervention groups with regards to weather conditions, and if a difference was detected, if it had an impact on MVPA time in 10-minute bouts. The weather information collected was temperature, humidity, precipitation, and humidex values. High and low temperatures and humidity values, along with daily precipitation were recorded from the Winnipeg Weather website [191], and humidex values were calculated based on the Environment Canada humidex chart [192]. This data was analyzed separately for phase 1 and phase 2 of the intervention. Mean temperature, humidity, and humidex were calculated and total precipitation was recorded for each of the two phases for every participant.

Education level

At baseline, all participants were asked their highest level of education. This data was coded based on whether participants did or did not have a college or university education. Those who did not have this level of education were coded with a zero value, and those who did have college or university education received a value of one.

Statistical Analysis

The first statistical analysis that was performed was a normality test to determine if the data was normally distributed. Based on a small sample size of 50, the Shapiro-Wilk test was used [193]. The variable 'time in MVPA in 10-minute bouts' was not normally distributed, and it was not possible to normalize it. Therefore non-parametric tests were used. The Chi-Square (e.g., sex) or the Mann-Whitney (e.g., BMI) tests were used to determine the differences between characteristics of two groups and the Wilcoxon tests were used to test the change within the same group (baseline vs. week six or week seven vs. week twelve). Spearman's correlations were done to verify what baseline descriptive variables were significantly associated with the change in MVPA time completed in 10-minute bouts from week seven to week twelve.

Linear regression could not be used because the main outcome (change in MVPA time completed in 10-minute bouts from week seven to week twelve), and the residuals were not normally distributed. In order to determine the variables that were most associated with a change in time in MVPA in 10-minute bouts, a logistic regression model was used. A bivariate variable used as a dependent variable was created based on the 'median of change' (change equal to or greater than median = 1; changed less than median = 0). The median percent change was a reduction of 17% in time in MVPA in 10-minute bouts.

The Mann-Whitney or Chi-square tests were used to compare the characteristics of the participants in each group, once these two groups had been computed.

CHAPTER 4: RESULTS

Phase 1 (week 1 to week 6)

Table 4 shows the main characteristics of participants at baseline, and differences in these variables from baseline to week six (Phase 1). The median age was 70 years old, the majority of participants were women, highly educated, and mostly overweight. The baseline information also indicates fairly low neighborhood walkability among participants, and how little time was spent in MVPA in 10-minte bouts at baseline. The only measured variables that increased significantly over this period of time were time spent in MVPA in 10-minute bouts ($p = 0.01$) and the total time in MVPA ($p = 0.03$).

Table 4. Characteristics for Completers of the Study (N=42) Baseline and Week 6

Characteristic (unit or range)	**Baseline**	**Week 6**
Age (years)	70 (66-77)	
Sex (male)	12 (29)	
Education (≥ university level)	26 (62)	
NEWS score (82-905)	233 (198-477)	
MVPA in 10-min bouts (minutes)	10 (0-32)	19 (8-53)**
Total MVPA (minutes)	100 ± 61	117 ± 64*
Total steps (daily)	6471 ± 2698	6791 ± 2810
BMI (kg/m^2)	28 ± 4	28 ± 4
Physical Capacity (0-8)	4 ± 2	5 (4-6)

Data represented in mean ± SD, median (25^{th}-75^{th} percentile) or N (%)
* ($p \leq 0.05$) between baseline and week 6
** ($p \leq 0.01$)
NEWS: Neighborhood Environment Walkability Scale, BMI: Body Mass Index, MVPA: Moderate to Vigorous Physical Activity

Phase 2 (week 7 to week 12)

Table 5 shows the data of interest from week seven to week twelve by groups. Some of the additional measurements that were taken during this time include VO_2 peak, as well as an individualized prescribed walking cadence based on 40% VO_2R. Besides a significant difference at baseline for the proportion of people per group having a university degree (greater in the intervention group; $p = 0.04$) no significant difference between the two groups was observed for any tested variables. However, between week seven and week twelve, group one significantly increased their time in MVPA in 10-minute bouts, as well as their total time in MVPA, whereas group two significantly decreased their time in both of these measures. By the end of the intervention, group one had an average of 88 (52 – 143) minutes of time in MVPA in 10-minute bouts, and 10 of the 42 participants were achieving $\geq$ 100 minutes of MVPA in 10-minute bouts and nine of these participants were in group one. We also observed a significant increase in group one, during phase 2, in VO_2 peak ($p = 0.02$). Significant differences in the changes from week seven to week twelve when comparing the two groups were seen in MVPA in 10-minute bouts, total MVPA, prescribed walking cadence, and VO_2 peak ($p \leq 0.05$). Another significant difference was seen in the total steps for group two ($p \leq 0.05$), and this also resulted in a significant difference in percent change between the two groups ($p = 0.03$). Four different weather related measurements were collected, and significant differences were seen in these variables during phase 2, as the seasons started to change, but no significant differences were seen when comparing these changes between the two groups.

CRF was assessed at week six, and these tests resulted in predominantly VO_2 peak results from the maximal CRF tests, as depicted below in Table 6. Only 26% of the participants reached a VO_2 max based on an oxygen consumption plateau of less than 150 ml/minute when workload was increased [40], and/or reaching a respiratory quotient of at least 1.15 [40]. Although this maximal CRF test resulted in the majority of participants reaching a VO_2 peak and not a VO_2 max, when VO_2 max was estimated using a two-point estimation based on heart rate and VO_2 peak, 41 out the 42 participants were reaching $\geq$ 75% of their estimated VO_2 max, and 79% were reaching $\geq$ 90% of their estimated VO_2 max.

To understand what baseline characteristics were associated with change in MVPA in 10-minute bouts between six and twelve weeks, correlations were performed with continuous variables collected at baseline and VO_2 peak measured at week six (Table 7). The analysis shows that the total physical capacity score at baseline and VO_2 peak at week six were associated with the dependent variable.

In order to determine if using a pedometer and an individualized cadence prescription to reach moderate to vigorous intensity (≥ 150 minutes/week) while walking for six weeks (phase 2: week 7 to week 12) was increasing total time in MVPA and 10-minute bouts in MVPA, once adjusted for confounders, compared with group two who did not receive any specification of how to identify walking intensity, logistic regression was used. The median percent change for MVPA in 10-minute bouts between week six and week twelve was used to create two groups, those who were below the median (0), and those who reached or surpassed the median (1). The median percent change was a reduction of 17%. Using the forward conditional method, the potential confounders variables were included in the analysis including group of intervention, age, sex, baseline education level, baseline MVPA, baseline BMI, and baseline physical capacity score. Only the group (Odds ratio = 0.16; p = 0.001), and the physical capacity score at baseline

(Odds ratio = 2.47; $p = 0.02$) remained in the final model. The result revealed that being in the intervention group increased the odds of reaching or surpassing the median change for time spent at MVPA in 10-minute bouts by 84%.

Table 5. Pertinent Information Collected from Week 6 to Week 12

Characteristic (unit or range)	Control (N = 22)		Intervention (N = 20)	
	Week 6	**Week 12**	**Week 6**	**Week 12**
MVPA in 10 min bouts (min)	17 (6-41)	9 (0-23)**	31 (11-55)	88 (52-143)** †
Total MVPA (min)	106 ± 59	88 ± 71*	129 ± 67	203 ± 91**†
Total steps (daily)	7234 ± 2414	6358 ± 2154*	6305 ± 3182	6714 ± 3199†
Prescribed cadence (steps/min)	116 ± 12	113 ± 12*	112 ± 9	113 ± 10†
BMI (kg/m^2)	28 ± 4	28 ± 5	28 ± 4	27 ± 3
Physical capacity (0-8)	5 (5-6)	5 (4-6)	5 (3-6)	5 (3-6)
VO_2 peak (kg/ml/min)	26 ± 7	26 ± 6	22 ± 4	24 ± 4*†
Temperature (Celsius)	16 (13-19)	8 (5-11)**	17 (15-19)	8 (7-13)**
Humidity (%)	73 (70-77)	67 (67-70)**	74 (70-78)	71 (70-75)
Humidex	24 ± 10	2 (2-5)**	23 ± 10	2 (2-12)**
Precipitation (mm)	3 (1-4)	0 (0-1)**	3 (1-4)	0 (0-1)**

Data represented in mean ± SD or median (25^{th}-75^{th} percentile)
* ($p \leq 0.05$) between week 6 and week 12
** ($p \leq 0.01$)
† ($p \leq 0.05$) between % change between the groups
MVPA: Moderate to Vigorous Physical Activity, VO_2 peak: Peak Oxygen Consumption, BMI: Body Mass Index, min: Minute

Table 6. Proportion of Participants Reaching Common Criteria for VO_2 max

	N = 42
Plateau (<150ml/min increase with increased work)	11 (26)
RER (≥ 1.15)	16 (38)
Borg Scale (> 17 RPE)	20 (48)
Predicted HR max (220-age)	25 (60)

Data represented in N (%)
RER: Respiratory Exchange Ratio, RPE: Rate of Perceived Exertion, HR: Heart Rate

