Walking Cadence to Attain a Minimum of Moderate Aerobic Intensity in People at Risk of Cardiovascular Diseases

By

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ABSTRACT

Problem: Walking cadence (steps/minute) is used to prescribe walking intensity. For healthy adults, the recommended cadence is generally 100 steps per minute to reach moderate intensity. However, the required walking cadence to reach that intensity for people having risk factors for cardiovascular diseases (CVD) is unknown.

Methods: Ninety-one people presenting risk factors for CVD completed a graded exercise test to assess maximum oxygen consumption. In a separate session, when participants reached moderate intensity based on their maximum oxygen consumption, walking cadence was recorded.

Results: Mean walking cadence to reach moderate intensity was 115.8 ± 10.3 steps per minute. Using linear regression analysis, only body weight (ß=0.24; P=0.018) significantly predicted the walking cadence required to reach moderate intensity.

Conclusions: The walking cadence needed for people presenting risk factors for CVD to reach moderate intensity is about 116 steps per minute. Body weight influences the walking cadence needed to reach moderate intensity.

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CHAPTER 1: INTRODUCTION

The Canadian Guidelines for Cardiac Rehabilitation and Cardiovascular Diseases Prevention recommend that people at risk of cardiovascular disease (CVD) engage in aerobic exercise three to five times per week, at a minimum of moderate intensity for 20 to 40 minutes each time[1]. These recommendations are similar to what other national and international agencies are recommending for the general public in terms of aerobic exercises[2-4]. For example, the Canadian Society of Exercise Physiology recommends the accumulation of at least 150 minutes per week of moderate intensity aerobic physical activity in 10-minute bouts[4]. One indicator of activities performed at moderate intensity is when someone cannot sustain a conversation during the activity[4].

Regular physical activity is associated with positive health changes in both healthy adults and people with risk factors for CVD[5] . The majority of people who are inactive, including those at risk of CVD[6], report walking as their preferable form of physical activity when starting an exercise program[7]. One strategy that has been shown to motivate them to become and remain active is the use of a pedometer[8]. Although pedometers are widely used as a physical activity monitoring and motivation tool (i.e., 10,000 steps per day)[9] , they do not guarantee that users are going to reach the recommended intensity suggested by most national and international agencies to optimize health benefits[10,11]. As a consequence, many studies have shown that people achieving 10,000 steps or more per day are not significantly getting the expected health benefits[12-14]. It is important to reach moderate intensity while exercising because such intensity is associated with greater health benefits and lower mortality risks[14-17]. For example, Schnohr et al[17] showed that people who walk 30 to 60 minutes per day at moderate intensity decreased their mortality risk by 44% compared to only 12% when walking at a lower intensity, even if such intensity is sustained for more than two hours per day.

Yet there are few valid, affordable, monitoring tools available to help people identify what is moderate intensity. Such tools are needed because we have shown in our laboratory that a large proportion of active and inactive people cannot identify what moderate intensity is[18,19]. Since 2005, pedometers have been suggested to be a potential tool to measure walking intensity by using walking cadence (steps per minute) in healthy adults[16], and the general recommendation is 100 steps per minute [16]. However, a previous study concluded that only 45% of adults reach moderate intensity by using this general prescription[15]. Most studies have used oxygen consumption to evaluate exercise intensity to establish the number of steps per minute required to reach moderate intensity and all used 3 METs (10.5ml/kg/min)[15,16,20,21] as the cut-off for moderate intensity. In addition, most these studies were conducted with a young population of 40 years old or younger, all of whom apparently were in good health[15,16,20,21]. Yet there is a need to determine if the same prescription in walking cadence is required to reach moderate intensity specifically for people older than 40 years old with chronic diseases since this group of people represents most older Canadian adults[22,23]. One recent study has explored the typical walking cadence of healthy older adults[24]. Participants were walking at a higher cadence than the proposed 100 steps per minute in young adults when asked to walk at moderate speed (118 ± 11)[24]. One of the reasons for that observation could be that older adults have a different walking pattern (e.g., short stride length[25,26]) than younger adults as suggested previously[25-27].

The proposed study aimed: 1- to identify what walking cadence is needed to reach moderate intensity for people having risk factors for CVD, using 40% of maximal aerobic capacity as the cut-off for such intensity, and 2- to develop and test an algorithm based on clinical measures (e.g. age, height) so that professionals working with that clientele can estimate and prescribe walking cadence to reach moderate intensity.

Terms Definition

Cardiovascular Disease (CVD)

CVD refers to a group of diseases involving the heart, blood vessels or both[28]. CVD includes heart attack, heart failure, stroke, and peripheral artery diseases[29]. The loss of natural elasticity of the arteries is a common factor in all types of CVD, and is referred to as atherosclerosis[30]. A chronic inflammation response occurs within the walls of the large- and medium-sized muscular arteries; as a result, atherosclerosis leads to a series of events that promote deposits of lipids, LDL-cholesterol, and calcium within the inner layer of the arterial wall. This slow and insidious process of deposits leads to the formation of different plaques within the inner wall of the arteries[30]. As atherosclerosis progresses, the diameter of the arteries involved narrows and the arteries become progressively less flexible. If blood supply to the narrowed area is decreased substantially, even for a few minutes, one can suffer irreparable damage[30]. Between 2008 and 2011, CVD was considered the main cause of mortality for Canadians, representing 29% of all deaths[31].

Risk Factors of CVD

A risk factor for CVD is a characteristic that predisposes a person to develop a CVD[29]. Many risk factors for CVD have been identified. Some are modifiable (i.e., smoking, high blood pressure, overweight/obesity, diabetes, dyslipidemia, physical inactivity) but others are not (i.e., aging, gender, family history, and ethnicity)[29].

Moderate Aerobic Exercise Intensity

Studies suggest time spent standing or physical activity at light intensity can improve all-cause mortality compared to being completely sedentary[32-34] for even greater benefits, moderate intensity is proposed by many national and international organizations as the target intensity to optimize health while doing aerobic exercise[11,35-37]. Moderate intensity can be identified in absolute or relative terms and can be either self-reported or objectively measured. Based on a measurement established by the American College of Medicine, the gold standard to identify such intensity is 40% to 59% of the maximal volume of oxygen that can be consumed minus resting oxygen consumption, commonly called volume of oxygen consumption reserve ($VO_{2reserve}$)[38].

Oxygen Consumption (VO_2)

Volume of oxygen consumption (VO_2) is used to determine how much oxygen a person is consuming when performing a specific task, and is considered a gold standard in evaluating fitness level[39]. The maximal oxygen consumption achievable by an individual is called VO_{2max}[40]. VO_{2max} is usually performed by open-circuit spirometry and relies on several closely monitored physiologic variables to verify whether an individual actually achieves their maximal capacity[41]. The most common variables analyzed are heart rate (HR), VO_2, and the respiratory exchange ratio (RER). The test should ideally last between 8 to 12 minutes. Shorter test durations can produce premature fatigue and a result below capacity[39]. VO_{2max} can be reported in an absolute term (e.g., L/min) or a relative term (e.g., ml/kg/min)[39]. The three most commonly used criteria to determine if a person has reached a physiological maximal aerobic capacity (VO_{2max}) are: 1- reaching a plateau (<150ml/min or <2.1 ml/kg/min of O_2 consumption) in VO_2 while the load increases[42], 2- reaching ≥90% of predicted maximum HR (220 –age)[43], and 3- having a respiratory exchange ratio equal or above 1.15[44]. Other criteria include lactate acid ≥ 8mmol/L and a plateau in HR with an increase in workload[45]. Typically, when the individual does not achieve a minimum of two of the three criteria, the maximal oxygen consumed during the test is called $VO_{2peak.}$ VO_{2peak} is correlated with VO_{2max} and, thus, is more realistic to achieve for older adults and people with risk factors for CVD[46].

The VO_{2max} procedures are similar between healthy individuals and people with CVD, or people having risk factors for CVD. The only difference is that people with CVD need an electrocardiogram measure to identify if and at what intensity the individual shows some cardiac symptoms such as a decrease in the ST segment[47]. For example, the mode of exercise to perform the test does not differ between individuals with or without risk factors for CVD (i.e., bike and treadmill). Some exercise protocols have been specifically developed for cardiac individuals (e.g., the Bruce Protocol [48]), and used extensively.

Besides VO_{2max}, another way to quantify fitness level is $VO_{2reserve}$, which is the difference between VO_{2max} and resting VO_2[48]. This is usually used to establish exercise recommendation as it is more individualized by taking into consideration inter-individual differences in resting oxygen consumption[39]. In addition, a proportion of $VO_{2reserve}$ is recommended to use for exercise prescription as it is 100% correlated with HR Reserve [HRR (maximal HR-resting HR)], and HRR can easily be estimated in a clinic setting by measuring resting HR and estimating maximal HR[49].

Pedometer

A pedometer is a small, portable, lightweight device clipped to the waist that displays the number of steps while walking[50]. It counts a step every time a motion of the hips is detected. Validated devices have the ability to identify motion associated with true steps versus noise[51].

Walking Cadence

Walking cadence, also called stride rate or step rate, refers to the number of steps taken in a given period of time (e.g., steps per minute) and has been proposed as a way to quantify walking intensity[15,16,20,21]. The current public health recommendation suggests 100 steps per minute to reach moderate intensity in healthy adults[16].

CHAPTER 2: REVIEW OF THE LITERATURE

Cardiovascular Disease (CVD)

CVD is a serious public health issue in Canada and around the world[30]. According to a 2014 Canadian Stroke Network report[52], an estimated 1.6 million Canadians have heart disease or are living with the effects of a stroke. Among older adults aged 65 to 74 years old, 14.8% report having heart diseases, with the rate going up to 22.9 among those over the age of 75. In addition, 7.1% of Canadian adults report living with such a condition[52].

CVD profoundly impacts the overall quality of life of the affected individual and his or her family[53], with a large number of people reporting fair or poor perceived health, limitations in activity, and needing help in daily life[54]. In addition, mental disorders can arise after a CVD diagnosis[55]. CVD carries a heavy financial burden. CVD is the primary reason for hospitalization, accounting for 17% of cases in Canada[56]. Finally, CVD accounts for the highest number of days in hospital when admitted[56]. And, as studies show, the number of people with CVD is growing[57]. Table 1 shows the proportion of Canadians that reported having at least one CVD (1.3 million Canadians, 4.8% of the population; 4.2% of girls and women and 5.3% of boys and men, 12 years of age and older) by each province in 2007. The CVD included in the analyses were: heart attack, atrial fibrillation, heart failure, congenital heart diseases, and stroke.

Table 1. Proportion of Canadians with at least one CVD by Province

Province	Proportion (%)
Alberta	3.3
British Columbia	3.9
Manitoba	4.7
New Brunswick	6.2
Newfoundland/ Labrador	6.3
Nova Scotia	6.4
Northwest Territories	2.7
Ontario	5.0
Prince Edward Island	5.5
Quebec	5.4
Saskatchewan	5.0
Yukon	2.9

Adapted from Public Health Agency of Canada 2009[58].

Exercise and CVD

Many agencies agree that regular physical activity significantly reduces the risk of someone developing CVD[59-61]. However, the recommendations do not address any difference in terms of exercise frequency, duration, nor intensity between the general public and people with CVD. Although the volume of physical activity is not specified on this population, studies certainly see the benefits in any addition of aerobic exercise. For example, an increase in physical activity level has been proven to improve functional capacity, and decrease specific CVD-related symptoms that limit exercise increment such as chest pain[62].

A reduction of resting HR is an indicator the heart is working more efficiently by increasing stroke volume[29] and a decrease in the resting HR has also been demonstrated in this population after starting to exercise regularly[63]. Moreover, higher intensity aerobic exercises are associated with greater health benefits (e.g., improvement in VO_{2max}) when compared to lower exercise intensities[35,64,65]. For example, one study has shown that if aerobic exercise is done at vigorous intensity level, all-cause mortality risk for people with established CVD is lower than if aerobic exercise is performed at lower intensities[66]. However, higher-intensity exercise may discourage people, especially for low-fit patients, because of discomfort, injury, or lack of sustained motivation[67]. Therefore, a realistic goal is to initiate exercise intensity at a low intensity towards reaching a minimum of moderate intensity as recommended in the general guidelines[11,60,68] and the one specific for cardiac people[1].

The goal to progressively increase exercise intensity is to sustain motivation, decrease discomfort, decrease risk of injuries, and to ultimately optimize health improvements[69,70]. Even if additional benefits can be obtained by doing exercise at vigorous intensity, the odds of people adhering to an exercise program as well as follow the entire exercise program prescribed are greater when such exercise is prescribed at moderate intensity if compared to vigorous intensity programs[71-73]. Although the exact prescription for specific heart conditions is unknown, there are strong associations between exercise intensity and reduction of risk when exercising at moderate intensity[74]. According to an epidemiologic study, an exercise program encompassing one hour at least five times a week showed after six months a 50% lower risk of developing any major cardiac events[75]. It is, however, debated whether this optimal exercise prescription can work with stroke victims and other specific CVDs, such as hypertension. Nevertheless, training three to five times weekly for 30 to 60 minutes per session at moderate intensity significantly reduces systolic and diastolic blood pressures in hypertensive subjects[70,73,76].