Table 7. Associations Between Change in MVPA in 10-minute Bouts from week 6 to 12 and Baseline Characteristics

Age (years)	-0.03
BMI (kg/m^2)	0.18
Education (≥ university level)	0.13
NEWS score (182-905)	0.01
Physical capacity (0-8)	-0.54**
VO_2 peak (ml/kg/min)†	-0.48**
10 min bouts MVPA (minutes)	0.07
Total MVPA (minutes)	0.18
Total steps (daily)	-0.23

** ($p \leq 0.01$) between week 6 and week 12
† VO_2 peak was measured at week 6
BMI: Body Mass Index, NEWS: Neighborhood Environment Walkability Scale, VO_2 peak: Peak Oxygen Consumption, MVPA: Moderate to Vigorous Physical Activity

Table 8. Characteristics of Median Groups for Change in MVPA in 10-minute Bouts Between Week 6 and Week 12

	Below median (N=20)	**Above median** (N=21)
Age (years)	72 (69-77)	69 (66-76)
Sex (male)	7 (35)	5 (24)
Group (group one)	3 (15)	17 (81)**
Education (≥ university level)	10 (50)	16 (76)
NEWS score (182-905)	219 (199-488)	232 (192-428)
BMI (kg/m^2)	27 ± 4	28 ± 4
Physical capacity (0-8)	6 (4-6)	4 (2-5)**
VO_2 peak (ml/kg/min) †	27 ± 6	21 ± 4**
10 min bouts MVPA (minutes)	10 (2-21)	16 (0-67)
Total MVPA (minutes)	94 ± 69	114 ± 68
Total steps (daily)	6994 ± 2567	6063 ± 2846

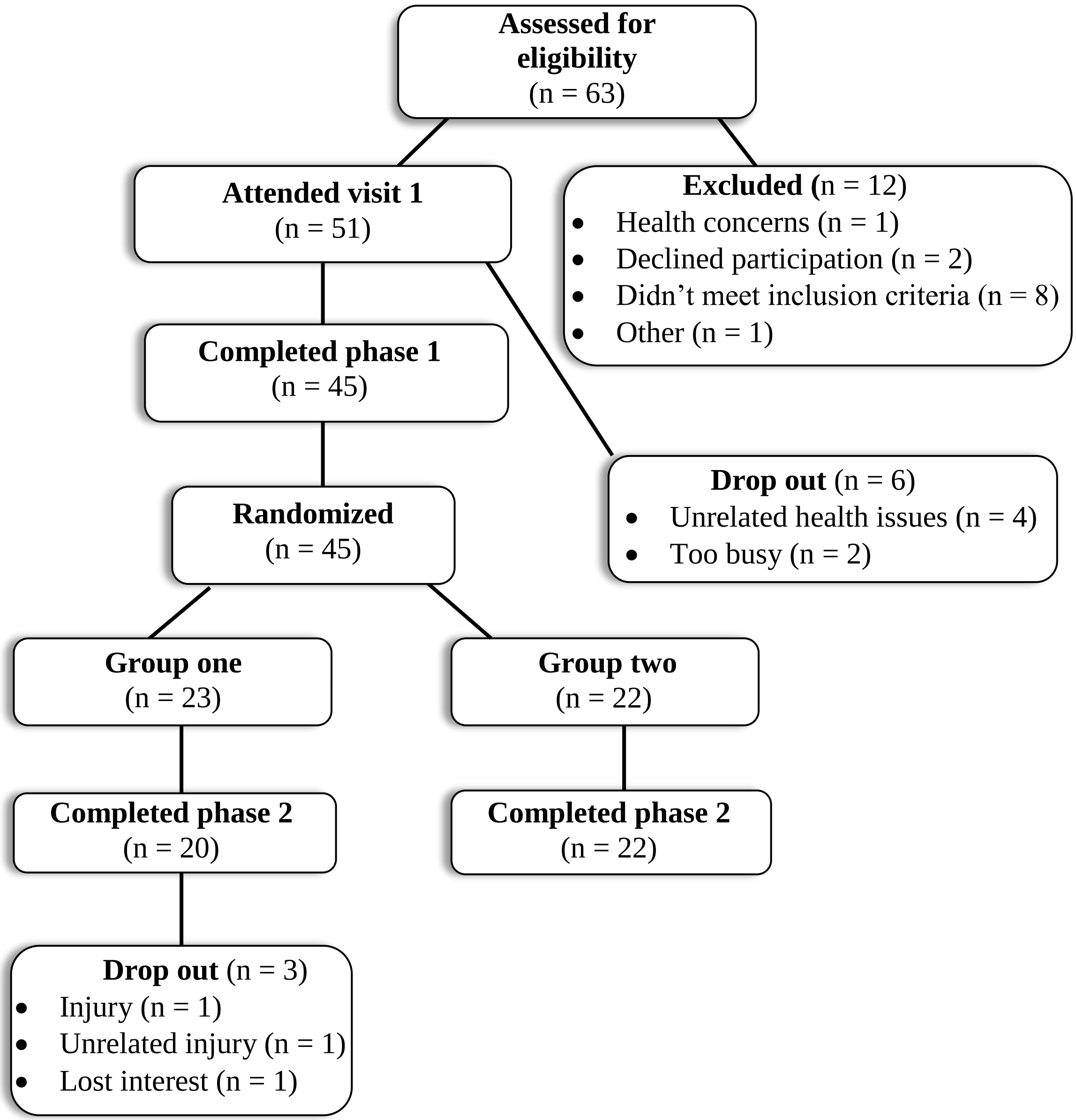
Data represented in mean ± SD or median (25^{th}-75^{th} percentile)
* significant difference ($p \leq 0.05$) between groups
** significant difference ($p \leq 0.01$)
† VO_2 peak was measured at week 6
NEWS: Neighborhood Environment Walkability Scale, BMI: Body Mass Index, VO_2 peak: Peak Oxygen Consumption, MVPA: Moderate to Vigorous Physical Activity

Table 8 shows the characteristics and differences between the two groups based on median change in time spent at MVPA in 10-mintue bouts. The group changing their proportion of time spent at MVPA in 10-mintue bouts equal or above the median has significantly more participants from the group one ($p \leq 0.01$), this group also had a lower score on the physical capacity tests, at baseline, compared to the below median group ($p \leq 0.01$). Lastly, the participants in the same group had a significantly lower VO_2 peak at week six ($p \leq 0.01$).

Completers vs. Non-Completers

A total of 63 older adults contacted us to potentially take part in the study. Fifty-one participants attended the first visit. Figure 2 depicts when participants withdrew from the study and the reason for doing so. As presented in Figure 2, 42 participants completed the study, 20 in group one, and 22 in group two. With the exception of a greater number of median (25-75th percentile) minutes of MVPA in 10-minute bouts at baseline, 10 minutes (0-32) vs. 0 minutes (0-27); ($p = 0.05$) for participants who completed the study ($n = 42$), no other significant difference was observed when compared to participants who did not complete the study ($n = 9$).

Figure 2. Flow Diagram of Participants

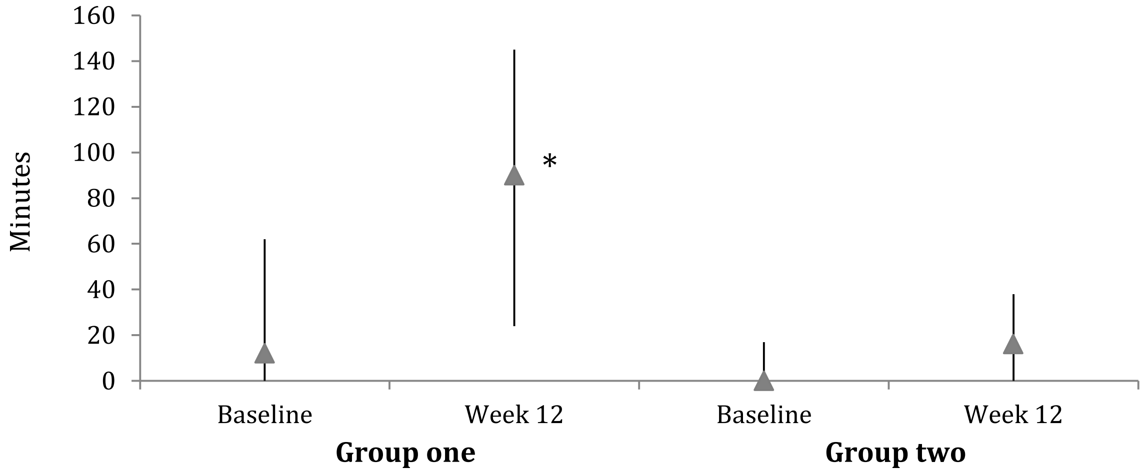


Accelerometer data

The pedometer was the main tool used to implement the intervention and was used to measure the main outcome, but accelerometer data was also collected for seven days at baseline and week twelve to compliment the pedometer information. Figure 3 shows the difference between the groups at baseline and week twelve, regarding the total amount of MVPA in 10-minute bouts completed over seven consecutive days. Similarly to what was observed for the pedometer, at baseline there was no significant difference, but by week twelve group one accumulated significantly more MVPA in 10-minute, compared to group two ($p \leq 0.01$).

Because the pedometer used in the study was not validated previously, correlation between the pedometer and accelerometer was evaluated. When comparing the time spent in MVPA and MVPA in 10-minute bouts there was a significant correlation for both total MVPA ($r = 0.65$, $p < 0.01$) and time in MVPA in 10-minute bouts ($r = 0.73$, $p < 0.01$). A comparison between the pedometer data and a validated cut point for the accelerometer data to identify MVPA in 10-minute bouts was also performed [177] even though this cut point was not validated in an older population. The correlation showed that although total MVPA was not significantly correlated, the time in MVPA in 10-minute bouts was ($r = 0.60$; $p < 0.01$).

Figure 3. Accelerometer 10-minute Bouts in MVPA (individualized cut points)



Data represented in median (25th-75th percentile)
* ($p \leq 0.05$) from baseline to week 12

CHAPTER 5: DISCUSSION

The primary objectives of this study were: i) study if only encouragements to be more active (no specific indication of how to measure intensity) in order to reach the CPAG in terms of aerobic exercise, by walking a minimum of 150 minutes at moderate to vigorous intensity will increase significantly have all participants increase total time in MVPA and 10-minute bouts in MVPA from baseline to week six (phase 1); ii) To study if using a pedometer and an individualized cadence prescription to reach MVPA (≥150 minutes/week) while walking for six weeks (phase 2: week 7 to week 12) will increase total time in MVPA and 10-minute bouts in MVPA, once adjusted for confounders, compared with group two who did not receive any specification of how to identify walking intensity. The results of this study show that, in the short term, it is possible to increase physical activity levels at moderate to vigorous intensity by simply encouraging older inactive adults to walk more. The hypothesis that all participants would see an increase in total MVPA but not in 10-minute bouts of MVPA during this stage was proven wrong as both of these variables did have a significant increase. However, after six weeks, the results of this study suggest that an intervention is needed to keep increasing time walking at moderate to vigorous intensity in order to eventually reach the CPAG. In our case, the intervention was to provide a pedometer that would display walking intensity based on walking cadence.

Four secondary objectives were targeted in this study. First, we wanted to determine if there was a difference in baseline characteristics between the completers and non-completers in the study. Our results show that the only significant difference at baseline was MVPA in 10-minute bouts ($p = 0.05$). Second, we wanted to evaluate if there was a significant change in clinical variables such as VO_2 peak, prescribed cadence, BMI, and physical capacity between weeks six and twelve. Our findings were that BMI and physical capacity had no significant change in either group from week six to twelve, but VO_2 peak significantly increased in group one ($p \leq 0.05$), and prescribed cadence significantly decreased group two ($p \leq 0.05$). Third, we wanted to study what covariates were most strongly associated with change 10-minute bouts between weeks six and twelve, resulting in significant correlations in both VO_2 peak at week six and physical capacity at baseline. Finally, we wanted to validate the physical activity levels recorded from the pedometer by recording the accelerometer from baseline to week twelve, and the results show similar findings in terms of significant changes.

Phase 1

The goal of the first phase was to have participants gradually increase their activity time, at no particular intensity. This was the aim in order to ease participants into activity as they were starting from an inactive state to eventually focus on the intensity. Although the intervention required no designated intensity at this time, time in MVPA was still measured, as this was the main outcome throughout the entire study because reaching at least moderate intensity is associated with greater health and functional benefits [45, 126, 127], and higher intensities are associated with lower mortality rates [84]. This gradual increase in activity is supported by other studies that have found this approach to be less overwhelming for older adults [13, 194]. During this first portion of each phase, participants had a lot of contact with the research staff as this has been shown to lead to greater adherence and adoption of physical activity [134, 195].

At baseline participants were not randomized into groups yet, as this took place at week six, but analysis was run to determine if there were any significant differences at baseline between the two groups. There were not many differences between the two groups, therefore factors such as age, NEWS score, and BMI did not play a significant role in this intervention. This may be due to the fact that the participants in this study were fairly homogeneous with regards to these variables. The age range was only between 65 and 87 years old, the similar NEWS scores indicate that the participants may live in similar types of neighborhoods and therefore have little variation in their walkability scores, and BMI in this study was normally distributed with an average score of 28 $\pm$ 4 kg/m^2 at baseline, which means that most of the participants in this study were classified as being overweight based on their BMI [196]. If there were a wider age variation it is likely that age may have had a more significant influence, as physical activity levels tend to decrease as age increases [20, 197].

During phase 1, participants were asked to gradually work up to walking 150 minutes per week. At baseline the median (25-75th) amount of walking done at moderate to vigorous intensity in 10-minute bouts was only 10 (0-32) minutes per week, and the average total time at this intensity was 100 $\pm$ 61 minutes per week. By the end of phase 1, MVPA time spent in 10-minute bouts almost doubled, reaching 19 (8-53) minutes per week, and total MVPA increased by 17% to 117 $\pm$ 64 minutes per week. Both of these improvements were considered statistically significant. Other studies have completed similar interventions and have shown significant improvements in total MVPA [30, 151], but studies have shown that accumulating MVPA in 10-minute bouts is rare [151, 198]. There are three studies that have similar outcomes for their interventions in older adults, but at this point the results have not yet been published, and only the study designs are available [174, 194, 199]. All of these studies are implementing a three-month walking intervention in older adults so it will be interesting to see how our results compare to theirs [174, 194, 199]. These statistically significant improvements seen during the first six weeks may be attributed to an initial increase in activity based on use of the pedometer, which has been seen in previous studies [13, 30, 161, 162, 200-202]. Another potential reason for this increase could be due to the flexible scheduling that was implemented with high contact during the first week of the study and then the freedom to complete walking on their own schedule in a location of their choice. The high contact at the start has been proven to aid participants in becoming more active [80, 134], and combining this with completing most of the walking on their own schedule can lead to better adherence [58, 130, 132]. At this time all participants were receiving the same intervention, and had not been randomized to group one or group two yet. Even if MVPA time spent in 10-minute bouts increased significantly, no participants were reaching 150 minutes in 10-minute bouts as recommended by the CPAG [9]. Even though reaching the CPAG brings optimal health benefits, Moore et al. [45] has proven that any increase in physical activity can lead to health benefits as achieving 0.1 to 3.74 METs/hour/week, which was associated with brisk walking less than 75 minutes per week, when compared to no activity, was associated with an increase in life expectancy of 1.8 years (95% CI 1.6-2.0). Because the second phase of the study was including a group of participants keeping the same intervention, it was interesting to see if that increase in total and 10-minute bouts would keep increasing or at least remain the same given the small investment to get these older adults to walk more. These findings lead into phase two of the intervention where the CPAG were emphasized for all participants, addressing intensity and 10-minute bouts.

Phase 2

The objective of phase 2 was to introduce intensity of exercise while walking, with two different interventions. During this time the participants were randomly assigned to group one who were provided with information regarding the cadence necessary to reach moderate intensity, and a pedometer and guidance on how to use it to determine if this cadence is being met in 10-minute bouts, or to group two who received the CPAG but had to identify moderate intensity on their own and had their pedometer locked. The benefits that come along with reaching at least moderate intensity are well documented [45, 126, 127], and the CPAG identifies 10-minute bouts at this intensity as the minimum in order to obtain optimal health benefits [128, 139-141]. This phase of the intervention led to significant increases in MVPA in 10-minute bouts ($p<0.01$) and total MVPA ($p<0.01$) for group one. Although the increase for group one was not enough to have the majority of participants reaching the CPAG, they have increased their MVPA in 10-minute bouts from a median of 31 (11 to 55) minutes, to 88 (52 to 143) minutes per week; 2.8 times more than at six weeks. This is especially important when compared to the group two who saw a significant reduction in their median time in MVPA in 10-minute from week six to week twelve. This decrease may be associated with the fact that they had no visual feedback from the pedometer during this time, while the intervention did, and this type of feedback has been associated with increased activity levels [13, 30, 161, 162, 200-202].

There are many factors that influenced group ones increase in MVPA in 10-minute bouts and total MVPA such as the use of the pedometer and its visual feedback, flexible scheduling, practice and guidance on how to walk at the right cadence to reach moderate intensity, and individualized walking cadence prescriptions. These factors are supported by the current literature, but to our knowledge this study is the first to incorporate them all into a walking intervention with the goal of increasing MVPA time in 10-minute bouts for inactive adults.

Pedometer

The pedometer has been proven in multiple studies as an effective device for increasing physical activity levels [13, 30, 161, 162, 200-202]. The majority of these studies had a main outcome of increasing the total number of steps taken which is a measure of increasing physical activity levels but does not take into consideration the intensity at which the steps are taken. For a purchase price of about $30, the pedometer used in this study was capable of recording much more than just the number of steps taken, most importantly for this study it was able to record time spent in moderate to vigorous intensity based on walking cadence, the number of 10-minute bouts accumulated in moderate to vigorous intensity each day, it can be individually programmed for cadences needed to reach moderate and vigorous intensity, and it has a memory of at least 14 days [31].