Cardiovascular Disease and Common Medications

People with CVD take a variety of medications and some drugs affect the typical responses to exercise (e.g., beta-blocker)[77]. However, most people who only have risk factors for CVD do not routinely take these medications. In 2009, Statistics Canada reported that among the different types of medication intended to treat CVD, diuretics were the most commonly prescribed[78]. Once diagnosed with a coronary artery disease, people generally take three main types of medication: aspirin (98%), beta-blockers (96%), and statins (87%)[79]. Beta-blockers are defined as a class of drugs that are used for the management of an irregular heartbeat[80]. By reducing cardiac output and lowering blood pressure this type of medication can reduce the risk of heart-related complications[80,81]. Among the treatments available, calcium channel blockers are also often considered[82]. This drug class lowers HR by reducing the pressure in the arteries and, therefore, the heart needs less oxygen for maximal efficiency[82]. Because many people with established CVD are using medications that affect HR[83], it can be erroneous to use maximum HR to determine fitness level in an exercise program designed for this population[84-86]. It is important to note that oxygen consumption is not as affected by common medications used by people with CVD[87]. Based on the latest research, although HR is considered a reliable method to access exercise intensity in healthy individuals, the same is not true for people with CVD taking medication that influences the typical HR responses to exercise.

CVD Risk Factors

As shown in Table 1, many people have at least one CVD[58]. In terms of risk factors, Table 2 illustrates the proportion of Canadian adults that have at least one risk factor for CVD by age groups (i.e., smoking, alcohol, physical inactivity, obesity, high blood pressure, high blood cholesterol, diabetes) [58].

Table 2. Proportion (%) of Canadians with Risk Factors Associated with CVD by Age Group

Age Group (years)	20-44	45-65	65-79	80+
1 Risk Factor	24.4	19.4	18.8	21.6
2 Risk Factors	31.1	27.9	27.2	28.6
3 Risk Factors	22.1	25.5	25.2	25.0
≥4 Risk Factors	11.1	19.9	20.6	16.0

Adapted from Public Health Agency of Canada 2009[58]. Data reported as %

Some risk factors for CVD are modifiable while others are not (Table 3). Regular exercise influences at least five of the seven modifiable risk factors: physical inactivity, lipid profile, blood glucose, body weight, and blood pressure[88], each of which are discussed in details below. In general, it has been concluded that the relationship between physical activity level and CVD risk factors was obvious[89-92], but more information is needed to determine the optimal exercise prescription to reduce each of the risk factors[93].

Physical Inactivity

Even a modest increase in physical activity can result in significant and measurable improvements in cardiovascular health independent of weight loss[69,70,94]. One of the reasons for the relationship between high physical activity level and low CVD risk factors is that energy demand and myocardial contractions increase while exercising[29], which results in strengthening the heart muscle, improving the body's ability to uptake and use oxygen, and by improving the capacity of the blood vessels to provide oxygen to muscles during exercise[29]. Research continues to show the benefits of physical activity in patients with any cardiovascular conditions[95-99]. Aerobic exercises performed at moderate intensity have been shown to be effective in improving exercise capacity, quality of life[96], and improving life expectancy in these people[96,98]. Furthermore, a regular exercise program can also reduce depression and psychosocial stress in patients living with CVD[100-102].

Table 3. Common Risk Factors Associated with CVD

Modifiable risk factors	Non-modifiable risk factors
High blood pressure	Age
Physical inactivity	Family history
High glucose level	Gender
Unhealthy diet	Ethnicity
Tobacco use	
High lipid profile	
Overweight/Obese	

Adapted from the World Heart Federation[2]

High Lipid Profile

The Canadian norms[103] for total cholesterol, HDL-cholesterol, LDL cholesterol, and triglycerides are presented in Table 4. Studies have been accumulating information regarding the association between lipid levels and CVD over the past 50 years[104-109]. For example, a large study involving over 365,000 men reported that cholesterol levels increased the risk of heart disease and this relationship was continuous, and graded[110]. More recently, many studies have been conducted to determine ways to improve lipid levels by exercise[111-115]. The research agrees with a negative relationship between total cholesterol levels[111-118], triglyceride concentrations[88,117,119-121], or low density lipoprotein (LDL) cholesterol[122], and physical activity level[111-118]. On the other hand, high density lipoprotein (HDL) cholesterol, responsible for removing excess cholesterol from the walls of blood vessels and transporting it from peripheral tissues to the liver for catabolism[123], is positively associated with levels of physical activity[122]. In another study, it was reported that HDL-cholesterol is the best clinical predictor of CVD[124]. HDL-cholesterol can be significantly increased through aerobic activity equivalent to 1,200 to 1,600 kcal/week of caloric expenditure[125].

High Glucose Level

High concentration of glucose in the bloodstream is the result of defects in insulin production, insulin action, or both[126]. A risk factor for CVD is elevated fasting blood glucose compared to the optimal value (≤ 99mg/dL or ≤ 5.5 mmol/l)[127]. Another way to establish the risk factor is by using the Oral Glucose Tolerance Test (OGTT), which measures blood glucose after ingesting a fixed dose of glucose (usually 75 grams) following a twelve-hour fast[128].

Table 4. Values for Lipid Levels

	Total Cholesterol	LDL-Cholesterol	Triglycerides
Desirable	< 5.2 mmol/L	< 2.6 mmol/L	< 1.7 mmol/L
Borderline High	5.2 – 6.2 mmol/L	2.6 – 4.1 mmol/L	1.7 – 2.2 mmol/L
High	> 6.2 mmol/L	4.1 – 4.9 mmol/L	> 5.6 mmol/L

HDL-Cholesterol	Men	Women
Poor	< 1 mmol/L	< 1.3 mmol/L
Fair	1-1.3 mmol/L	1.3-1.5 mmol/L
Best	> 1.6 mmol/L	> 1.6 mmol/L

Adapted from New Canadian Guidelines for Diagnosis and Management of Dyslipidemia[103].

After two hours of ingestion, if the blood glucose level is greater than 140 mg/dL or ≥ 7.7 mmol/L it is considered a risk factor for CVD[129] If high glucose levels are constantly observed, there is an increased risk of Type 2 diabetes[130]. Physical activity has the potential to also provide numerous benefits for people living with Type 2 diabetes, including blood glucose control, better insulin sensitivity, lower medication requirements, and a reduction in body fat[131]. In addition, many studies argue that high physical activity levels represent an effective way to delay or avert the development of Type 2 diabetes[132,133]. For example, exercise intervention studies show that aerobic exercise can improve insulin sensitivity by up to 50 μU/ml after only a few weeks of aerobic training[134,135]. Resistance training has also been associated with lower fasting blood glucose and insulin concentrations[136].

Overweight/Obese

Overweight and obesity are associated with numerous comorbidities[137]. Because measuring fat mass can be challenging, many clinical tools have been used to estimate body fat such as body mass index (BMI) and waist circumference. A BMI $\geq$ 25.0 kg/m^2 is considered overweight and a BMI$\geq$ 30 kg/m^2 is considered obese[138]. Measurement of waist circumference is a method that it is extensively used worldwide; it is easy, feasible and an accurate predictor of visceral fat[139]. A waist circumference equal to or greater than 102 cm for men and 90 cm for women is increasing the risk of developing CVD[138]. The mechanisms leading overweight or obese individuals to develop CVD have yet to be determined, even though these two conditions are strongly correlated[140].

The role of exercise alone towards long term weight loss is modest[141], but favorable changes in many comorbidities and body composition can be expected[29]. A meta-analysis study reported aerobic exercise programs in obese middle age adults lasting an average of 15 weeks induced a weight reduction of .79% per week[142]. However, when the energy intake is reduced, exercise can increase the expected weight loss[143]. Despite the small independent role of exercise in weight loss, many studies have shown that exercise was crucial for weight loss maintenance[144].

High Blood Pressure

The pressure generated by the left ventricle while the heart is filling with blood is known as the diastolic blood pressure, while the pressure the blood exerts on the blood vessels during the contraction phase of the heart beat is known as the systolic blood pressure[39]. Hypertension is considered a chronic elevation in either or both systolic blood pressure ($\geq$140 mmHg) and/or diastolic blood pressure ($\geq$90 mmHg) at rest[29]. In 2002, the World Health Organization reported the number of people living with hypertension worldwide was estimated to be as much as one billion, and is responsible for 7.1 million deaths per year[59]. In 2014, the prevalence of hypertension in Canada was reported to be 7.4 million[145]. This number would be even higher if everyone were tested. The prevalence of hypertension increases with age, and a higher percentage is observed in men aged 45 and older, while women surpass men's percentage after menopause[146].

Although HDL-cholesterol is considered to be the best single predictor for CVD[124], chronic high blood pressure is also recognized as a major risk factor for developing CVD[147]. The risk of cardiovascular morbidity and mortality increases linearly as blood pressure rises[148]. One study has shown that the mortality risk doubles for every 20 mmHg increases in systolic blood pressure above 115 mmHg or for every 10 mmHg increase above 75mmHg of diastolic blood pressure[149]. Lowering blood pressure results in a reduction in the rates of death from CVD and stroke[150]. For example, a reduction in diastolic blood pressure of 5mmHg over a period of five years was associated with 34% less stroke and at least 21% less CVD[148]. A reduction of systolic and diastolic blood pressure between 7.5 mmHg and 10 mmHg is associated with 46% and 56% less strokes, and 29% and 37% less CVD[148].

The role of physical activity to prevent or treat hypertension has been extensively studied[150-153]. After controlling for traditional confounders, the findings of these studies suggested that regular physical activity is associated with low blood pressure[150-153]. In addition, other studies reported that the relative risk for developing hypertension was 35% to 70% higher in inactive people when compared to those who are physically active[88,154,155]. Most of the current literature suggests that it is possible to reduce high blood pressure with regular aerobic exercise even in hypertensive older adults[89,152,156,157]. For example, in a group of 70- to 79-year-old hypertensive participants, Cononie et al.[158] reported a reduction of 8 mmHg in systolic blood pressure, and 9 mmHg in diastolic blood pressure after six months of aerobic exercise at vigorous intensity. In a similar study, the investigators noted a reduction of 15 mmHg in systolic blood pressure, and 9 mmHg in diastolic blood pressure in 68- to 84-years-old hypertensive participants following a walking program with an exercise intensity at a lactate threshold for 30 min., three to six times per week for nine months[156].

Age/Sex

Age is a non-modifiable risk factor for CVD. As a person becomes older, there is an increasing risk of developing at least one CVD[2]. This is particularly important in the context of an aging population[159] where the age group of 65 years old or more is expected to represent 25% of the Canadian population by 2051[159]. Interestingly, age only becomes a risk factor for CVD after a certain period in a person's life [men (≥ 45 years old) and women (≥ 55 years old)][160]. Although the cut-off age for risk of CVD is different for man and woman, results from various meta-analyses have shown that similarities exist in all the modifiable risk factors[161-168].

Recommendation and Barriers to Exercise

According to the most recent Canadian Physical Activity Guidelines, published in 2011[4] all adults should engage in a minimum of 150 minutes of moderate aerobic exercise per week in 10-minute bouts. In addition, it is recommended all adults perform resistance training a minimum of two times a week[36]. Only 15.3% of Canadians are currently reaching the aerobic recommendations[10]. For people with established CVD, the specific guidelines suggest engaging in aerobic exercise three to five times per week, at a minimum of moderate intensity for 20 to 40 minutes each time, adding resistance training to routine at least twice a week[62]. Thus, this recommendation is similar to what is suggested for the general public[36].

There are many barriers for regular physical activity[169,170]. A large study consisting of 6,448 people reported that lack of motivation, lack of time, and high cost related to organized activities are the main perceived barriers to regular exercise in adults[171]. Moreover, the study showed that 51.9% of older individuals report illness and disability as obstacles to regular exercise[171]. Another study involving older adults revealed specific reasons why people do not engage regularly in exercise: They did not know how to start a physical activity program; classes, facilities, and exercise specialists are expensive; class times are not convenient; and they did not have the skills or capability to be physically active[169].

Walking, of course, is a great strategy to motivate inactive people to engage in physical activity, because of its low cost[172]. It does not require equipment or facilities to be performed, and it is the preferred activity for most Canadians[173]. A recent study of 1,600 participants between the ages of 70 and 89 reported that walking at moderate intensity for at least 150 min/week reduces the risk of becoming disabled (defined by the inability to walk about 370m without support) by up to 28% when compared to a group that attended an educational workshop on healthy aging[174]. In addition, improvement in bone mineral content can be observed in older adults if walking is performed regularly (a minimum of three times a week) after nine months[175]. The improvement is even higher after one year[175], suggesting that walking is associated with favorable bone changes in this specific population[176]. Walking represents an ideal choice for older adults to become more active as it addresses many barriers, it is a social activity, and people enjoy doing it[177]. It is also a low-risk activity, does not require supervision, and can be performed pretty well everywhere[178]. It is known that older adults are able to reach moderate intensity while walking but do not necessarily do it constantly[179]. In an attempt to address this issue, some studies have suggested that pedometers could be a motivational tool to help individuals achieve and maintain a minimum of moderate intensity when using walking cadence as a prescription[180]. In addition, having a specific goal for a walking session may motivate inactive people to be more active[180,181].

Why is reaching moderate intensity is important?

It is well known that any increase in physical activity level is associated with health benefits, especially for inactive people[36]. However, these benefits can be enhanced if the intensity is increased[17]. Schnohr et al.[17] found that people who walk 30 to 60 minutes per day at high intensity decreased their mortality risk by 44% compared to only 12% if people walk more than two hours per day at low intensity, indicating that it is not the duration of walking that is important, but the intensity. Similarly, Nemoto et al.[157] have evaluated the benefits of walking intensity and found greater improvement in blood pressure and muscle strength in the highest intensity group (70%-85% of maximum capacity) compared with the lowest intensity group (50% of maximum capacity). Furthermore, another study found a positive relationship between higher intensity while walking and greater oxygen uptake post-exercise in overweight adults, which could help promote weight loss by increasing energy expenditure[182]. Since low cardiorespiratory fitness is associated with mortality[29] and high intensity exercise is linked to greater cardiorespiratory fitness[39], moderate to vigorous exercise intensity is believed to be a key element in promoting greater impact on mortality risk compared with low exercise intensity.

How do we measure intensity?

The rate at which an activity is performed is called intensity[183]. There are different ways to prescribe intensity, either subjectively, where people report how they feel (e.g., talking test) or objectively, using a tool (e.g., HR monitors) or the result of an objective test (e.g., VO_{2max}). The most frequently used objective measures to prescribe exercise intensity[60] are shown Table 5.

Subjective Measures

Talking Test: The talking test is a subjective method to estimate cardiorespiratory exercise intensity while walking[184]. The method aims to estimate moderate intensity with the assumption that such intensity is reached when an individual cannot have a comfortable conversation when performing an activity such as walking. The talking test was previously validated to identify walking intensity against HR and oxygen consumption (r= 0.82) [184].

Table 5. Common Methods to Assess Moderate Intensity

Method	Cut-off for moderate intensity
Objective Measures	
Mets	3 to 5.9 Mets[185]
Heart Rate	≥ 40% of Heart HRR[1,61]
Oxygen Consumption	40% of $VO_{2reserve}$ [61]
Pedometers	100 $steps.min^{-1}$ [15,16,20,21]
Actical Accelerometer	Adults ≥1535 counts/min[186] Older adults ≥1065 counts per minute[187]
Subjective Measures	
Talking Test	Not able to talk comfortably while walking[188]
Borg Scale	11-13 on a scale of 20[189] 4-6 on a scale of 10

PAG: Physical Activity Guidelines; CACRC: Canadian Association of Cardiovascular Prevention and Rehabilitation; Mets = Metabolic equivalent of task; HRR = Heart rate reserve.

Borg scale: In 1970, Gunnar Borg proposed the Rate of Perceived Exertion (RPE) scale, better known as the Borg Scale to self-report exertion levels[188]. This widely used scale categorizes different levels of activity intensities represented by numbers 6 to 20 or from 0 to 10[190]. The greater the number, the greater self-perception of exercise intensity[189]. Moderate intensity is equal to 4 out of 10 or 12 out of 20[190]. There is a strong correlation (r = 0.75) between a HR and a person's perceived exertion based on the Borg Scale[191].

Objective Measures

Metabolic Equivalence of Task (MET): One MET refers to the energy needed to respond to the basic needs of the human body when resting[192] By default, it is considered to be 3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$ which is equivalent to one kcal per kilogram of body weight per hour[193,194]. The energy expenditure each physical activity has is based on The *Compendium of Physical Activities* in which each activity is given an intensity in METs[192]. The number of METs represents the intensity compared to the resting value (1 MET). For example, an activity considered 5 METs is five times more intense than at rest and requires five times more oxygen consumption to be completed. Activities are categorized into three different intensity levels: Light-intensity from 1.1 METs to 2.9 METs; Moderate-intensity from 3.0 to 5.9 METs; Vigorous-intensity when equal to or greater than 6.0 METs[185]. Activities that require individuals to work at moderate intensity include brisk walking, dancing, or intense household chores[11]. The problem with this method is that it does not consider inter-individual difference in maximal capacity. In other words, two people could spend the same amount of oxygen while doing an activity, but one could be working at 50% of maximal capacity while the other could be at 90% of maximum capacity. To avoid that situation, it is recommended that professionals use a proportion of VO_{2max} or HR_{max} either instead of an absolute value such as METs.

Heart Rate (HR): HR refers to heart beat per given unit of time[195]. It provides a direct indication of the physiological response to physical activity[196] as long as no medication is consumed that could alter the typical response. Although there are different ways to assess HR (e.g., manual pulse)[197], HR monitors are among the most commonly used devices because they are relatively cheap and the measurements are reliable[198]. HR can also be used to assess energy expenditure and to prescribe exercise intensity[199,200]. HR does not directly assess physical activity intensity, but such a method is based on the positive linear relationship with oxygen consumption which is known as the gold standard[201]. To reach moderate intensity while measuring the intensity of HR, the recommendation is 40% of HRR[61]. The following calculation is made: (Maximal HR-Resting HR) X .40 + Resting HR. Maximal HR can either be measured on a maximal graded test or estimated with predicting equations.

Maximal Oxygen consumption (VO_{2max}): Maximal Oxygen consumption refers to the maximal amount of oxygen consumed by unit of time and normally reported relative to body weight (ml/kg/min)[48]. It is considered the gold standard in measuring fitness level and in prescribing exercise intensity[202]. This measurement is compiled in a laboratory setting by collecting a sample of oxygen while performing a graded maximal exercise test. According to the protocol used, the workload is increasing progressively until the participant reaches his or her maximum limit of effort[203]. Typically, it is possible to improve VO_{2max} with aerobic training by about 20%[204]. VO_{2max} is limited by two main factors: the ability of the heart to efficiently pump blood out to supply the demands of the body during exercise, and the ability of the muscular-tissue system to extract the oxygen delivered[29]. Even if VO_{2max} is a reliable and valid tool to measure aerobic fitness, such a method is very expensive, requiring specialized equipment, and trained staff[205]. Compared to HR, VO_{2max} is not as easily affected by medication, especially if the intensity remains below moderate intensity[77]. Some experts report that it would not be affected at any intensity[83]. To reach moderate intensity while measuring the intensity as a proportion of VO_{2max}, the recommendation is 40% of $VO_{2reserve}$[61] which is calculated in an equation: (VO_{2max} -Resting VO_2) X .40 + Resting VO_2. VO_{2max} can either be measured on a maximal graded test or estimated with predicting equations using a submaximal exercise effort[48]. Similarly, Resting VO_2 can be measured with a metabolic cart following a standard protocol or by using a default value of 3.5ml/kg/minute[39].

Pedometers: Pedometers are small devices most commonly worn on the waist. They are designed to display the number of steps that one takes while walking. Using total steps per unit of time, they can be used as an indication of physical activity volume (e.g., steps per day)[9]. Pedometers have shown to be effective in increasing physical activity levels of people who were previously inactive[206-209]. Bravata et al. reported that the use of pedometers promoted significant decrease in blood pressure and BMI[206]. Some studies suggested that people should walk at least 10,000 steps or more per day to attain optimal health benefits[207,209,210]. This recommendation was based on the argument that 10,000 steps per day was the minimum needed to reach the physical activity guidelines at the time [i.e., minimum of 30 minutes of aerobic exercise for most days[211]. However, many studies report that 10,000 steps in a day is not necessarily associated with health benefits and it was hypothesized that the steps were not taken at a sufficient intensity (i.e. moderate intensity) to optimize health benefits[212]. Since then many studies have tried to identify how many steps per minute are needed to reach the minimal intensity in order to reach moderate intensity, commonly called walking cadence.

Walking cadence: what do we know so far?

At least seven studies have previously explored the necessary number of steps required to reach moderate intensity (Table 6). In 2005, Tudor-Locke et al.[16] studied 25 men and 25 women, between the ages of 18 to 39 years old, with an average VO_{2max} of 34.8 ± 2.9 ml/kg/min. The researchers found that 100 steps per minute could be a good public message to reach moderate intensity as most people were between 90 and 110 steps per minute. The evaluation was done on a treadmill in a laboratory setting, and the intensity was evaluated by oxygen consumption and transferred into METs. The cut-off chosen was 3 METs or 10.5 ml/kg/min as recommended by the American College of Sport Medicine (ACSM) for moderate intensity[213]. By using their average VO_{2max} it is possible to estimate the percentage of $VO_{2reserve}$ used when performing 100 steps per minute [10.5 / (34.8-3.5)]. Therefore, the estimated $VO_{2reserve}$ would be 33.5%; therefore lower than the recommended 40% to reach moderate intensity when individualizing the prescription[213]. A different study by Marshall et al[15]. evaluated if BMI (29. 7 ± 6.3 kg/m^2) and age (32.1 ± 10.6 yrs) was influencing the walking cadence to reach moderate intensity. They reported that 100 steps per minute would be sufficient to reach moderate intensity regardless of BMI and age[15]. However, this study was done with adults under the age of 40 and exercise intensity was once again evaluated using 3 METs as the cut-off for moderate intensity.

Additional analyses from the same study showed that when using 100 steps per minute as the exercise prescription, only 55% of their sample would reach moderate intensity when 100 steps per minute is reached. Nonetheless, they concluded that the recommendation of 100 steps per minute was a good population based recommendation, but should not be used for individual prescription. Since then more studies have been published to better individualize the walking cadence[20,21]. In one study, the goal was to verify if measuring or estimating resting metabolic rate (i.e., 3.5 ml/kg/min) was associated with a different walking cadence to reach moderate intensity. In other words, the researchers measured resting metabolic rate and multiplied it by three (since 3 METs is the threshold for moderate intensity[213]) instead of using the conventional value of 10.5 ml/kg/min. They concluded that there was no significant difference in walking cadence when using the measured resting metabolic rate when compared with the default one. They also confirmed that 100 steps per minute was an acceptable public message for adults aged 28.0 ± 6.8 yrs to reach 3 METs while walking[20]. In another study that included 38 women and 37 men (mean age: 23.9 ± 12.4 years), researchers found that walking cadence needed to be adjusted for height[21]. They concluded that walking cadence to reach moderate intensity can vary by more than 20 steps per minute depending on height (90 to 113 steps per minute)[21]. The report stated that 100 steps per minute can be used as a simple public health message when needed, but height should be taken into consideration for a more individualized walking cadence prescription to reach moderate intensity in healthy adults[21].

Table 6. Main Studies on Walking Cadence

First Author	Description	Variables Associated with WC	Method Used to Identify WC	Walking Cadence
Tudor-Locke 2005[16]	N= 50 (25 women) 25.4 ± 4.7yrs BMI = 23.9 ± 2.3 kg/m^2	METs	Walk/jog a track and/or treadmill mile at 6.4, 9.66, and 12.8 km/h	96 steps/min (men) 107 steps/min (women)
Marshall 2009[15]	N = 97 (58 women) 32.1 ± 10.6yrs BMI = 29. 7 ± 6.3 kg/m^2	METs	6-minute treadmill bouts at 3.86, 4.83, 5.64, and 8.04km/h	98 steps/min (men) 105 steps/min (women)
Beets 2010[214]	N = 20 (11 women) 26.4 ± 4.6yrs BMI = 26.1 ± 4.4	Leg length	Over-ground walk at five speeds (1.8, 2.7, 3.6, 4.5, and 5.4km/h), lasting 6 min each	98 steps/min
Rowe 2011[21]	N= 75 (38 women)	Height	6-minute treadmill	102 steps/min

	32.9 ± 12.4yrs BMI = 25.6 ± 4.4 kg/m^2		bouts at randomly assigned set speeds (4.3, and 5.8km/h) and over-ground track walks at treadmill-determined cadences	
Abel 2011[20]	N= 19 (10 women) Age = 28.0 ± 6.8yrs BMI = 23.2 ± 3.7 kg/m^2		10-minute treadmill bouts at walking (3.24, 4.8, and 6.42 km/h) and running speeds (8.04, 9.66, 11.28km/h)	94 steps/min (men) 99 steps/min (women)
Tudor-Locke 2013[179]	N= 15 (8 women) Age = 67.38 ± 4.31yrs BMI = 25.16 ± 2.64 kg/m^2	Gait speed (cm/sec), and steps/day.	GAITRite-determined normal and dual-task walks and wore objective monitors for 1 week.	103 steps/min (men) 108 steps/min (women)
Peacock, 2014[24]	N = 29 (29 women) Age = 71.21 ± 6.96 BMI = 25.44 ± 1.41	Age, and height	Walking trials self-selected speeds, each lasting 4 min. Stride rate was recorded	111 steps/min

N = number of participants; BMI = Body Mass Index

More recently, a study involving 29 older women (mean age 71.3 ± 12.4 years) who were categorized as being physically active (self-reported) concluded that this age group required a greater walking cadence (average of 111 steps per minute) to reach 3 METs, suggesting that older adults might need to take more steps to reach moderate intensity compared with younger counterparts.

Based on previous studies, more work is needed to better prescribe walking cadence for older people or people with chronic conditions. First, all the studies were done with either adults or healthy older adults[15,16,20,21,24,179,215]. Second, older people tend to be less fit than younger adults [24,179] so they might need fewer steps to attain moderate-intensity level. Third, older people tend to shorten their stride length while walking compared to younger adults due to a decrease of muscle strength, a reduction in flexibility, fear of falling, and some age-related diseases, all of which could increase the walking cadence to reach moderate intensity[24]. Fourth, a recent study suggested that the mean walking cadence would exceed the current recommendation of 100 steps per minute in older adults, however, that study was conducted with apparently healthy older adults and a small sample[24].

To date, at least three studies were conducted with the aim of increasing the physical activity level at moderate intensity by prescribing walking cadence[15,16,21]. Marshall et al.[215] recruited 180 Hispanic women, between the ages of 18 and 55 years old, with an extremely low income status. The women were randomly assigned to one of the following: 1- self-selecting steps goal per day; 2- 10,000 steps per day; 3- 3,000 steps in 30 minutes per day. The median time spent at least at moderate intensity between pre- and post-intervention increased by 41% in the third group compared to 23% and 15% in the other two groups (p=.06). Even if that difference was not significant, unlike the other groups, participants in the third group significantly increased the time spent in bouts of 10 minutes which is recommended by the Canadian Physical Activity Guidelines[4]. Curiously, the proportion of people reaching these guidelines increased noticeably only in the third group. In another study[18], 25 inactive older adults were recruited. Participants were randomized to one of three groups (i.e., manual pulse, pedometer, or HR monitor). The study had three goals: 1- to demonstrate that most of the participants did not know how to identify exercise intensity while doing aerobic exercise, 2- to evaluate the impact of an 8-week home-based intervention aimed to increase the proportion of participants who reach the Canadian Physical Activity Guidelines in terms of aerobic exercise, and 3- to explore the use of different tools (pedometer, HR monitor, and control) to help participants identify and reach the correct exercise intensity. Although there was an increase in exercise intensity in both the pedometer and the HR monitor groups, after eight weeks there was no difference between the two groups. However, the participants in the pedometer group reported that their prescription was easy to follow compared to the participants in the HR monitor group, which reported problems with the equipment[18]. In addition, participants in the pedometer group reported that the intensity was easy to attain, which suggests that walking cadence should be individualized. Because pedometers are simpler to use, less expensive, and more readily accepted among participants than those in the control group or HR monitor group, it was determined that using pedometers as a primary tool to help identify exercise intensity in older adults should continue.