Plenty of studies that have used other pedometers as intervention tools, and these studies support that using the pedometers and receiving the instant visual feedback from them can lead to an increase in physical activity levels and motivation [13, 30, 161, 162, 200-202]. Some of these studies indicate that the effects of the pedometer may only be influential during the short term and that in order to see greater improvements goal setting should be included [30, 161, 162]. This might explain why we observed an increase in total MVPA and MVPA in 10-min bouts during the first phase on the study but not in the second phase for the group two.

These findings are similar to those of Clemes et al. [201], and Marshall [202], who both found that when comparing groups who received feedback to those that did not receive the instant visual feedback from the pedometer, the feedback groups in both studies significantly increased their physical activity levels based on total step counts, suggesting that instant feedback has a positive influence on physical activity levels. Although the outcome measures from these studies are not exactly the same as our main outcome, they all support the use of pedometers as a tool to increase physical activity. Interestingly, when total step count was looked at in our study, although this was not a main outcome, group two saw a significant decrease from week six to week twelve ($p \leq 0.05$) which aligns with the decreases seen in total MVPA and time in MVPA in 10-minute bouts, but group one did not see a significant change in total steps. This means that although group one increased both total MVPA and MVPA in 10-minute bouts in phase 2 of the intervention, they did this without significantly increasing the total steps taken. These findings are similar to a recent study by Barreira et al. [203] that that aimed to increase steps per day. In this study there were no significant difference in the change in total steps per day when comparing the control and intervention group, but similar to our findings, the intervention group accumulated more steps at higher cadences [203].

Flexible schedule

Providing a study that had some contact and some freedom to do the activity on your own may have provided a good balance to increase total MVPA and MVPA in 10-minute bouts. Previous studies have shown that having contact with participants can lead to greater adherence to the physical activity intervention [134], and it can also increase self-efficacy, and low self-efficacy has been associated with decreased adherence [80]. All participants in our study, regardless of the group received the same amount of contact; three testing visits, six walking visits, and one final walking visit. Even though there were 10 visits required in this study, the majority of the activity was not completed with the research staff, and participants had the flexibility to do their walking whenever and wherever they wanted to throughout the week. By doing this we hoped to have the benefits provided through high contact as mentioned previously [80, 134], but also wanted to use predominantly a home-based program as these types of programs have been shown to have better adherence [58, 130, 132]. Home-based programs have also been identified as a necessary component to any intervention in order to have lasting effects [130], which should be the goal of any intervention.

Guidance on how to achieve moderate intensity

As is shown in some of the recent studies on walking cadence in older adults, that group of people are able to achieve cadences $\geq$ 100 steps per minute [26-28], but when their activity levels are monitored during free living, these cadences are not achieved very often [28]. In our study it was found that the average cadence required to reach moderate intensity for group two was 112 $\pm$ 9 steps per minute, and by the end of the intervention they were spending a median of 88 (52-143) minutes per at this cadence in 10-minute bouts, which was a significant improvement from week six ($p \leq 0.01$). These findings indicate that achieving these higher cadences is possible. Participants in group one were not only told what cadence they needed to walk to reach moderate intensity, but they also walked at this cadence with research staff at three different visits and learnt how to use the pedometer, which provided instant visual feedback on whether this cadence was being achieved every ten consecutive minutes. The idea of practicing the appropriate walking cadence has been proven effective at being able to walk at this speed again as was shown in a study done by Rice et al. [204]. Participants in this study were randomly assigned to two different groups, one only received information regarding physical activity recommendations, whereas the other group also had one practice session walking at moderate intensity based on 55 to 70% of predicted HR max for ten minutes [204]. Interestingly enough, when participants returned one month later and were asked to walk at moderate intensity, measured by research staff based on achieving and maintaining 55 to 70% of their predicted HR max, those who had the one practice session were more successful at achieving and maintaining this intensity for at least ten minutes ($p \leq 0.05$) [204].

Benefits of individualizing walking cadence prescriptions

METs are a common absolute measurement of exercise intensity that are frequently used in the literature with a threshold of reaching 3 METs being equivalent to achieving moderate intensity [22-25, 150-152]. By default one MET is equal to 3.5 ml/kg/min [153]. Thus, reaching 3 METs is equal to 10.5 mL O_2/kg/min [153] by default. Although METs are a commonly used measurement, they provide no adaptation for individual differences in CRF levels. It is well known that CRF will reduce with age [89] and the number of METs to reach moderate intensity should be adjusted as recommended by the ACSM [38], but studies on walking cadence are ignoring that fact when using 3 METs for all [22-25]. Therefore, prescribing 3 METs to everyone, regardless of their maximal CRF level and age does not offer the most valid prescription. For example, if two different people with different CRF levels perform the same task, the individual who has a lower CRF level will be working at a higher percentage of their CRF level in comparison to a person with a higher CRF level. This will result in different intensities being achieved, and potentially create a difference in the health benefits being achieved with the same exercise. Using a relative measure of CRF, such as 40% VO_2R [38], to prescribe intensity may be more favorable since this takes into consideration the individuals characteristics and maximal CRF level.

The literature on walking cadence to date has used reaching 3 METs as a threshold for reaching moderate intensity [22-25, 30], and this has resulted in general prescription of walking 100 steps per minute to achieve moderate intensity [22-25]. In our study a relative prescription method based on VO_2R was used, and a greater cadence was identified to reach moderate intensity (114 ± 11 steps per minute) even if the sample was older than most previous studies. The walking cadence prescribed in this study to reach moderate intensity was based on the cadence required while walking on an indoor flat surface when reaching 40% VO_2R, determined based on the VO_2 peak measured during the maximal CRF test. With this information we were able to determine the equivalent METs being used for each individual when they reached 40% VO_2R (ml/kg/min ÷ 3.5), and based on the cadence needed to reach 40% VO_2R, we were able to calculate the cadence that would be equivalent to reaching 3 METs for each participant. When converting our median cadence to reach moderate intensity to a cadence equivalent to reaching 3 METs, 105 ± 17 steps per minute was the average. It is also interesting to note that if the prescription of 100 steps per minute would have been used in this population only 14% of the participants would have reached moderate intensity, when the prescription was based on 40% VO_2R. When the cadence prescribed at 40% VO_2R was compared to the estimated cadence based on reaching 3 METs using a Wilcoxon test, there was a significant difference ($p \leq 0.01$), indicating that prescribing a relative measure of moderate intensity will lead to the need to achieve a higher cadence to reach moderate intensity while walking. Our analysis shows us that moderate intensity based on 40% VO_2R has participants achieving about 3.4 METs compared to the typical 3 METs that are often prescribed [22-25, 30]. It is important to note that even the difference is only 0.4 METs, it was significantly different and it is likely that the discrepancy between 3 METs and the METs required to reach 40% VO_2R would be larger in younger samples because CRF levels decrease with age [89]. Studies on older adults support that a cadence of approximately 100 steps per minute it equivalent to reaching 3 METs [26-28], which is similar to our findings were when average cadence at 3 METs was calculated it was 105 steps per minute, but whether this is truly reaching moderate intensity is debatable as these same studies have found that older adults self-select cadences higher then this, even when asked to walk at a slow pace [26-28].

Both the estimated VO_2 max and the estimated cadence based on the estimated VO_2 max were significantly higher ($p \leq 0.01$) than the measured VO_2 peak (24 ± 6; 25 ± 6) and prescribed walking cadence (114 ± 11; 121 ± 16). Therefore it can be interpreted that if these older adults were to be prescribed a walking cadence based on their true maximum aerobic capacity, it likely would have to be even higher than the cadence that was prescribed in this study, and much higher than the commonly prescribed 100 steps per minute.

Changes in clinical variables

In our study, clinical variables such as VO_2 peak, prescribed cadence, BMI, and physical capacity were measured. In phase 1, only BMI and physical capacity were measured and no significant improvement was observed. In phase 2, no difference was observed in most of the variables, but VO_2 peak increased in group two. Although it is proven that endurance exercise training in older adults can lead to similar increases in VO_2 max as younger adults [205], and an increase is seen in group one during the second phase of this study, it is important to recognize that this may be due to factors other than simply increased aerobic capacity. Familiarization with exercise protocol has been proven to impact results [206], although in this study both groups had the same number of tests and familiarization sessions on the treadmill. This difference could also be attributed to the fact that group one likely worked at a higher intensity during phase 2 of the intervention and therefore felt more confident pushing harder in their final CRF test. When VO_2 peak values were compared at week 12 between the two groups using a Mann-Whitney test no significant difference was observed, but because this test does not take into consideration the VO_2 peak values at week 6 it is still important to recognize the difference that is presented based on the percent change over this six week period.