Unpublished data from our research group investigated if meeting people once and providing them with an individualized walking cadence based on HRR instead of 100 steps per minute was effective to increase time spent at least at moderate intensity after eight weeks, compared with a control group simply receiving a pedometer. We recruited 46 participants, including 21 in the intervention group. Moderate-to-vigorous physical activity was assessed with accelerometers in 10-minute and sporadic bouts (<10 minutes) as well as total steps and steps at moderate-to-vigorous intensity. Although participants reported that receiving an individualized walking cadence prescription increased their motivation by 50%, none of the outcomes between the two groups were significant after eight weeks of intervention. It was suggested that one visit providing an individualized walking cadence was not enough to teach people how to follow a walking cadence prescription. Moreover, this study suggested that using a pedometer to prescribe walking cadence might not be as easy as previously thought.

Summary of the Literature Review

The literature above shows that walking cadence is an interesting way to prescribe exercise to people who choose to walk as their primary mode of aerobic exercise, which reportedly is about 70% of the population in Canada [216]. Of particular importance, this strategy might work even better for people with a low fitness level (e.g., older adults) as there is a good chance they could reach moderate intensity while walking. However, it is currently uncertain what the recommended walking cadence should be for older people especially those CVD or at risk of it.

CHAPTER 3: METHODS

Objectives

The first objective of this study was to identify what is the walking cadence needed for people at risk of CVD in order to reach moderate intensity using 40% of maximal aerobic capacity. The second objective was to use clinical information (e.g., body weight, age) to develop and test an algorithm to estimate the walking cadence needed by individuals at risk of CVD to reach moderate intensity without the use of costly equipment.

Hypothesis

We hypothesized that individuals with a risk factor for CVD would reach moderate intensity with a lower walking cadence when compared to the one suggested for young healthy adults (100 steps per minute[16]) because some risk factors for CVD (age[65], being smoker[217], being overweight[35], and physical inactivity[4,11,29,60,61,66,70,185,190,218]) are associated with a low fitness level.

Participants

Participants were recruited from two fitness facilities in Winnipeg. The two centres were the Reh-Fit Centre and the Wellness Institute at Seven Oaks Hospital. The goal was to recruit 100 participants. Because the objectives of this study were descriptive, there was no need for calculating the sample size. Instead, the sample size was determined by having a sample large enough to create an algorithm to estimate an outcome, a walking cadence to reach a minimum of moderate intensity. As most studies in the literature have reported, between three and five variables are involved in estimating the walking cadence needed to reach moderate intensity[15,16,20,21,214], we aimed to recruit 100 participants so that a minimum 10 people for each independent variable were included in a linear regression model for a stable regression analysis[219]. The plan was to use 50 people selected randomly to create the algorithm and 50 different people to validate the developed algorithm[219]. In addition, recruiting 100 participants surpassed all previous studies looking into determining the walking cadence needed to reach a minimum of moderate intensity. For example, the two studies on the topic recruiting older adults had a sample size of 15[179] and 29[24] participants.

The only exclusion criterion for the study was if one needed support to walk (e.g., cane, walkers). People were eligible if they were offered a graded exercise test on a treadmill as part of their membership services at both Reh-Fit Centre, and Wellness Institute Seven at Oaks Hospital facilities. This test is normally offered to members presenting two or more of the following risk factors for CVD:

- Men older than 45 years;
- Women older than 55 years, who have had a hysterectomy or are postmenopausal;
- Smoker, or quit smoking in the last six months;
- Blood pressure greater or equal to 140/90 mmHg or do not know it;
- Taking blood pressure medication;
- Blood cholesterol greater or equal to >=5.2mmol/L;
- History of heart attack or heart surgery in family before the age of 55 for men or 65 for women;
- Inactive (self-reporting less than 30 minutes at least three times per week);
- Fasting blood glucose >=6.1 mmol/L;
- Obese (BMI $\geq$30 kg/m^2).

The fitness facilities determined whether someone had a minimum of two risk factors. However, in the results section the number of risk factors for CVD was determined by using the ACSM criteria [160]. If members signed an authorization form, the information was made available to the research staff. Except for BMI (body weight and height) and blood pressure that were measured by the fitness facilities' staff, all risk factors were self-reported, unless members received a fasting blood draw as part of their evaluation and the results were available for total cholesterol and fasting blood glucose. The questionnaires used to collect self-reported information are described in details at the end of this chapter (Appendix 1 and 2). In order to count the number of risk factors for each participant, the objective information was used whenever available. For example, if someone did not self-report being obese, but the BMI was $\geq 30 kg/m^2$, it was counted as a risk factor for CVD.

Recruitment

Recruitment was done at the two fitness facilities simultaneously. Ethics approval was received from the University of Manitoba and both facilities. After being referred to a medically supervise graded exercise test, participants were informed about the study. The fitness facilities provided information about the study through e-mail or a pamphlet that was available at the reception desk when appointments were made (Appendix 3). If interested, potential participants were asked to contact us either by e-mail or telephone before their scheduled appointment for the graded exercise test. Participation in the study involved two visits with the research staff.

First Visit

During the first visit, participants were asked to meet the research staff 30 minutes before their scheduled graded exercise test. Participants started by reading the consent form and signing it upon agreement (Appendix 4). People were given an authorization form to sign once they agreed to share the information (e.g., age, physical activity level, body weight, height) collected by fitness facilities. At both locations, a private assessment room was provided for the research staff to meet with participants.

During that first visit, an exercise consultant from the fitness facility took body weight, height, and blood pressure measurements in accordance to the Canadian Society of Exercise Physiology procedure manual[220]. Once weight and height information was collected, the data was entered in the portable metabolic cart (K4*b*^{2} Cosmed, Chicago IL)[221] to collect oxygen consumption while doing the treadmill test. The portable metabolic cart (Appendix 5) was calibrated before each visit. Participants were asked to wear a mask while doing the test to collect breath-by-breath samples of oxygen (O_2) and carbon dioxide (CO_2). The mask was adjusted for each participant to prevent any air leaks. The exercise test consisted of a medically supervised walking test on a treadmill based on either a modified Balke protocol or the Bruce protocol[41]. Technically, it did not matter which protocol was used because gas was analyzed and both protocols are designed to reach VO_{2max} within 10-12 minutes as recommended [222].

The Balke protocol consists of increasing the slope by 1% every two minutes, and by keeping the same speed throughout the test[223]. The starting speed was self-selected by asking the participant to walk at a comfortable speed for about 15 minutes. On the other hand, the Bruce protocol changes the speed by 1.3 mph, and the slope by 2% every three minutes. The starting speed is 1.7 mph and the starting slope is 10%. The tests proceeded until either the participant was too tired to go any further, reported any kind of pain or presented any cardiac symptoms (e.g. arrhythmia, angina). Participants were asked to self-report the intensity using the Borg scale (0-10[188]) 5-10 seconds before the end of each stage throughout the test. The maximum self-reported perceived exertion score was kept for analyses. Maximal aerobic capacity was determined by the highest oxygen consumption sample collected during the treadmill test. After the test, the research staff decided if the participant achieved a VO_{2max} or a VO_{2peak} based on typical criteria used to establish a VO_{2max}[202].

There are many criteria used to determine if a person has reached VO_{2max} such as reaching lactate threshold, reaching theoretical maximal HR 220-age[224], Respiratory Quotient (RQ) ≥ 1.11[225], reaching a perceived rate of exertion ≥17/20 or ≥ 9/10[48] and observing a plateau in O_2 (≤ 2 ml/kg/min for two consecutive loads) even if the load increases[202]. The most common criteria involves RQ, reaching the theoretical maximal HR, and the plateau in O_2[202]. Typically, when the individual does not achieve a minimum of two of the three main criteria for VO_{2max} criteria (i.,e RQ, plateau, reaching the estimated maximal HR) the result is called $VO_{2peak,}$ because it is possible that the person could physiologically consume more oxygen in another test or on a different occasion. VO_{2peak} is correlated with VO_{2max} and is more realistic to achieve for inactive people, especially among those presenting risk factors for CVD[46]. Once VO_{2peak} was determined, the next step (second visit) was to identify how fast each participant needed to walk (cadence) in order to achieve moderate intensity. At the end of that first visit, a second visit was schedule for this purpose.

Second Visit

A walking test was performed to determine the cadence needed to reach at least moderate intensity (40% of $VO_{2reserve}$) based on the VO_{2max} or the $VO2_{peak}$ obtained during the first visit. This second visit took approximately 20 minutes. In addition to the portable metabolic cart to measure oxygen consumption, participants were asked to wear a foot pod (Garmin FR60, Rome, Italy) to determine walking cadence. Once the equipment was installed, the participant was asked to start walking at his or her usual pace for a warm-up. Once participants were comfortable with the equipment, they were given verbal queues to speed up or down until they reached 40% of $VO_{2reserve}$ (values of which had been calculated before meeting the participant) displayed on the portable metabolic cart. Once the participant reached 40% of $VO_{2reserve}$ he or she was asked to maintain that cadence for two minutes before slowing down the cadence and removing the equipment. A research assistant recorded the cadence when the participant reached 40% of $VO_{2reserve}$ by walking close to him/her during the test, so he was ready to see the instant results (VO2) displayed by the portable metabolic cart.

Stride length and lower leg length were also measured. To measure lower leg length, participants were asked to remove their shoes and sit on a chair with both feet touching the floor. The measurement was taken from floor to the knee mid-patela using a measuring tape. The measure was taken three times as proposed[226]. Stride length (the distance between successive ground contacts considering one of the body sides[227]) was measured according to a validated method[228]. A 16-metre flat walkway was then divided in three parts, the second part being the actual measure. The first five metres were used by the participants to reach their typical pace when walking. The next six metres were used to measure the distance of each stride. The final five metres were used to allow the participants to slow down. The procedure involved a piece of chalk that was strapped to the back of the participant's shoe, leaving marks on the ground for every stride taken. The stride length value was considered to be the average of all valid stride length recorded.

To measure the self-selected walking cadence, participants were asked to walk at their typical pace for a 200-metre distance (1 lap on the indoor track) giving them enough time to reach a steady-state walking cadence. A foot pod was attached to the participants' shoes to record walking cadence. Self-selected walking cadence was then recorded at the moment participants crossed the 200-metre mark. Walking speed was determined using the same test by dividing the time needed by the distance (200 metres).

Feedback and Recommendations

During the second visit, each participant was provided with an individualized walking cadence, based on the cadence needed to reach moderate intensity (40% of $VO_{2reserve}$[229]). It was explained that this was the minimum cadence to walk in order to reach moderate intensity and therefore, meet the minimum intensity recommended to optimize health and functional benefits [60]. Each participant received a pedometer as compensation for taking part in the study and were instructed how to apply their personalized walking cadence with the device to reach moderate intensity while walking.

Measures Obtained from Fitness Facilities

Some data was collected by the staff at each fitness facility and made available in the members' dossier. These dossiers include self-reported information on risk factors for CVD, chronic conditions, medications for chronic conditions, and physical activity levels. Some objective measures were also available such as BMI and blood pressure. In some cases (73% of the sample), results from fasting blood work (e.g., cholesterol level) were available. The information was accessed and analyzed after the completion of the study by the research staff. The questionnaires, developed by each fitness facility, were not validated. These questionnaires are typically filled out when someone first registers at the fitness facility, usually when scheduled for a graded exercise test or when requested by a physician. Although the questionnaires from both fitness facilities are similar, it was difficult to combine all information for data analysis. For example, Reh-Fit asks members to self-report being diagnosed for 17 specific chronic conditions, but Wellness Institutes only seeks information for nine conditions. In addition, some of the chronic conditions from both fitness facilities are not the same. The information in the results section is the only documentation that matched in both fitness facilities. As a result, only the information regarding CVD, diabetes, pulmonary disease, and arthritis are reported. The details on how each fitness facilities collected these data are presented below.

Data Collected at the Reh-Fit Centre

Data from the Reh-Fit Centre was collected from a questionnaire entitled "Health & Lifestyle Questionnaire" (APPENDIX 1). This questionnaire is divided into nine sections. Only four sections of the questionnaire were used for the purpose of the study. In the first section members have to check each box that applies to them in regards to CVD, metabolic diseases, pulmonary diseases, and major signs and symptoms of cardiovascular, pulmonary or metabolic diseases. There is a question: "Do you have a history of any of the following?" For CVD, the conditions were: cardiac disease, stroke, congenital heart disease, heart failure, heart valve disease, peripheral, and, vascular disease. For pulmonary disease, the conditions were: asthma, chronic obstructive pulmonary disease, cystic fibrosis and interstitial lung disease. Diabetes (type I or type II) was the only metabolic disease kept in the analysis because the Wellness Institute did not ask a question regarding renal disease. Major signs and symptoms of cardiovascular, pulmonary or metabolic diseases were not analyzed.

Section 2 asks 10 questions in regards to the main risk factors for CVD, following the same pattern of checking the boxes that apply to them. For example, there is a question "Are you presently a male and older than 45 years?" The third section is related to medication and/ chronic conditions. In this section, members are asked, “Have you ever been diagnosed with or prescribed medication for any of the following conditions?” sixteen conditions are listed and there is a possibility to include other conditions. Categories were created to combine chronic conditions into groups based on the fact that both fitness facilities collected the information: Diabetes, CVD, pulmonary diseases, and arthritis. In terms of medication, some members have a separate form filled out by their physician where members have to self-report what medication (s) they are currently taking. When available, the research staff preferred information from a physician rather than self-reported information. Some members say the reason they take a medication (e.g., blood pressure), but others report the name of the medication (e.g., Metformin). If that was the case, the research staff referred to the *Compendium of Pharmaceuticals and Specialties*[230] to identify what the medication is normally prescribed for. Then, the chronic conditions were grouped into categories: diabetes, CVD, pulmonary diseases, and arthritis. The sum of the chronic conditions was then calculated among these four categories, using the sub-conditions included for CVD. Each sub-conditions for CVD, and all the other categories, was given a score of “1” if the member was self-reporting the condition. If not, a score of “0” was given. Therefore, the maximum was nine. In terms of the sum of medications, the total was based on taking at least one medication for each category. Here, the maximum was four. In the final section of interest, members have to self-report their physical activity level spent at moderate to vigorous intensity per week. They are asked about the frequency and amount of time per week. The number of minutes spent doing exercise per week is then calculated.

Data Collected at the Wellness Institute

In what is called "You Could Be at Risk Questionnaire" members of the Wellness Institute are asked to answer questions in six parts (Appendix 2). As with the Reh-Fit centre, members are asked about their chronic conditions, their risk factors for CVD, physical activity level and medications. Members have to circle "yes" or "no" from a list of chronic conditions, risk factors for CVD, and physical activity level. For all "Yes" answers, a code of "1" was entered in the data. Only the information that matched that documented at the Reh-Fit was kept for analysis. The biggest difference between the two facilities is how they collect the information regarding medications. At the Wellness Institute, the staff do not select the conditions for which people take medication. Instead, members are asked to answer the following question: "What medications are you currently taking?" The *Compendium of Pharmaceuticals and Specialties* [230] was also used to identify what the medication is normally prescribed for. Then, the chronic conditions were grouped into the same categories as Reh-Fit members.

Statistical Analysis

The distribution of every continuous variable was tested using the Shapiro-Wilk tests. If variables were not normally distributed variables were described using the median (25^{th}-75^{th} percentile) instead of means ± SD. Chi-square testes were used to compare the walking cadence between groups of individuals having or not having specific risk factors for CVD (sex/age, tobacco use, blood pressure, high glucose level, physical inactivity, high lipid profile, overweight/obese, family history). Depending on the distribution, Spearman's or Pearson's correlation tests were used to evaluate what continuous variable was associated with walking cadence. To develop and validate an algorithm to predict walking cadence to reach moderate intensity, the sample was randomly divided into two groups using Statistical Package for the Social Sciences (SPSS) software: development sample (n=46) and validation sample (n= 45). We performed a linear regression using a stepwise procedure with the development sample. Walking cadence to reach moderate intensity was determined as dependent variable, and clinical variables associated with it in bivariate analyses were entered in the model: body weight, height, BMI, and cadence at a selected pace. The best model was identified as that having the highest adjusted R^2.

The Variance Inflation Factor (VIF) score was verified to avoid collinearity in the model (i.e, score ≥10)[231]. The variance inflation factor quantifies the severity of multicollinearity in a regression analysis, and provides a sense if one regression coefficient is mistakenly increased because of collinearity[232]. Interaction terms were tested in the final model. Then, the model was validated using a cross-validation method[233] with participants not involved in the development of the algorithm. This model validation technique assesses how the results of a statistical analysis will be applicable to an independent dataset. It is mainly used in settings where the goal is to predict a dependent variable and when one wants to estimate the accuracy of a predictive model for clinical practice[233]. By utilizing the created algorithm, the predicted walking cadence was calculated and compared with the measured walking cadence to reach moderate intensity using the Mann Whitney test. Finally, a Pearson's correlation was performed between the predicted cadence to reach moderate intensity and the measured walking cadence to reach moderate intensity. All statistics were performed using SPSS version 1

CHAPTER 4: RESULTS

Of the 100 participants recruited for the study, 80 were from the Reh-Fit centre. Nine participants were excluded from the analyses. One person did not attend the stress test after showing interest; four did not attend their second visit, and four were excluded because the research team experienced technical problems with the metabolic cart while collecting the data during the first visit. The analyzed sample consisted of 91 participants: 49 women and 42 men (Table 7) with a mean ± SD age of 64.3 ± 10.3 years, and a median (25^{th}-75^{th} percentile) BMI of 29.2 kg/m^2 (24.7-33.3). The median time of self-reported physical activity per week spent at least at moderate intensity was 120 minutes (48.8–180.0). Although 39.5% of the study sample did not self-reported any chronic condition that we analyzed from questionnaires, 29% reported at least one CVD, 17% at least one pulmonary disease, 17% reported having arthritis, and 13% reported being diabetic. The mean number of chronic conditions analyzed (CVD, pulmonary diseases, diabetes and arthritis) was 1.7 ± 1.3. As for medications, 75% of our sample self-reported taking one or less medication for CVD, pulmonary diseases, diabetes and arthritis, with 20% of the sample reporting taking at least one medication for CVD. Characteristics of participants who were later randomly selected to create or validate the algorithm for walking cadence are presented in Table 7. No statistical difference was observed between the two groups.

Table 7. Descriptive Characteristics of the Sample

	Total (n=91)	Sample for Algorithm Development (n=47)	Sample for Algorithm Validation (n=44)
Age (yrs)	64.3 ± 10.3	63.9 ± 0.2	64.7 ± 10.5
Sex (women)	49 (53.9)	21 (44.7)	20 (45.4)
Height (m)	1.7 ± 0.1	1.7 ± 0.1	1.7 ± 0.1
Body Weight (kg)	83.9 (70.4 – 95.3)	84.3 ± 1.9	87.0 ± 21.9
Body Mass Index (kg/m^2)	29.2 (24.7 – 33.3)	29.8 ± 6.8	31.1 ± 7.0
Self-Reported MVPA (min/week)	120 (48 – 180)	119 ± 18	122 ± 7
Selected Self-Reported Chronic Conditions			
At least one CVD	26 (28.6)	14 (29.8)	12 (27.3)
Cardiac Disease	17 (18.7)	8 (17.0)	9 (20.4)
Stroke	3 (3.3)	1 (2.1)	2 (4.5)
Congenital Heart Disease	0 (0.0)	0	0
Heart Failure	2 (2.2)	2 (4.2)	2 (4.5)
Heart Valve Disease	4 (4.4)	1 (2.1)	3 (6.8)
Peripheral Vascular Disease	0 (0.0)	0	0
Diabetes	12 (13.2)	6 (12.8)	6 (13.7)
At least one Pulmonary Disease	15 (16.5)	8 (17.0)	7 (15.9)
Arthritis	15 (16.5)	7 (14.9)	8 (18.2)
Not Reporting any of the Selected Chronic Conditions	36 (39.5)	19 (40.4)	17 (38.6)
Sum of the Selected Chronic Conditions (0-9)	1.7 ± 1.3	1.9 ± 0.2	1.5 ± 3.0
Selected Condition for which Participants Report Taking Medication			
CVD	18 (19.8)	6 (12.7)	12 (27.3)
Diabetes	5 (5.4)	3 (6.4)	5 (11.4)
Pulmonary Disease	12 (13.2)	4 (8.5)	8 (18.2)
Arthritis	15 (16.5)	4 (8.5)	11 (25.0)
Sum of Medication (0-4)	0.5 (0.0-1.0)	0.5 ± 0.1	0.5 ± 0.1

Data presented as Mean ± SD, median (25th-75th percentile) or N (%): MVPA = moderate-Vigorous physical activity.

Table 8. Risk Factors for CVD

	N (%)	Walking Cadence with Risk Factor	Walking Cadence without Risk Factor
Men older than 45	42 (100.0)	115 (108-120)	-
Women older than 55	36 (73.4)	116 (110-123)	120 (110-128)
Current Smoker or quit <6 months	6 (6.6)	112 (108-121)	116 (110-122)
Blood Pressure (≥140/90mmHg)	18 (19.8)	116 (112-120)	116(108-124)
Glycaemia (≥5.6mmol/L or 100 mg/dL)	5 (5.5)	112 (105-121)	116 (109-122)
Physical Activity (<150min/week)	29 (31.9)	116 (112-122)	118 (108-124)
Total Cholesterol (≥5.2mmol/L or ≥200mg/dL)	33 (36.3)	116 (112-128)	116 (108-122)
Overweight (≥25kg/m^2)	67 (73.6)	114 (110-120)	119 (108-125)
Family History (yes)	25 (27.5)	118 (112-123)	116 (108-123)
Number of risk factors			
1 risk factor for CVD	10 (11.0)		
2 risk factors for CVD	27 (29.7)		
3 risk factors for CVD	26 (28.6)		
4 risk factors for CVD	21 (23.1)		
5 risk factors for CVD	6 (6.6)		
7 risk factors for CVD	1 (1.1)		
Sum of Risk Factors for CVD	3 (2-4)		

Data presented as N (%) or median (25th-75th). The cut-off for each risk factor was based on the ACSM[160].

The most prevalent risk factors for CVD are shown in Table 8. All men in the study were 45 or older. Among the women, 73% were 55 years old or older. Family history, physical inactivity, and being overweight were the most prevalent risk factors for CVD in our sample, measured at 25%, 29%, and 67%, respectively. For each risk category, Mann-Whitney tests were performed to identify if the walking cadence was different between people having or not having that particular risk factor. No significant difference was noted. About 80% of our sample had between two and four risk factors for CVD. The median (25^{th}-75^{th} percentiles) of total risk factors for CVD for the sample was 3 (2–4).

The results obtained from the aerobic test are presented in Table 9. The purpose in showing these results is to indicate if most participants performed a VO_{2max} or a VO_{2peak}. Since only 32 participants (35%) reached a minimum of two criteria for VO_{2max}, the term VO_{2peak} was used for the remaining part of the test. The median (25^{th}-75^{th} percentile) VO_{2peak} for participants was 21.3 ml/kg/min (17.9 – 25.5). When participants reached their VO_{2peak} the median respiratory quotient was 1.2 (1.1 – 1.3) and the mean ± SD rate of perceived exertion was 6.1 ± 1.6. The maximum HR reached during the test was 146 beats per minute (134–164); 9.7 beats lower than the maximum HR estimated with the common formula 220-age. Among the 91 participants, 76 people stopped the aerobic test due to exhaustion (83.5%). RQ and maximal HR were the two physiological criteria most observed for VO_{2max}. However, we did not observe a plateau in VO_2 for anyone. Finally, only 35% of our sample reached a minimum of two criteria out of four for VO_{2max}.

Table 9. Aerobic Test

VO_{2peak} (ml/kg/min)	21.3 (17.9 – 25.5)
Respiratory Quotient at VO_{2peak}	1.2 (1.1 – 1.3)
Peak Rate of Perceived Exertion (1-10) at VO_{2peak}	6.1 ± 1.6
HR_{max} (beats/min) at VO_{2peak}	146 (134.0 – 164.0)
Estimated HR_{max} based on the equation 220-age	156 ± 10.3
Reason to Stop the Test	
HR_{max} achieved	8 (8.8)
Exhaustion	76 (83.5)
Pain	7 (7.7)
Selected Criteria for Reaching VO_{2max}	
Respiratory Quotient ≥ 1.1	54 (59.3)
Rate of Perceived Exertion ≥ 9/10	7 (8.1)
HR ± 10 beats from Estimated HR_{max} (220-age)	52 (57.1)
Plateau in oxygen (≤ 2ml/kg/min for two consecutive loads)	0 (0)
Reaching two or more criteria	32 (35.2)

Data presented as median (25^{th}-75^{th} percentile), Mean ± SD or N (%); VO_{2max} = maximum volume of oxygen consumption; VO_{2peak} = peak volume of oxygen consumption; METs = maximal metabolic equivalent of task; HR= Heart Rate.

The mean walking cadence to reach moderate intensity was 115.8 ± 10.3 steps/min (Table 10). Also, our results did not show a significant difference in walking cadence between men [114 (109 – 119)] and women [117 (108 – 122), $p > 0.05$]. When participants were asked to walk at a comfortable pace the mean walking cadence selected was 122.1 ± 10.2 with a mean speed of 1.44 ± 0.23 m/s.

Table 10. Information Collected During the Second Visit

Lower Leg Length (cm)	**42.5 ± 5.3**
Stride Length (cm)	148.2 (137.0 – 161.3)
Walking Cadence to Reach Moderate Intensity (steps/min)	115.8 ± 10.3
Cadence at Selected Pace (steps/min)	122.1 ± 10.2
Walking Speed at Selected Pace (m/s)	1.44 ± 0.23

Data presented as Mean ± SD or median (25^{th}-75^{th})

The correlation between the measured walking cadence to reach at least moderate intensity and variables known to be associated with walking cadence, or potentially associated with it, are presented in Table 11. Pearson's correlations walking cadence to reach moderate intensity, was significantly associated with height ($r = -0.31$, $p<0.01$), body weight ($r = -0.36$, $p<0.01$) body mass index ($r = -0.26$, $p<0.05$), measured VO_{2peak} ($r = 0.52$, $p<0.01$), and cadence at selected pace ($r = 0.37$, $p<0.01$).

Linear regression was used to first create an algorithm to predict which of the associated variables identified in bivariate analyses would help estimate measured walking cadence to reach moderate intensity. The sample was randomly split in two groups: one group used to create the algorithm (n=47) and one group used to validate the algorithm (n=44). No statistical difference was observed between groups (Table 7). To create the algorithm, all clinical variables that were statistically significant in bivariate analyses (i.e., height, body weight, body mass index, and cadence at selected pace) were included in the linear regression model. When doing so only body weight (p=0.018) remained significant.