In a systematic review on interventions done with pedometers to increase physical activity levels, an average significant decrease in BMI ($p = 0.03$) was observed among these studies [162], which is interesting when compared to our study were no significant difference was found. Some of the main differences between the studies in this review and our study were the main goal, theirs was to increase total step count whereas ours was focused on time and intensity, the average intervention length was 18 weeks, compared to our which was only 12 weeks, and the average age in these studies was about 20 years younger than ours [162]. Physical capacity scores were the total scores of whether the norm, based on age and gender, was met for eight different tests. The issue with this method is that some of the tests are more strongly related to walking then others, for example the chair stand is to measure lower body strength and the 6-minute walk is for aerobic endurance [6], both closely associated with the goal of trying to increase walking, whereas tests that were included such as the arm curl for upper body strength and the back scratch for upper body flexibility [6] may not be as significant in influencing the main outcome of this study. It has been shown that increasing the distance of a 6 minute walk test by as little as 20 meters can lead to a meaningful change in physical performance measures [207], therefore in an attempt to display an overall picture of the participants' physical capacity by combining all the scores, this may have minimized the association between certain tests and our main outcome.

The positive health outcome that was seen in this study was group ones improved VO_2 peak scores from week six to week twelve ($p = 0.02$), indicating an increase in CRF levels. This is impressive to find after only six weeks of an intensity intervention because these results in the older population prove that regular aerobic physical activity can help to decrease the age related decline in maximal aerobic capacity [89] which in turn helps to sustain functional capacity [55], preserve bone mass [20], and lead to a decreased risk for the many chronic diseases that are associated with physical inactivity [3, 41]. A decrease of about 10% of maximal aerobic capacity per decade happens with age if an individual is sedentary [89], but if an active lifestyle is maintained this decrease can go down to only a 5% decrease per decade [89]. These findings are supported by some of the exercise interventions that have been done on an older population as they have shown increases in VO_2 peak of 8.5% [208], and 8.4% [209], compared to the 9% increase we saw. It has also been shown that longer interventions on this population align with these results, and even more substantial improvements in VO_2 peak are possible [210]. Even with the significant increase seen in VO_2 peak in phase 2 in group one, the prescribed cadence did not increase, suggesting that more than 2ml/kg/min is needed to change the prescribe cadence to reach moderate intensity when established based on 40% of VO_2R.

The increase in VO_2 peak values seen in group one from week six to week twelve ($p = 0.02$), are consistent with the findings of Posner et al. [208] where a significant increase ($p \leq 0.01$) in VO_2 peak was also seen in the intervention group after a 16 week low to moderate intensity exercise program when compared to the non-exercise control group. The meta-analysis done by Huang et al. [211] also supports that it is common to see a significant increase in VO_2 peak in previously sedentary older adults in the intervention group, and not in the control group after an exercise intervention. It is believed that a VO_2 max of about 20 ml/kg/min is the minimum in order to live and independent lifestyle [211], therefore finding simple ways to increase an individuals VO_2 peak is important in order to be able to support functional ability and independence. Based on the VO_2 max norms that are based on age and gender, provided by the Physical Fitness Specialist Manual [212], 43% of the participants at week six were reaching or surpassing the fair category, showing that the majority of the participants in this study could use an improvement. When VO_2 peak scores at week six are compared to the minimum requirement for maintaining an independent lifestyle [211], 24% of the participants were below this threshold, but by the end of the study this percentage dropped to 14% which is representative of the clinical significance this intervention had on VO_2 peak and therefore CRF. This information is quite representative of the type of participants that we tried to recruit for this study because they had to be in fairly good health in order to pass the PAR-Q+ questionnaire which explains why most have a VO_2 peak equal to or greater then that associated with being able to function independently [211], but they were also required to be inactive at the start of the study, so seeing low VO_2 peak values was not surprising.

Completers vs. non-completers

Most of the characteristics at baseline; age, sex, education, NEWS score, total MVPA, total steps, BMI and physical capacity, when comparing participants who completed the study and those who did not, did not have a significant difference. The only variable that was significantly different ($p = 0.05$) between these two groups was the number of minutes of MVPA in 10-minute bouts at baseline. At baseline the completers had a median time of 10 minutes (0-32) per week, while the non-completers had a median of 0 minutes (0-27) per week. The study started with 51 participants, who all completed their first visit and were eligible to continue, 42 participants completed the entire 12-week intervention which means there was approximately an 18% drop out rate. Previous studies that implemented a 12-week walking intervention saw dropout rates of only about 5% [30, 138], which is lower than the rate that we saw in our study. These studies were both done on a younger population [30, 138], which is interesting because it has been shown that adherence to exercise prescriptions in older adults is usually higher than in a younger population [213]. Gender may have played a role in dropout rates because although there was a smaller number of men that participated in the study, they had a 24% decrease from baseline to week twelve while participation by women decreased by 15%. Some other factors that can influence older adults adherence to an exercise prescription are the level of fitness at baseline, history of having a physically active lifestyle, and the level of exercise self-efficacy [213]. The last two points were not measured during our study, but the level of fitness was measured for all participants at week six, and this may give some insight into why there was more drop out in the intervention group. Higher fitness levels are associated with better adherence to exercise prescriptions [213], and in this study when CRF was measured at week six it is evident that group two had a significantly higher ($p = 0.05$) VO_2 peak than group one, and this could be a reason that no participants dropped out from group two during phase 2, and there was a 13% drop out rate in group one during the same time period.

During the entire intervention there was only one participant that dropped out due to an injury from walking. This participant was in group one and sustained a sprained ankle during the second phase of the intervention, when the intensity target was implemented. It could be hypothesized that the intensity prescribed was too high and that this may have led to the injury, but the walking cadence prescribed at week six was based on 40% VO_2R and was 105 steps per minute. This cadence is on the lower end of the prescriptions given, as the average cadence to achieve this intensity based on all participants was 114 ± 11 steps per minute. In addition, the chosen normal cadence was measured at baseline, and this typical walking cadence was 102 steps per minute. Based on these facts, the walking cadence prescribed appears to be accurate and achievable, and the injury, although unfortunate, is not an uncommon form of injury for this population [214]. In fact, Statistics Canada reports that 55% of the injuries that occur in seniors take place during walking or household chores, and strains or sprains are the most common type of injury despite age classification [214].

Who is more likely to increase MVPA in 10-minute bouts?

An influential variable for determining whether participants were reaching the median change in MVPA in 10-minute bouts from week seven to week twelve was the group ($p = 0.04$), with a higher proportion of participants in group one reaching the median. These findings support that the intervention was making a significant difference and this intervention should be tested on a longer term and add measures of health and function. This is also supported based on the results that 9 of the 10 people achieving $\geq$ 100 minutes of MVPA in 10-minute bouts at the end of the study were from group one. This result is encouraging because although the CPAG are not being fully met, this amount of activity for these participants increased from 75 ± 63 minutes per week to 142 (131-177) minutes per week, which is a significant increase ($p \leq 0.01$). Any increase in activity is beneficial and is associated with health benefits, especially when starting from an inactive level [81, 82]. The CPAG recommends reaching 150 minutes of moderate to vigorous physical activity per week, but they also state clearly that every little bit of activity counts, but more is better [33]. In addition, research has shown that as little as one hour of walking per week, at as little as a light to moderate intensity, can be associated with lowering cardiovascular disease mortality [83]. This supports that an increase in MVPA in this intervention can be seen as a significant accomplishment for these participants, and these improvements were achieved over a period of only twelve weeks, with only six of those weeks focusing on intensity. Therefore with a longer intervention these results have the potential to increase even further and might be sustainable because of the nature of the activity. During this intervention it is also possible that any increase in walking time could have improved participants' health and decreased risk of all-cause mortality [215].

Some of the advantages to this intervention are that it was fairly low cost, and did not require substantial resources. The use of pedometers as the main tool for the intervention is a cost effective strategy. The only costly component to this study was the maximal test, as these require not only the metabolic cart, but also a CEP to administer the test. Although both groups received the same information regarding the CPAG, and both had the same number of testing and walking visits, the data shows that the extra information regarding the cadence needed to reach moderate intensity, and having the pedometer as a tool to help them achieve the correct speed, aided in group ones ability to increase MVPA in 10-minute bouts. These findings are similar to those found by Marshall et al. [30]. In this study there were three different groups who all received different step goals; the first group was a self-selected goal, the second was a goal of accumulating 10,000 steps per day, and the third group was a goal of walking 3000 steps in 30 minutes [30]. This was also a 12-week intervention that resulted in the group who was prescribed walking 3000 steps in 30 minutes, which is equivalent to walking 100 steps per minute, significantly increasing their MVPA in 10-minute bouts as compared to both of the other two groups ($p \leq 0.01$) [30].