Table 11. Correlation between Measured Walking Cadence and Collected Variables

Variables	r (p value)
Age	- 0.18 (0.76)
Height	-0.31 (< 0.01)
Weight	-0.36 (< 0.01)
Body Mass Index	-0.26 (<0.05)
Measured VO_{2peak}	0.52 (< 0.01)
Weekly Physical Activity Time at MVPA	0.73 (0.58)
# of Self-reported Chronic Conditions	-0.19 (0.09)
# of Self-reported Medications	-0.18 (0.10)
Total Risk Factors for CVD	0.01 (0.93)
Predicted Maximum Heart Rate (220-age)	0.19 (0.08)
Lower Leg Length	-0.22 (0.03)
Stride Length	0.08 (0.44)
Cadence at Selected Pace	0.37 (< 0.01)
Walking Speed	0.10 (0.69)
Predicted Walking Cadence	0.23 (0.14)

MVPA = Moderate-to -Vigorous Intensity; CVD = Cardiovascular DiseasesVO_{2peak} = Peak volume of oxygen

The identified algorithm to predict the walking cadence to reach moderate intensity was:

$$134.4 - 0.24\ (body\ weight\ in\ kg)$$

This algorithm explains 13% of walking cadence ($p<.01$). Once the algorithm was identified, it was tested with the validation sample. When using the developed algorithm in the validating sample to estimate the walking cadence needed to reach moderate intensity, differences between the predicted walking cadence and the measured walking cadence in that sample was a median (25^{th}-75^{th}) 3.9 (-1.6; 9.6). However, this difference between the two results (measured and estimated walking cadence to reach moderate intensity) was not significant (p=0.18). The correlation between the predicted walking cadence and the measured walking cadence in the validation sample was 0.36 (p=0.01).

CHAPTER 5: DISCUSSION

The first objective of this study was to identify the walking cadence needed for people with risk factors for CVD to reach moderate intensity using laboratory measures. Our results showed that the mean walking cadence to reach moderate intensity in our sample of adults aged 64.3 ± 10.3 years old was 116 ± 10 steps per minute. Up to 95.6% (87 out of 91) of our participants needed more than 100 steps per minute to reach moderate intensity. In addition, the correlation between the measured and the predicted walking cadence needed to reach moderate intensity (using our algorithm) was significant (r=0.36; p=0.01). As a result, we are proposing that the developed algorithm should be used to predict the walking cadence in similar individuals instead of using the 100 steps per minute commonly prescribed.

The second objective was to use the collected clinical information (e.g., body weight, age) to develop and test an algorithm to help professionals working with individuals having risk factors for CVD to estimate the walking cadence needed to reach moderate intensity without the use of costly equipment. The algorithm developed was:

$$134.4 - (0.24 \text{ x body weight}_{(kg)}).$$

Walking Cadence and CVD

We hypothesized that people with risk factors for CVD were going to need a slower walking cadence to reach a minimum of moderate intensity. The reason stemmed from the fact that at all four risk factors for CVD are directly related to a lower fitness level (i.e., age[65], smoking[217], being overweight[3,234], and being physically inactivity[4,11,29,60,61,66,70,185,190,218]). Age and being overweight are also known to influence the gait pattern[235]. Thus, an individual risk factor or a combination of risk factors could potentially be associated with a lower walking cadence to reach moderate intensity. In addition, the current public health recommendation of 100 steps per minute was either conducted with adults[15,16,20,21,215] or with apparently healthy older adults[24,179]. Despite that rational, our results are not pointing in that direction even if our sample had a median of three risk factors for CVD. In fact, neither the total number of risk factors nor the individual risk factors were associated with walking cadence needed to reach moderate intensity. For example, people classified as being inactive based on self-reported information (<150 minutes per week of aerobic exercise at moderate to vigorous intensity) did not have a significant difference in walking cadence (116 steps per minute vs. 118 step per minute; $p=0.67$). However, it is well known that self-reported physical activity is biased and normally overestimated compared with an objective measure of physical activity level[236-238]. It is possible that an objective measure of physical activity could have led to a different result. In our study, a median physical activity time of 120 minutes per week was self-reported even if most participants were only starting a structured exercise program when they answered the questionnaire. This is confirmed by the fact that the median VO_{2peak} was 21.3 ml/kg/min, which, according to the ACSM norms[35], is considered “poor” or “really poor”, depending on age and sex. Because of the strong association between VO_{2peak} and physical activity level[44], it is possible that that the actual physical activity level reported by our participants may have been lower if objectively measured. Based on the information reported in this section, our results suggest that the risk factors for CVD are not associated with the walking cadence needed to reach moderate intensity. Everything discussed in the following sections will be based on our sample presented with at least two chronic conditions, which is common for Canadians age 65 and older[57].

Walking Cadence and Individual Characteristics

The number of steps measured in our study to reach moderate intensity was greater than what is currently reported (116 steps per minute vs. 100 steps per minute[15,16,20,21,179,214,215]). An explanation for such a difference might be a disparity in individual characteristics. For example, many studies in the literature looked at younger samples[15,16,20,21]. From these studies, only one reported a difference in walking cadence between men and women[15]. In our study no difference was observed between men and women. The median walking cadence for men was 114 (109 – 118) and 117 (108 – 122) for women. Five variables including four clinical variables were significantly correlated with walking cadence in bivariate correlation analyses: height ($r = -0.31$, $p<0.01$), body weight ($r = -0.36$, $p<0.01$), BMI ($r = -0.26$, $p<0.05$), VO_{2peak} ($r = 0.52$, $p < 0.01$), and cadence at selected pace ($r = 0.37$, $p<0.01$). Other studies have also reported that to reach moderate intensity there is a correlation to height[21,24], age[24], and fitness level[16]. However, when entering a regression model the four clinical variables associated with the walking cadence required to reach moderate intensity (i.e., height, body weight, BMI and cadence at selected pace) we have found that only body weight remained in the model, which is not supported by the current literature in adults. Collinearity might explain why the other three clinical variables (i.e. height, BMI, and cadence at selected pace) did not remain significantly associated with the required walking cadence needed to reach moderate intensity in the regression model. Collinearity is defined as a high association between variables to predict an independent variable[239]. In our study, the correlation between body weight and BMI, height, and self-selected walking cadence was 0.85, 0.51, and 0.77, all statistically significant ($P<.01$). In other words, if we were to include these variables in the model, the R^2 would not significantly increase, however, individually these variables are associated with the walking cadence needed to reach moderate intensity, which is consistent with the literature studying younger adults[16,24].

Walking Cadence and Body Weight

Although many studies have argued that carrying more weight influences walking pattern, it appears we are the first to report that body weight is associated with walking cadence needed to reach moderate intensity once adjusted for other potential confounders[240]. Even if BMI did not remain in the final regression model, the correlation between BMI and body weight was 0.87 ($p<0.01$). In most cases, if a person weights more, there is a greater chance to be overweight or obese. In addition, BMI was associated with the walking cadence required to reach moderate intensity in bivariate correlation ($r= -0.26$; $p= 0.04$). Therefore, we decided to compare our results with the literature reporting information about overweight and obese versus normal-weight individuals. With that being said, we are not the only study reporting no association between BMI and the walking cadence required to reach moderate intensity. Two previous studies have tested the impact of BMI on walking cadence and reported no association with walking cadence using linear regression analyses[15,241]. Both have reported that BMI was not associated with the required walking cadence to reach moderate intensity. One of these studies suggested that gender might play a role in walking cadence; women would need a greater cadence to reach moderate intensity (107 steps per minute) compared to men (102 steps per minute)[16]. The other study reported that older subjects would have lower walking speed because of a smaller stride length compared to young adults[241].

At first glance, it seems odd that body weight would be a significant predictor of walking cadence required to reach moderate intensity, but not a risk factor for CVD of being overweight.

Additional sub-analysis on the influence of BMI on walking cadence required to reach moderate intensity revealed that the median required number of steps per minute between normal weight, overweight and obese was 114, 116, and 119, respectively. In other words, it is possible that if body weight or BMI is evaluated with the continuous variable, it is more sensitive to the change in the required walking cadence to reach moderate intensity compared to whether the analysis is done by categories.

Obese individuals are known to have a higher prevalence of falls and stumbling during ambulation[242]. As a result, they are prone to shorten the distance of their steps, and to take more steps to cover the same distance in an effort not to fall[242]. As observed in our study, such a walking pattern could lead to a greater walking cadence to reach moderate intensity compare to young adults. Supporting the same idea, a recent study concluded that overweight people have significantly less physical activity time performed using 100 steps per min when compared to individuals considered to have a "normal" body weight[243].

Another reason why we are the first to report that body weight is a significant predictor of the walking cadence required to reach moderate intensity could be the fact that most published studies on the subject of walking cadence recruited participants lighter than our sample[15,16,20,21,24]. For example, in Rowe et al.[21], the mean body weight was almost 10 kg lighter than our sample (75.6 kg vs. 83.9 kg).

Even if body weight was the only significant variable predicting walking cadence to reach moderate intensity when analyzing the data with a linear regression model, the body weight difference to change the prescription of walking cadence was relatively small (-0.24). In other words, to increase the walking cadence prescription by one step, one would have to be 4.2 kg heavier. Although a considerable amount of body weight is needed to change the walking cadence prescription to reach moderate intensity this difference becomes significant as the range of body weight in the population changes widely. This issue is relevant because of the growing obesity epidemic [183].

Walking Cadence and Age

The number of studies completed to determine walking cadence to reach moderate intensity in older adults is minimal[24,179]. A common classification for older adults is age 60[162]. The first study was a cross-sectional examination of 15 people, mean age of 69.12 ± 6.4, who were asked to walk in laboratory settings and use an accelerometer for seven consecutive days, 24 hours each day. The researchers found that older adults were performing at an average cadence of 107.9 ± 9.4 when asked to move at their comfortable walking cadence in a laboratory setting. However, when monitored for intensity duration, only an average of eight minutes per participant was spent at that cadence per day in free-living conditions[179]. This suggests that even if we observed that the average walking cadence at self-selected cadence was greater (122 steps per minute) compared with the walking cadence prescription to reach moderate intensity (116 steps per minute) it is possible that our sample is not walking at that pace very often in free living activities. The second study was conducted with older adults (mean age 71.2 ± 7.0). Participants were asked to walk at three different self-selected speeds on a treadmill, each speed lasting 4 minutes. As with us, they found that "medium speed" exceeded the 100 steps per min (111 ± 12)[24].

Until now, most studies have been conducted with young adults (18-55 years old)[15,16,20,215,241]. Our results showed that older adults take more steps per minute to reach moderate intensity compared to younger people[15,16,20,21,215]. This is supported by Tudor-Locke et al.[179] who also reported a higher walking cadence to reach moderate intensity (average 110 steps per minute) with an older sample (69.1 ± 6.4 years old). Similarly, in a sample of 29 people ranging from 60 to 87 years old, Peacock et al. reported that age was an important predictor of walking cadence[24]. In order to achieve at least moderate intensity in older adults, a lower walking cadence was expected than what is observed in younger adults, since aging is associated with more chronic conditions[244], greater body weight[24], lower fitness level[46,245], lower physical activity level[46], and a fear of falling while walking[27]. However, older adults have a different gait pattern that seems to increase the walking cadence to reach the same intensity[246]. Nagasaki et al. have shown that walking pattern tends to change as people age and older adults take more steps than younger people to cover the same distance[246]. Echoing this premise, Herman et al. reported that gait unsteadiness is a key feature for the change in walking pattern[27], while Friedman et al. found that fear of falling resulted in walking more carefully by taking shorter steps compared to younger adults[26].

A study conducted with 15 older adults (68.0 ± 3.9 years old) found that older people have a shorter step length [25] compared with younger people. Thus, older adults could need more steps per minute to reach moderate intensity while walking. Although age seems to be a factor that could potentially explain why older people take more steps to reach moderate intensity compared to younger adults, we did not observe an association between age and walking cadence needed to reach moderate intensity ($r = -0.18$, $p = 0.76$). This observation may be explained by the fact that we have mostly recruited people over the age of 60 with a range from 54 to 74 years old. A sub-analyses was made to compare the walking cadence needed to reach moderate intensity in three different age groups based on tertiles with a median age of 55, 65, and 75 years old. No significant difference was observed between the youngest and oldest tertiles in the walking cadence needed to reach moderate intensity ($p = .12$). According to the literature and our results, we hypothesize that if one would recruit people in a broad age range, age would be a predictor for the walking needed to reach moderate intensity.

Walking Cadence and Methods to Determine Moderate Intensity

In comparing our findings with the literature, a difference in methods is another explanation why we observed a greater walking cadence needed to reach moderate intensity. All other studies have used 3METs[15,16,20,21,24,179,215] to identify moderate intensity, while we used 40% of $VO_{2reserve}$. We suggest that using a proportion of $VO_{2reserve}$ is better than using METs to evaluate exercise intensity. First, although both methods can be used to evaluate exercise intensity[61,68], METs are absolute values, and, therefore, do not consider individual characteristics (e.g, age, fitness level)[192], whereas $VO_{2reserve}$ is a relative measure of intensity and does consider these individual characteristics[223]. Two people could have a different fitness level but be prescribed the same intensity based on METs. In our sample, one participant achieved a VO_{2peak} of 39.6 ml/kg/min (11.3 METs) on the graded exercise test. For another participant, the VO_{2peak} achieved was 28.3 ml/kg/min (8.1 METs). For these two people, 3 METs would be equivalent to 10.5 ml/kg/min [192] (3 X 3.5ml/kg/min). This would represent 27% of VO_{2peak} for the first example and 37% for the second participant. In addition, when evaluating moderate intensity based on 40% of $VO_{2reserve}$[229], neither of these participants would reach moderate intensity. Tudor-Locke et al. acknowledged the fact that the association between METs and walking cadence to reach moderate intensity is not perfect when using 3 METs as the criteria for moderate intensity[16]. In fact, they reported that only 50% to 60% of individuals would be correctly classified as walking at moderate intensity when walking at 100 steps per minute[16].

Since $VO_{2reserve}$ (VO_{2max} – resting VO_2) and HRR (HR_{max} – resting HR) are 100% correlated[229], it is possible for clinicians to predict HR_{max} (using 220-age equation [224]) and measure resting HR to prescribe exercise and prescribe exercise intensity based on HRR with the assumption that it is strongly correlated with $VO_{2reserve}$.

Only two studies have recruited older adults using 3 METs as the criteria to reach moderate intensity[24,179] by recruiting small samples. The first one published in 2013 recruited 15 people with a mean age of 69.12 ± 6.4[179] and reported that walking cadence to reach moderate intensity was 106 steps per minute. The other study using a similar age sample[24] included 29 active older women. The researchers concluded a similar or even higher average walking cadence to reach moderate intensity (mean of 111 ± 12 steps minute [114 steps/min for 65-75 years old and 104 steps per min for women age over 75 years old]), compared to the typical recommendation of 100 steps per minute to reach moderate intensity. These studies recruited participants who were similar to those in our research, but found a lower walking cadence compared to our findings, perhaps because of a difference in how moderate intensity was identified (3 METs vs. 40% of $VO_{2reserve}$).

One of the two studies developed an algorithm to estimate energy expenditure: METs = stride $\text{rate}_{steps/min}$ x 0.06 + height_{cm} x 0.07 + age_{yrs} x 0.06 – 18.30 [24]. When using their algorithm with our information (METS = $115.8_{steps/min}$ x 0.06 + 170_{cm} x 0.07 + 64.3_{years} x 0.06 – 18.30), we obtained a result of 4.4 METs. This means that 40% of $VO_{2reserve}$ our study had the equivalent about 4.4 METs based on Peacock's algorithm[24]. Peacock et al.[24] also measured the walking cadence needed to reach 4 METs and the average cadence was 114 steps per minute, which is very close to our results. On the other hand, when implementing our algorithm [134.4 – 0.24 x (body weight $(_{kg})$] to predict walking cadence using the descriptive information from Peacock et al. ($134.4 - 0.24 \times 63.85_{kg}$)[24], their walking cadence would be 119 steps per minute, which is also very close to our results. That being said, we are suggesting that if one wants to use METs to predict walking cadence to reach moderate intensity, 4METs should be the target, and not 3 METs, in an effort to be a bit closer to the relative measure of walking cadence to reach moderate intensity in a similar population group. In our study, if 4 METs were used as the cut-off to reach minimum of moderate intensity, 91% of our sample would reach moderate intensity equivalent to 40% of $VO_{2reserve}$. Also, because of all the benefits associated with vigorous intensity [186,247], the problem is not to surpass the actual threshold to reach moderate intensity, but to be lower than the threshold and not optimally obtain the health benefits from reaching moderate intensity while exercising. By recommending 4 METs instead of 3 METs, it is simply more likely that one would reach moderate intensity.

Walking Cadence at Self-Selected Pace

In our study, when asking participants to walk at a comfortable pace, the mean walking cadence was 122 ± 10, which was six steps above the minimum walking cadence needed to meet moderate intensity based on our results. This outcome suggests that our sample was already reaching moderate intensity in a free-living walking environment. However, this was only tested over a 200-metre distance and does not tell us if these people would be able to sustain that walking cadence for an entire walking session and reach the current guidelines[4]. One study has actually demonstrated that by recruiting 15 older adults to evaluate free-living walking cadence. Researchers found a mean walking cadence of 108 steps per min when participants were asked to walk at their normal cadence in a laboratory setting[179], but when participants wore accelerometers for one week (seven consecutive days, 24 hours each day), the time spent above that walking cadence was only eight minutes. Therefore, although older adults are able to reach the proposed minimum walking cadence to reach moderate intensity in a laboratory setting, this intensity does not seem to be maintained in free-living conditions[179].

Usefulness of the Developed Algorithm

In our study, the predicted walking cadence to reach moderate intensity was an average of 3.9 steps per minute from the measured walking cadence to reach moderate intensity, with an error of 3%. Given that 94.5% of our sample needed more than 100 steps per minute to reach moderate intensity, our algorithm could be used as a tool to help similar people reaching moderate intensity while walking. Clinicians could use our algorithm to prescribe walking cadence to reach moderate intensity in a similar population group by simply measuring body weight in kilograms and compute the information in the algorithm. On the other hand, for the algorithm to be useful for participants, they would have to purchase a pedometer giving walking cadence (about $30) or use a conventional pedometer ($10) that provides the total number of steps, and divides the workout time to get the walking cadence once they received their individualized walking cadence.

Since most people deem walking as their preferred form of exercise[7], including sedentary people who plan to become physically active[7], our algorithm could help these people introduce exercise in their routine, along with having a goal to reach and maintain a minimum intensity known to be associated with optimal health benefits. In addition, pedometers are considered to be a motivator in helping people maintain an exercise program[8]. Thus, it is likely that people could stick longer to the exercise prescription when using a pedometer as a tool to walk at the optimal intensity.

Limitations

Despite the novelty of this study, some limitations need to be mentioned. First, some participants had never walked on a treadmill prior to taking the treadmill test so it is possible that the VO_{2peak} was significantly lower from their VO_{2max}. Second, some participants were fasting for 12 hours as required for a blood test prior to taking part in the aerobic test. Even if they managed to have a snack between the two tests, this might have jeopardized their performance due to not having enough time for digestion, and comfortably perform the exercise test. Third, some data collected during the study was self-reported which tends to be inaccurate (e.g., body weight, amount of medication[248]). Even if there is some value to self-reported data, it is generally not objective. Trusting participants' memory as well as staff ability/accuracy on filling out questionnaires, especially if the questionnaire is not validated, may be biased. Fourth, many specific details on medication (e.g., type, history, dosage) and chronic conditions (e.g., history) were not collected by fitness facilities. As a result, it was not possible to adjust for the specific type of medication or chronic condition that could have affected participants' walking cadence to reach moderate intensity. Another important limitation to be mentioned is the compatibility between the questionnaires of the two fitness facilities. Although some information collected from both questionnaires could be adequately combined and then entered in the dataset for analysis, some information was not considered because of a mismatch in how the two facilities compile data. In addition, some of the known risk factors for CVD, such as diet, were collected nor analyzed in the current study. Finally, the algorithm developed in this study only explains 13% of the measured walking cadence. This means that further research in this area is needed to increase the reliability of the algorithm to predict the walking cadence needed to reach moderate intensity.

Potential Impact of the Study

Fitness facilities and the general public could benefit from the results. In the case of fitness facilities, the results could get their staff to use our algorithm to prescribe an individualized cadence needed for similar individuals (with or without risk for CVD) to reach moderate intensity while walking. For the general public, purchasing a pedometer that provides feedback on walking cadence could help them do more steps at moderate intensity once they measured their body weight and adjust the cadence required to reach moderate intensity in their pedometer. This new way of measuring moderate intensity is important as most people in the age range studied are choosing to walk as their primary form of aerobic exercise. Future research in this area should test if an intervention using the developed algorithm to prescribe walking cadence is helping people with risk of CVD to reach moderate intensity when walking. More research is also needed to identify how to adjust the walking cadence prescription when one's become fitter or if ones loses weight.

Conclusion

People in their sixties presenting one or more risk factors for CVD are reaching moderate intensity while walking at a cadence above the one officially recommended for healthy adults. Our sample showed a median of 116 steps per minute was needed to meet moderate intensity while walking. According to our study, the number and the type of risk factors for CVD evaluated were not significantly associated with the walking cadence required to reach moderate intensity. The collected data shows only body weight was associated with the walking cadence needed to reach moderate intensity. Subsequently, an algorithm was developed [134.4 – (0.24 x body weight $_{(kg)}$)] to help clinicians working with a similar clientele. This would require them to measure body weight, to ask their client to purchase a pedometer that cost from $10 to $30, and for the clinician, to take the time to explain the approach. Based on our results we suggest using our algorithm to prescribe walking cadence to reach moderate intensity instead of using the common 100 steps per minute as the target. This study is a starting point in an effort to understand how many steps such population needs to reach moderate intensity while walking. However, research is certainly needed in order for this proposed algorithm to become well-established.

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APPENDIX

Appendix 1: Reh-Fit Centre Questionnaire

Health & Lifestyle Questionnaire

reh-fit centre

1390 Taylor Avenue, Winnipeg, Manitoba, R3M 3V8
Phone: (204) 488-8023 / Fax: (204) 488-4819

Name: ______________________ **Date:** ______________

DOB: ______________________
Month Day Year

HEALTH SCREENING

Section 1

Do you have a history of any of the following? (*please check all that apply to you*)

Cardiovascular Disease:
- ☐ cardiac catheterization
- ☐ cardiac disease
- ☐ cerebrovascular disease (stroke/TIA)
- ☐ congenital heart disease
- ☐ coronary angioplasty
- ☐ heart attack
- ☐ heart failure
- ☐ heart surgery
- ☐ heart transplantation
- ☐ heart valve disease
- ☐ pacemaker/implantable cardiac defibrillator
- ☐ peripheral vascular disease (PVD)

Metabolic Disease:
- ☐ diabetes (Types 1 and 2)
- ☐ renal disease

Pulmonary Disease:
- ☐ asthma
- ☐ chronic obstructive pulmonary disease
- ☐ cystic fibrosis
- ☐ interstitial lung disease

Major Signs and Symptoms of Cardiovascular, Pulmonary or Metabolic Disease:
- ☐ chest discomfort with exertion
- ☐ dizziness, fainting, or blackouts
- ☐ unpleasant awareness of a forceful rapid heart rate
- ☐ take heart medications
- ☐ ankle swelling
- ☐ unreasonable breathlessness (at rest, with mild exercise, or when lying down)
- ☐ burning or cramping sensation in your lower legs when walking short distances
- ☐ pain or discomfort in the chest, neck, jaw, arms or elsewhere that may be due to ischemia (relative lack of blood supply)

Section 2

Are you presently?
- ☐ male and older than 45 years
- ☐ female and older than 55 years, had a hysterectomy (with ovaries removed), or are postmenopausal
- ☐ smoker (or quit within the past 6 months)
- ☐ hypertensive (blood pressure is >140/90 mm Hg) or on blood pressure medication
- ☐ more than 20 pounds overweight (BMI> 30)
- ☐ physically inactive (not exercising >=30 minutes, 3x/week for past 3 months)
- ☐ pre-diabetic (impaired fasting glucose 6.1 to 6.9 mmol/L or oral glucose tolerance test 7.8 to 11.0 mmol/L)

Do you have?
- ☐ a close blood relative who had a heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister)
- ☐ high total cholesterol >5.2 mmol/L

HEALTH QUESTIONS

Y N Are you pregnant?

Y N Do you have any musculoskeletal problems/recent injuries (muscle, bone, or joint) that may affect your ability to exercise at Reh-Fit? If yes, please explain: ____________________

____

Y N Do you have concerns about your ability to exercise safely at Reh-Fit (weakness, lack of coordination, poor balance, poor memory, pain, swelling or decreased range of motion etc.)? If yes, please explain: ____________________

____

Y N Have you undergone any surgeries that may limit/affect your ability to exercise safely at the Reh-Fit? If yes, please explain: ____________________

____

Y N Do you have a history of falls? Do you use a walking aid? *(please circle in addition to selecting Y/N)*

Have you ever been **diagnosed** with or **prescribed medication** for any of the following conditions?

- ☐ Neuropathies (problems with sensations)
- ☐ Multiple sclerosis
- ☐ Other neurological conditions
- ☐ Arthritis
- ☐ Parkinson's disease
- ☐ Polio/post-polio syndrome
- ☐ Osteoporosis
- ☐ Cancer
- ☐ Epilepsy or other seizure disorder
- ☐ Anxiety/Depression
- ☐ High cholesterol
- ☐ Cardiovascular disease
- ☐ High blood pressure
- ☐ Stroke
- ☐ Diabetes
- ☐ Thyroid disease
- ☐ Other (*please specify*): ____________

Y N Do any of your medications cause side effects that might affect your ability to exercise (weakness, drowsiness, dizziness, confusion, lack of coordination, muscle or joint pain etc.)? If yes, please explain: ____________________

Y N Do you have any allergies to medication? If yes, please specify: ____________________

BODY COMPOSITION

Current Height__________ cm/inches Current Weight ____________ kg/pounds

HEALTH & FITNESS GOALS

- ☐ Weight Loss
- ☐ Improved Strength and Flexibility
- ☐ Improved Overall Health
- ☐ Performance
- ☐ Other (*please specify*): ____________________

PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR HISTORY

PHYSICAL ACTIVITY

Frequency: In a typical week, how many days do you do moderate-intensity (such as brisk walking) to vigorous-intensity (such as running) aerobic physical activity? _________ days per week

Time or Duration: On average for days that you do at least moderate-intensity aerobic physical activity (as specified above) how many minutes do you do? _________ minutes per week

In a typical week, how many times do you do muscle strengthening activity (such as resistance training or very heavy gardening)? _________ times per week

SEDENTARY BEHAVIOUR

On a typical day, how many hours do you spend in continuous sitting: at work, in meetings, volunteer commitments and commuting (i.e. by motorized transport)?

☐ None ☐ < 1 hour ☐ 1 to < 2 hours ☐ 2 to < 3 hours
☐ 3 to < 4 hours ☐ 4 to < 5 hours ☐ 5 to < 6 hours ☐ > 6 hours

On a typical day, how many hours do you watch television, use a computer, read, and spend sitting quietly during your leisure time?