One of the limitations to this study is that the intervention tool was a pedometer, but the tool used to measure the outcome was an accelerometer at baseline and at week twelve [30]. To address this issue we used the pedometer as the main tool for intervention and analysis. Although we did collected accelerometer data at the beginning and end of the study, the pedometer was used for the main outcome because this pedometer has the ability to record time spent in moderate to vigorous intensity, as well as the number of 10-minute bouts accumulated at this intensity each day [31], which is more information than many other pedometers provide. The accelerometer data was used to verify that the similar changes occurred between the two devices, but based on being able to set the pedometer to the individualized cadence necessary to reach moderate intensity, this information was more reliable for measuring the outcome we were looking for. These two devices were evaluated for their correlation to see how accurately the pedometer measured MVPA in 10-minute bouts. The correlation for 10-minute bouts in MVPA was fairly strong, but not as great for total MVPA. This suggests that both devices detect 10-mintue bouts fairly consistently, but the pedometer may not pick up as much of the movement as the accelerometer for the total MVPA values. This could be because the pedometer most accurately measures only ambulatory movement [31] whereas the accelerometer is more sensitive to other movements as well. These results will have to be confirmed with a validity study in the future.

Similar to Marshall et al. [30], Ayabe et al. [151] also prescribed a cadence of either 1000 steps in 10 minutes or 3000 steps in 30 minutes, both equivalent to 100 steps per minute, and found that these prescriptions increased total MVPA time, but did not see the same increase in MVPA in 10-minute bouts that were seen in our intervention. Both of these studies align with our results in finding that using a pedometer as a tool, along with a walking cadence to reach moderate intensity, resulted in increasing MVPA time [30, 151]. The results of the study by Ayabe et al. [151] show that bouts of 10-minutes are not being achieved, and based on our baseline data this is found to be true, even in group two at the end this is still evident, which emphasizes that the intervention used in our study had an important impact on increasing MVPA in 10-minute bouts because group one saw a median increase from 7 (0–39) minutes at baseline to 88 (52-143) minutes at the end of the intervention. Bouchard et al. [13] also carried out a walking intervention in an inactive older population, in this study different tools were used by the participants, and although the difference in time spent at moderate to vigorous intensity was not significant between the groups at the end, the pedometer was the favored tool, supporting that this tool is a good choice for this particular population.

Another factor that was significantly different between the groups was VO_2 peak values. This data shows that people with a lower VO_2 peak when starting phase 2 were more likely to see a change in MVPA in 10-minute bouts. This is interesting because, it could have been hypothesized that older adults with a better VO_2 peak at start would have respond positively to the intervention. However, it is well documented that those starting from a lower fitness level are likely to see more significant improvements from increasing activity levels as it is proven that the greatest improvements in health are seen in the initial stages when sedentary individuals become active [81, 82]. The difference that becomes evident between groups one and two could be attributed to more successfully reaching moderate intensity because with the extra guidance on how to achieve this intensity group one was more successful at achieving moderate to vigorous intensity in 10-minute bouts, and reaching this intensity is associated with improved health and functional capacity [45, 126, 127], and this intensity influences mortality risk based on its strong association with CRF [45, 126, 127].

Physical capacity was significantly different between the two median groups ($p \leq 0.01$) and remained significant in the logistic regression model, showing that the group with a greater median percent change in MVPA in 10-minute bouts had a lower physical capacity level at baseline. This implies that the intervention is achievable for individuals with a lower physical capacity level which is an important population to target with this type of intervention because increases in CRF are associated with improved physical capacity [55].

One factor that was not controlled for when randomizing participants into groups was education level, and there was a significant difference between the two groups ($p \leq 0.05$), with group one having more participants with a college or university education. This is important because education level is associated to an individual's socioeconomic status [216] and knowledge about health [217], which has the potential to influence motivation, understanding, and compliance to the intervention. However, the education level did not play a role in the proportion of change in MVPA in 10-minute bouts.

Four weather conditions were tracked throughout the 12-week intervention, temperature, humidity, humidex, and precipitation. Out of all of these factors only one that had any significance on the main outcome of increasing MVPA in 10-minute bouts was the humidity measured at week twelve. Table 5 shows the changes in weather that occurred between week six and week twelve of the intervention, comparing the two groups. During this time both groups saw significant decreases ($p \leq 0.01$) in all aspects, as the seasons started to change, the only variable that did not see significant decrease was the humidity for group one. These findings may help to explain why humidity at week twelve was the only weather factor that had a significant correlation ($r = 0.37$; $p = 0.02$) with change in MVPA in 10-minute bouts from week six to week twelve. Although this correlation does not remain significant when comparing group one and group two, when comparing the median groups higher humidity is associated with being in the above the median group ($p = 0.001$). Previous research has shown that weather can impact physical activity levels, and that poor weather can be seen as a barrier to being physically active [64]. It is also shown that due to this seasons can impact activity levels, with peak activity usually taking place during the spring and summer seasons (April to August) [64]. These findings could help to explain why the higher humidity at week twelve was associated with being in the group above the median for percent change in MVPA in 10-minute bouts, because the intervention went to the end of October for some, therefore higher humidity during this time may have been associated with warmer and more enjoyable conditions to walk in.

Limitations

One of the limitations for this study is the sample size, because it's a small group the effects, whether positive or negative, may appear more significant than they are because every individual has a larger impact when there are fewer participants. This is also the reason that non-parametric tests for statistical analysis had to be used, because the sample was not large enough to have the data normally distributed. Based on this it is important to recognize that the results should only be generalized to a similar population.

A power calculation was not done in order to determine the number of participants for this intervention. This is a limitation to our study, but this would have been challenging because there are no studies done previously that implemented this type of intervention in older adults. 50 participants as the recruitment goal was the largest sample that would be possible based on budget and available resources. With a final number of 42 participants completing the study, this still represents the largest sample of older adults recruited to identify if an intervention based on walking cadence, using individual cut-points can help increasing the weekly total time and 10-minute bouts spent weekly.

Not measuring maximal aerobic capacity at the beginning of the study is a limitation. The reason this was not done is because aerobic intensity was not being addressed until week six of the intervention, and to save on cost. However, this provides some challenges because there will not be a comparative individualized cadence for participants from baseline. Pedometer MVPA time at baseline was adjusted using the equation related to their prescribed cadence at week six. Fortunately the accelerometer data that was collected at baseline was able to support the trend in physical activity levels between the two devices. Even though the minutes in MVPA in 10-minute bouts were not identical between the accelerometer and pedometer, they were significantly correlated It was also shown that time in MVPA in 10-minute bouts was significantly correlated with an accelerometer when using a valid cut point [177], helping to support the validity of this measure.

Because the prescription for moderate intensity in this study was based off of the VO_2 peak from the CRF test at week six, a concern could be that participants may not have reached a true maximum and therefore their walking cadence prescription would not truly have them reaching moderate intensity. This can be disputed by the data presented regarding the average walking cadence and METs achieved based on prescribing 40% VO_2R. The average prescribed walking cadence was 114 $\pm$ 11 steps per minute which was equivalent to reaching 3.4 METs, and both of these values surpass the standard 100 steps per minute and 3 MET guidelines that are currently in the literature [22-25, 30]. This argues that not only did the CRF tests give a good indication of aerobic capacity, but also prescribing moderate intensity based on the relative measure of 40% VO_2R is an effective way to have individuals reaching an appropriate intensity to gain optimal health benefits. It is also important to recognize that when two-point estimation was used to see what the estimated VO_2 max would have been, and the corresponding cadence, both of the estimations were significantly higher than the data based on VO_2 peak. The VO2 peak compared to the estimated VO2 max was about one ml/kg/min higher which was statistically significant ($p \leq 0.05$), and the walking cadence that was prescribed was 114 $\pm$

11 step per minute compared to the estimated value of 121 ± 16 ($p \leq 0.01$). This shows that if participants would have reached closer to their maximum aerobic capacity the prescribed walking cadence would have been significantly higher then what was prescribed, but even more so it would have been about 20% higher than the typically recommended 100 steps per minute. It should be noted that this walking prescription was not based on cadence on the treadmill, it was prescribed using a portable metabolic cart so that walking took place on an indoor flat surface, in hopes of prescribing the most accurate cadence possible.

The cadence on the pedometer can only be set by every five steps which caused us to round the walking cadence prescriptions, therefore they were not as accurate as they could have been, but they are still the first relative walking cadence to be prescribed. Pedometers also do not account for differences in terrain which can impact the difficulty and cadence of walking, and they are not able to adjust for different loads, for example if someone is carrying a heavy bag this will impact their walking but will not be reflected in pedometer data. Lastly, pedometer data was used from all days that it was supposed to be worn; unlike the accelerometer there is no measure of non-wear time or a standardized threshold for valid days.

Accelerometer data was not used as the main outcome because although the accelerometer is more validated in the literature than the Piezo Step pedometer [175, 177], the accelerometer was only used to measure physical activity levels at baseline and week twelve. This is a problem because the randomization into different groups, and the true intervention started after week six, so the accelerometer data does not give a true representation of the interventions effects from week six to twelve. Based on the literature it is also known that the use of different cut points on the accelerometer can make a large difference in the outcome of the data, and therefore how it is interpreted [178, 179]. In order to try and determine the most accurate cut point for the accelerometer on this population, the cut point at 40% VO_2R was used to determine time spent in 10-minute bouts of MVPA, and total time in MVPA. Once the individualized cut points were determined based off of the walking cadence at 40% VO_2R, a correlation between the individualized cut points for each participant and their VO_2 peak, as well as their prescribed walking cadence was run. Both of these tests resulted in significant correlations with the VO_2 peak at week six having a correlation of $r = 0.78$ ($p \leq 0.01$), and the prescribed walking cadence $r = 0.68$ ($p \leq 0.01$), demonstrating that this individualized approach may be a good strategy when using the accelerometers.

Physical capacity was measured based on the SFT and the unipedal stance tests from the CSEP protocol, and whether the norms, based on age and gender, for each test were met was scored for each participant. These scores were then totaled and used as comparison of physical capacity. It is possible that some of these tests may be more strongly correlated with increasing MVPA in 10-minute bouts, and that combining all the tests may take away some of the significant effect these tests could have had. The reason for doing this was because all of these tests give an overall representation of physical capacity, which encompasses more than just being able to walk, so utilizing them all seemed the most logical.

It also must be taken into consideration that typically activity increases in the summer months, so although participants are inactive when starting the intervention we do not have information regarding their activity levels the previous summer, so there is a chance that they would have become more active over the summer even without the walking intervention.

Another limitation that should be addressed is the education level difference between the two groups. Group one had a higher education level in comparison to group two, and this has the potential to impact the study because education level is associated with an individuals socioeconomic status [216] and knowledge about health [217]. These factors have the potential to influence the participants motivation for the physical activity intervention and therefore potentially their compliance as well. However, when statistical analysis was performed, although there was a significant difference between the groups based on education level, this did not play a role in the proportion of change in MVPA in 10-minute bouts.

Finally, all participants were volunteers and this is a limitation because they are likely more motivated than a non-volunteer population [195]. It has been shown that women are more likely to volunteer than men [218], which may be a reason for the gender difference in our study. Although this could be seen as a limitation as 71% of the participants were women, when running the analyses, gender was controlled for and did not present itself as being a significant factor related to walking in MVPA or accumulating time in MVPA in 10-minute bouts.

Impact of Research

This research is novel based on the fact that it was a randomized balance design intervention, participants received an individualized cadence based off of their own maximal CRF test, not a standard prescription, and participants in group one received instant visual feedback from the pedometers on their ability to reach moderate to vigorous intensity, which has never been done before. This research has the potential to impact the large number of older adults who are currently not reaching the CPAG with an intervention that does not require extensive resources. This study shows that this intervention, using a simple tool such as a pedometer, can help older adults to increase the proportion of time they spend walking in moderate intensity in 10-minute bouts, and this increases their opportunity for achieving the aerobic component of the CPAG.

Conclusion

This intervention shows that the use of a prescribed walking cadence along with the knowledge of how to achieve this cadence and being able to track time at this intensity with a pedometer can lead to an increase in physical activity levels. This intervention shows that the impact of having practice walking at the correct cadence, along with the ability to receive instant visual feedback regarding whether this cadence is being accurately achieved makes a large impact on whether total MVPA time, MVPA in 10-minute bouts, and VO_2 peak increase. These findings were made apparent based on the difference that was shown between the two groups from week six to week twelve, as well as by the fact that the group was a significant variable in having a change in time in MVPA in 10-minute bouts. Another important finding is that people with a lower VO_2 peak and lower physical capacity were more likely to improve their time spent doing MVPA in 10-minute bouts following this intervention.

The next steps for this area of research would be to validate the pedometers providing feedback on moderate to vigorous intensity in older adults, and develop an algorithm to predict the needed walking cadence to reach moderate intensity to avoid having to use a metabolic cart to individualize the walking cadence needed to reach moderate intensity.

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Appendix A: Advertisement

Research Study

Are you walking fast enough to optimize your health?

UNIVERSITY of MANITOBA

Health, Leisure & Human Performance RESEARCH INSTITUTE

Are you older than 65 years old and interested in taking part in a walking program as part of a research study?

We want to help you get active and successfully reach the Canadian Physical Activity Guidelines

- Meet with exercise professionals for free
- Get a fitness and health assessment for free
- Increase your physical activity level

You are eligible if:

- 65 years or older
- Agree to increase physical activity
- Doing less than 150 minutes of organized exercise per week

Interested?

Contact Jana Slaght

204-474-7878 or slaghtj@myumanitoba.ca

The Education/Nursing Research Ethics Board, University of Manitoba, has approved this research. If you have any concerns or complaints about this project you may contact the Human Ethics Coordinator (HEC), Margaret Bowman at 204-474-7122, or margaret.bowman@umanitoba.ca.

Appendix B: Personal Feedback

UNIVERSITY OF MANITOBA

Health, Leisure & Human Performance
RESEARCH INSTITUTE

Personal Measures

Canadian Physical Activity Guidelines – Walking Intervention
Summary of Results

Hello______,

Thank you again for participating in our study! Your contribution is greatly appreciated and highly valuable to the overall findings. You will receive information on the results on the study as soon as they are available. The following document consists of your personal results.

On the following page you will find the current Canadian Physical Activity Guidelines as set out by the Canadian Society of Exercise Physiology. You will notice that they encourage people to participate in aerobic exercise at a 'moderate to vigorous' level of intensity, to determine your moderate intensity we measured your maximal oxygen consumption during the treadmill test. After measuring your maximal oxygen consumption we were able to calculate 40% of this and determine the number of steps per minute (cadence) you need to take in order to reach moderate intensity.

Based on your results, in order to reach:

- Moderate intensity when you walk, your cadence should be ___
- Vigorous intensity when you walk, your cadence should be ___

On behalf of everyone involved in the study, I would like to thank you once again for choosing to participate. Hopefully you are able to take the following information and continue reaching the Canadian Physical Activity Guidelines. If you have any concerns with your personal measures, please contact your family doctor. For any questions directly involved with the study, contact myself at (204) 474-7878, or slaghtj@myumanitoba.ca.

Sincerely,
Jana Slaght

Height (m):

Weight (kg):

Start: End:

Body Mass Index (kg/m^2):

Start: End:

The optimal BMI is between 18.5 and 25.0 to avoid health related conditions.

Waist circumference (cm):

Start: End:

To maintain a low risk of poor health, your waist circumference should be lower than 88 cm for women and lower than 102 cm for men.

Body Fat Percentage:

Start: End:

A range of 10-22% for men and 20-32% for women is considered as satisfactory for health.

Blood Pressure (mmHg):

Optimal blood pressure is below 120/80 mmHg to avoid heart diseases. It's important to note that we only measured your blood pressure at one point in time. You might want to take it several times in a week to see a more accurate, consistent pattern.

Heart Rate at Rest (bpm):

The lower is the better as the heart will need to pump fewer times in a minute to deliver the required blood. The average for an adult is 73 bpm.

Maximum VO_2:

Week 6: Week 12:

Maximum VO_2 reflects the capacity of the heart, lungs and blood can deliver oxygen to the working muscles during exercise. A good VO_2 max score for women is 27-31 while men's is 31-38.

** Should you have any concerns regarding any of the information, please consult your doctor.

Personal results throughout the study compared to the norm within age range.

	Norms (age)	*Baseline Data*	*6 Week Data*	*12 Week Data*
6 min Walk (m)				
30 sec Chair stand (reps)				
30 sec Arm curl (reps)				
Chair sit & reach (cm)				
Back scratch (cm)				
8 foot up and go (sec)				
Single leg balance: eyes open (sec)				
Single leg balance: eyes closed (sec)				

Appendix C: Phase 1 activity tracker

Activity Tracker - Phase 1

Contact Jana Slaght with any questions

slaghtj@myumanitoba.ca

204-474-7878

Please record the time you spend active every day.

There is room for you to record up to three activities each day. This does not mean you need to do exactly three, you can do more or less, just record the activity you do, and remember you are trying to walk 150 minutes per week.

Please record your activity in the correct week. There are six weeks to record activity. Week one starts when you have your first scheduled walk at the University of Manitoba.

Thank you for your participation! Have fun walking!

Week 1:

	Activity 1	Activity 2	Activity 3
DAY 1			
Name of activity			
Duration			
DAY 2			
Name of activity			
Duration			
DAY 3			
Name of activity			
Duration			
DAY 4			
Name of activity			
Duration			
DAY 5			
Name of activity			
Duration			
DAY 6			
Name of activity			
Duration			
DAY 7			
Name of activity			
Duration			

Week 6:

	Activity 1	Activity 2	Activity 3
DAY 1			
Name of activity			
Duration			
DAY 2			
Name of activity			
Duration			
DAY 3			
Name of activity			
Duration			
DAY 4			
Name of activity			
Duration			
DAY 5			
Name of activity			
Duration			
DAY 6			
Name of activity			
Duration			
DAY 7			
Name of activity			
Duration			

Week 3:

	Activity 1	Activity 2	Activity 3
DAY 1			
Name of activity			
Duration			
DAY 2			
Name of activity			
Duration			
DAY 3			
Name of activity			
Duration			
DAY 4			
Name of activity			
Duration			
DAY 5			
Name of activity			
Duration			
DAY 6			
Name of activity			
Duration			
DAY 7			
Name of activity			
Duration			

Week 4:

	Activity 1	Activity 2	Activity 3
DAY 1			
Name of activity			
Duration			
DAY 2			
Name of activity			
Duration			
DAY 3			
Name of activity			
Duration			
DAY 4			
Name of activity			
Duration			
DAY 5			
Name of activity			
Duration			
DAY 6			
Name of activity			
Duration			
DAY 7			
Name of activity			
Duration			

Week 5:

	Activity 1	Activity 2	Activity 3
DAY 1			
Name of activity			
Duration			
DAY 2			
Name of activity			
Duration			
DAY 3			
Name of activity			
Duration			
DAY 4			
Name of activity			
Duration			
DAY 5			
Name of activity			
Duration			
DAY 6			
Name of activity			
Duration			
DAY 7			
Name of activity			
Duration			

Week 2:

	Activity 1	Activity 2	Activity 3
DAY 1			
Name of activity			
Duration			
DAY 2			
Name of activity			
Duration			
DAY 3			
Name of activity			
Duration			
DAY 4			
Name of activity			
Duration			
DAY 5			
Name of activity			
Duration			
DAY 6			
Name of activity			
Duration			
DAY 7			
Name of activity			
Duration			

Appendix D: Phase 2 activity tracker (Group two)

Please record the time you spend active every day.

The activity tracker is the same as the last 6 weeks.

Please record your activity in the correct week. There are six weeks to record activity. Week one starts when you have your first scheduled walk at the University of Manitoba for phase 2.

Thank you for your participation! Have fun walking!

Activity Tracker - Phase 2

Contact Jana Slaght with any questions

slaghtj@myumanitoba.ca

204-474-7878

Week 1:

	Activity 1	Activity 2	Activity 3	Total Time
DAY 1				
Name of activity				
Duration				
DAY 2				
Name of activity				
Duration				
DAY 3				
Name of activity				
Duration				
DAY 4				
Name of activity				
Duration				
DAY 5				
Name of activity				
Duration				
DAY 6				
Name of activity				
Duration				
DAY 7				
Name of activity				
Duration				

Week 6:

	Activity 1	Activity 2	Activity 3	Total Time
DAY 1				
Name of activity				
Duration				
DAY 2				
Name of activity				
Duration				
DAY 3				
Name of activity				
Duration				
DAY 4				
Name of activity				
Duration				
DAY 5				
Name of activity				
Duration				
DAY 6				
Name of activity				
Duration				
DAY 7				
Name of activity				
Duration				

Week 3:

	Activity 1	Activity 2	Activity 3	Total Time
DAY 1				
Name of activity				
Duration				
DAY 2				
Name of activity				
Duration				
DAY 3				
Name of activity				
Duration				
DAY 4				
Name of activity				
Duration				
DAY 5				
Name of activity				
Duration				
DAY 6				
Name of activity				
Duration				
DAY 7				
Name of activity				
Duration				

Week 4:

	Activity 1	Activity 2	Activity 3	Total Time
DAY 1				
Name of activity				
Duration				
DAY 2				
Name of activity				
Duration				
DAY 3				
Name of activity				
Duration				
DAY 4				
Name of activity				
Duration				
DAY 5				
Name of activity				
Duration				
DAY 6				
Name of activity				
Duration				
DAY 7				
Name of activity				
Duration				

Week 5:

	Activity 1	Activity 2	Activity 3	Total Time
DAY 1				
Name of activity				
Duration				
DAY 2				
Name of activity				
Duration				
DAY 3				
Name of activity				
Duration				
DAY 4				
Name of activity				
Duration				
DAY 5				
Name of activity				
Duration				
DAY 6				
Name of activity				
Duration				
DAY 7				
Name of activity				
Duration				

Week 2:

	Activity 1	Activity 2	Activity 3	Total Time
DAY 1				
Name of activity				
Duration				
DAY 2				
Name of activity				
Duration				
DAY 3				
Name of activity				
Duration				
DAY 4				
Name of activity				
Duration				
DAY 5				
Name of activity				
Duration				
DAY 6				
Name of activity				
Duration				
DAY 7				
Name of activity				
Duration				

Appendix E: Phase 2 activity tracker (Group one)

Please record the time you spend active every day.

The first part of the tracker is the same as the last 6 weeks, but there are also two additional columns.

Please record your total time spent at moderate to vigorous physical activity every day. This is from your pedometer. It is shown in Hours:Minutes:Seconds.

Also record the number beside the star on your pedometer screen which indicates the number of 10 minute bouts of MVPA you have done each day.

Please record your activity in the correct week. There are six weeks to record activity. Week one starts when you have your first scheduled walk at the University of Manitoba for phase 2.

Thank you for your participation! Have fun walking!

Activity Tracker - Phase 2 Cadence

Contact Jana Slaght with any questions

slaghtj@myumanitoba.ca

204-474-7878

Week 1:

	Activity 1	Activity 2	Activity 3	Time spent in MVPA	Number of stars
DAY 1					
Activity					
Duration					
DAY 2					
Activity					
Duration					
DAY 3					
Activity					
Duration					
DAY 4					
Activity					
Duration					
DAY 5					
Activity					
Duration					
DAY 6					
Activity					
Duration					
DAY 7					
Activity					
Duration					

Week 6:

	Activity 1	Activity 2	Activity 3	Time spent in MVPA	Number of stars
DAY 1					
Activity					
Duration					
DAY 2					
Activity					
Duration					
DAY 3					
Activity					
Duration					
DAY 4					
Activity					
Duration					
DAY 5					
Activity					
Duration					
DAY 6					
Activity					
Duration					
DAY 7					
Activity					
Duration					

Week 3:

	Activity 1	Activity 2	Activity 3	Time spent in MVPA	Number of stars
DAY 1					
Activity					
Duration					
DAY 2					
Activity					
Duration					
DAY 3					
Activity					
Duration					
DAY 4					
Activity					
Duration					
DAY 5					
Activity					
Duration					
DAY 6					
Activity					
Duration					
DAY 7					
Activity					
Duration					

Week 4:

	Activity 1	Activity 2	Activity 3	Time spent in MVPA	Number of stars
DAY 1					
Activity					
Duration					
DAY 2					
Activity					
Duration					
DAY 3					
Activity					
Duration					
DAY 4					
Activity					
Duration					
DAY 5					
Activity					
Duration					
DAY 6					
Activity					
Duration					
DAY 7					
Activity					
Duration					

Week 5:

	Activity 1	Activity 2	Activity 3	Time spent in MVPA	Number of stars
DAY 1					
Activity					
Duration					
DAY 2					
Activity					
Duration					
DAY 3					
Activity					
Duration					
DAY 4					
Activity					
Duration					
DAY 5					
Activity					
Duration					
DAY 6					
Activity					
Duration					
DAY 7					
Activity					
Duration					

Week 2:

	Activity 1	Activity 2	Activity 3	Time spent in MVPA	Number of stars
DAY 1					
Activity					
Duration					
DAY 2					
Activity					
Duration					
DAY 3					
Activity					
Duration					
DAY 4					
Activity					
Duration					
DAY 5					
Activity					
Duration					
DAY 6					
Activity					
Duration					
DAY 7					
Activity					
Duration					

Appendix F: Informed Consent

oversight responsibilities for the study. For example, the University of Manitoba may look at the research records to ensure that the research is being done in a safe and proper way.

Feedback: The main results of the study and your personal results will be sent to you if you sign the feed-back form at the end of this document. If after receiving this information you have questions, a phone number and an email will be provided in order to individually discuss your results with the primary investigator, Danielle Bouchard.

Costs: All research-related procedures performed as part of this study will be provided at no cost to you.

Compensation: After visit 15, you will receive $35 compensation to cover your parking fees. Costs required to obtain physicians clearance to begin exercise will be covered.

Alternative: You do not have to participate in this study to start engaging in physical activity, or to learn how to adequately reach the Canadian Physical Activity Guidelines.

Voluntary Participation/Withdrawal from the Study: Your decision to take part in this study is voluntary. You may refuse to participate, or you may withdraw from the study at any time. To withdraw you only have to give notification to the research assistant, Jana Slaght, by phone (204) 474-7878 or by email at slaghtj@myumanitoba.ca. She will then communicate the information to all research staff by email. At this time, all data collected before your withdrawal will be destroyed unless you agree to let the research team to use this information. You are not waiving any of your legal rights by signing this consent form or releasing the research team from their legal and professional responsibilities.

Questions: You are free to ask any questions that you may have about your treatment and your rights as a research participant. If any questions come up during or after the study, contact the primary investigator of this study, Dr. Danielle Bouchard by phone (204) 474-8627 or by email at danielle_bouchard@umanitoba.ca.

Do not sign this form unless you have had the chance to ask questions and have received satisfactory answers to all of your questions.

Statement of Consent:

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this study at any time, and/or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Education/Nursing Research Ethics Board, University of Manitoba. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator (HEC), Margaret Bowman at (204) 474-7122, or margaret.bowman@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

Participant signature ___________________________ Date_______________

Research and/or Delegate's signature: __________________________Date______