☐ None ☐ < 1 hour ☐ 1 to < 2 hours ☐ 2 to < 3 hours
☐ 3 to < 4 hours ☐ 4 to < 5 hours ☐ 5 to < 6 hours ☐ > 6 hours

READINESS

The following questions will help us determine the best approach to help you achieve your goals and recommend the most appropriate programs and services available at the Centre.

1. Check the statement which most closely describes you.
   - ☐ I am not physically active and I do not plan on becoming so in the next six months.
   - ☐ I am not physically active, but I have been thinking about becoming so in the next six months.
   - ☐ I am physically active once in a while, but not regularly.
   - ☐ I am currently physically active, but have begun doing so within the last six months.
   - ☐ I am physically active and have done so for more than six months.

   - ☐ I was physically active in the past, but not now.
2. If you are not currently physically active, were you physically active in the past? Y/N

I have answered all questions truthfully and to the best of my knowledge. I have not knowingly withheld any information regarding my health.

I understand it is my responsibility to update the Reh-Fit Centre staff about any changes in health status that could affect my ability to safely participate at the Reh-Fit Centre.

_______________________________ _______________________________
Participant/Guardian Signature Date

Thank you for taking the time to complete our Health & Lifestyle Questionnaire.

OFFICE USE ONLY

Risk Stratification:

☐ 1. Low
☐ 2. Moderate
☐ 3. High

Stage of Change:

☐ Pre-Contemplation
☐ Contemplation
☐ Preparation
☐ Action
☐ Maintenance

Recommended:

☐ Level 1 Assessment
☐ Level 2/3 Assessment (without 12 lead GXT)
☐ Level 2/3 Assessment (with 12 lead GXT)
☐ Physiotherapist Consultation
☐ Nutrition Consultation
☐ Cardiac Rehabilitation Program

Staff Comments:

Staff Signature

Appendix 2: Wellness Institute Questionnaire

thewellness Institute

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CERTIFIED
MEDICAL FITNESS
FACILITY

You Could Be at Risk Questionnaire

Name: .... Date: ....

Part 1

1. Has a doctor ever told you that you have heart disease (heart attack, heart bypass surgery, valve disease/repair, congestive heart failure, angina)?
   Describe: .... yes no
2. Do you feel pain in your chest at rest, during daily activities, OR when you do physical activity? yes no
3. Has a doctor ever told you that you have diabetes? yes no
4. Have you ever had a stroke (this includes Transient Ischemic Attack (TIA) or Cerebrovascular Event)? yes no
5. Has your doctor told you that you have a blockage to the circulation in your legs (peripheral vascular disease)? yes no
6. Have you had a Graded Exercise Test (Stress Test) in the past 4 months? DR. ....

Part 2

7. Are you a male over 45 years or a female over 55 years? yes no
8. Does your waist measure more than 40 inches? (Male) yes no
9. Does your waist measure more than 35 inches? (Female) yes no
10. Do you smoke or have you quit smoking in the last 6 months? yes no
11. Do you have high blood pressure or are you being treated for high blood pressure? yes no
12. Do you have high cholesterol or are you being treated for high cholesterol? yes no
13. Do you get less than 30 minutes of moderate intensity exercise per day, most days of the week? (Moderate activities include walking, active gardening, swimming, dancing, biking, etc.) yes no

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You Could Be at Risk Questionnaire

14. Were any of your blood relatives (parents or siblings) diagnosed with heart disease or stroke before the age of 55 (male) or 65 (female)? yes no

15. Do you have or have you ever had high blood sugar or borderline diabetes? yes no

Part 3

16. Do you have:

a) A rheumatoid condition? yes no Describe: ....

b) A joint, back or neck injury that significantly limits your exercise? yes no Describe: ....

c) COPD, Pulmonary Fibrosis or Emphysema that significantly limits your exercise? yes no Describe: ....

17. Have you had a:

a) Joint replacement within the last year? yes no Describe: ....

b) Stroke (excluding TIA)? yes no

c) Spinal cord injury? yes no Describe: ....

d) Neurological condition? yes no Describe: ....

Part 4

18. Has a doctor ever told you that you have a Lung Disease? (Asthma, Chronic Bronchitis, Emphysema, COPD or Pulmonary Fibrosis)? yes no

19. Do you cough regularly? yes no

20. Do you cough up phlegm regularly? yes no

21. Do you get frequent colds that persist? yes no

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CERTIFIED MEDICAL FITNESS FACILITY

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You Could Be at Risk Questionnaire

22. Do you become short of breath easily? yes no

23. Do you wheeze when you exert yourself or at night? yes no

Part 5

24. What medications are you currently taking? ....

....

....

25. Have you had a recent seizure or been diagnosed with seizure disorder? Do you take mediciation for it?

....

....

Part 6

26. What are your health and wellness goals? (check all that apply)

- ❑ Eat Healthy
- ❑ Quit Smoking
- ❑ Gain Strength
- ❑ Increase Endurance
- ❑ Improve Sport Performance
- ❑ Lose Weight
- ❑ Rehab and Injury
- ❑ Other: ....

27. Reasons for joining the Wellness Institute are: (check all that apply)

- ❑ Accessibility Features
- ❑ Family Day and Kids Corner
- ❑ Pool
- ❑ Badminton
- ❑ Fitness Classes
- ❑ Sport Training
- ❑ Doctor Recommended
- ❑ Good Location
- ❑ Staff Expertise
- ❑ Facility is Great
- ❑ Medical Condition
- ❑ Good Value
- ❑ Other: ....

thewellness Institute

wellnessinstitute.ca
CERTIFIED
MEDICAL FITNESS
FACILITY

You Could Be at Risk Questionnaire

Please carefully read the following Consent to Participate. Once you have read the Consent, please initial each of the statements to which you agree and leave blank any statement to which you do not agree. Finally, sign and date the form at the bottom where indicated.

I, ..., (print name) hereby consent to participate in the Health Risk Assessment Screening that may include a cardio metabolic risk assessment, stress test, and personal wellness plan. I understand that personal health information collected about me will be used to assist the Wellness Institute in developing an individualized wellness plan and to evaluate the Wellness Institute's membership programs. I understand that the information collected about me will be collected, stored, and destroyed in compliance with The Personal Health Information Act of Manitoba (PHIA). If I have any questions or concerns about the collection, storage, or destruction of my personal health information, I understand that I may direct them to the Seven Oaks General Hospital PHIA Officer at (204) 632-3288.

1. I have read and understood the above Consent and agree to participate in the Health Risk Assessment Screening. .... (Initial)
2. I agree to have all medical information and test results forwarded to and/or received from the following physicians: .... (Initial)

   1. Physician: ....
      Address: ....
      ....
   2. Physician: ....
      Address: ....
      ....
   3. Physician: ....
      Address: ....
      ....

3. I agree to have the Wellness Institute at Seven Oaks General Hospital contact me in the future regarding follow up and evaluation. .... (Initial)

Date: .... Members Signature: ....

Appendix 3: Advertisement Material

Health, Leisure & Human Performance RESEARCH INSTITUTE

RESEARCH OPPORTUNITY

UNIVERSITY OF MANITOBA

How fast do you need to walk to achieve the optimal health benefits?

Congratulations! You have decided to become more active. Even though you will move more and potentially have health benefits, there is a specific intensity level that you need to reach if you want to have "more bang for your buck". The Canadian Physical Activity Guidelines recommend that all adults do a minimum of 150 minutes of moderate- to vigorous-intensity aerobic exercises + 2 days of resistance training per week to optimize health benefits. However, it is hard to identify what is considered moderate-to vigorous intensity.
Two researchers from the University of Manitoba want to give you the opportunity to identify how fast YOU need to walk in order to reach moderate-to vigorous intensity.

To be part of this study, you will be asked to wear a small mask to collect your breathing while you do the stress test. This test will identify your maximum capacity. Then, you will be asked to meet an exercise specialist to walk for a maximum of 20 minutes on the indoor track at your gym. This test will determine how many steps per minute YOU need to do in order to reach moderate- to vigorous-intensity as recommended to achieve optimal health benefits.

As a token of appreciation, for your participation, you will be offered a pedometer and an individualized cadence prescription that you can use in future workouts, OR ten dollars cash.

There is no obligation to take part in this research and your decision will not affect the service you receive in the future at your facility.

To participate or have more information, contact the research assistant, Fagner Serrano by phone at 204-474-7878 or by email at fagner.serrano@gmail.com.

Appendix 4: Inform Consent

TITLE: Walking Cadence to Attain Optimal Aerobic Intensity in Patients at Risk of Cardiovascular Diseases

Principal Investigator: Danielle Bouchard, PhD.
Faculty of Kinesiology and Recreation Management. Health, Leisure and Human Performance Research Institute. 318 Max Bell Centre, University of Manitoba, Winnipeg, Manitoba, Canada. Phone (204) 474-8627, danielle_bouchard@umanitoba.ca.
Co-Investigator: Todd Duhamel, PhD.
Faculty of Kinesiology and Recreation Management. Health, Leisure and Human Performance Research Institute. 318 Max Bell Centre, University of Manitoba, Winnipeg, Manitoba, Canada. Phone (204) 474-8922, todd.duhamel@ad.umanitoba.ca

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

You are being asked to participate in a research study because you qualify in taking part in a treadmill test before you start exercising in your fitness facility. Please take time to review this consent form and discuss any questions you may have with the research staff. The research staff includes one graduate student and his supervisors, the staff at the reception, a physician and, a technician that will supervise your treadmill test. You may take your time to make your decision about participating in this study, and you may discuss it with your regular doctor, friends and family before you make your decision. You can be assured that your level of service through the facility will not be affected by your decision to participate in this study. This consent form may contain words that you do not understand. Please ask the research staff to explain any words or information that you do not clearly understand.

Purpose of Study: The main reason why most people, at risk of cardiovascular diseases, who join a fitness facility is to become healthier. The initial strategy is usually to start walking more. However, walking more does not necessarily guarantee significant positive health benefits (e.g., weight management, reduce blood pressure). The current Physical Activity Guidelines recommend doing aerobic exercise for a minimum 150 minutes at moderate- to vigorous-intensity. This study is exploring a novel strategy to help you and other patients at risk of cardiovascular diseases to reach that intensity while you walk, whether it is in our facility or when you are home.

Study procedures: 100 men and women that qualify to perform a treadmill test will be recruited for this study. If you choose to participate in this study, you will be asked to come meet the research staff **only twice**. Below is a brief description of the different measurements and questionnaires that will be assessed at your fitness facility. The first visit will be the treadmill test and the second visit will involve a walking evaluation on the indoor track. Each visit will be completed within an hour.

Visit 1: The treadmill test will consist of walking on a treadmill. After a short warm-up, the treadmill will progressively increase slope and speed according to a specific protocol adapted for adults with cardiovascular risks. The test will continue until you either reach your predicted maximum heart rate (220-age), become exhausted, or if you experience any cardiac symptoms (e.g., arrhythmia, angina). YOUR maximal capacity will be determined by oxygen consumption at the maximum intensity achieved on the treadmill test. To collect oxygen during your test, you will be asked to wear a small mask covering your nose and mouth. This mask will not obstruct in any way your normal breathing.

Once your maximal capacity has been determined on the treadmill test, the next step will be to define how fast you need to walk to achieve the intensity recommended by the Physical Activity Guidelines. Based on your availability, staff at the front desk will schedule your second visit for the walking cadence test on the flat indoor track.

Visit 2: The field test will identify the walking cadence required to reach at least 45% of your capacity previously determined on the treadmill test. During the test, you will be asked to wear the same small mask you wore during the treadmill test, wear a heart-rate monitor and a foot pod [small equipment (2 cm X 2 cm) placed on your sneaker]. You will simply be asked to walk at your rhythm starting slow and increasing your cadence progressively. Once the minimal intensity target is reached, the cadence will be recorded by a research staff member and the test will stop. Based on our experience, the test itself should take between five and ten minutes.

In addition to the two visits that shall provide valuable information, participants will also be asked to give permission to researchers to access additional clinical information. This information is already available from the centre as part of the initial assessment. Those variables are age, resting heart rate, blood pressure, weight, waist circumference, height, medication type (s) and dose. If you accept to share this information, the fitness facility staff will make a copy of the requested information. This information will be useful to better understand our results.
All data will be treated as confidential in accordance to the Personal Health Information Act of Manitoba. Any information that may reveal personal identity such as name, address or telephone number will be removed prior to data analysis in order to ensure patient anonymity and confidentiality.

Risks and Discomforts: Some people may fear doing exercise when they are identified as having cardiovascular disease risk factors. However, there is a large amount of evidence that demonstrates that the benefits of regular exercise out-weight the risks. In fact, the risk of death while exercising for cardiac patients is estimated to be minimal. For example a study reported only one death for each 334,000 exercise hours. In our study, these risks are further reduced because the Reh-Fit Centre and the Seven Oaks General Hospital Wellness Institute have trained medical personnel on site and all treadmill tests are medically supervised.

Benefits: By participating in this study, you will have personal benefits and you will help other members from your fitness facility to obtain a walking cadence prescription without by only doing the first treadmill test (no mask). Personally, you will learn how fast you need to walk to optimize health benefits when you are walking for exercise. In addition, you will also acquire knowledge about the physical activity guidelines and exercise intensity.

Confidentiality: Information gathered in this research study may be published or presented in public forums, however your name and other identifying information will never be revealed. All your information kept at the university will be identified by your participant number and not your name. All records will be kept locked and only the research assistant, Fagner Serrano, and the two investigators will have access to these records. Certain authorized organizations may inspect and/or copy your research records for quality assurance and data analysis purposes. These organizations may include representatives of the study sponsor or funding agencies who may have oversight responsibilities for the study. For example, the University of Manitoba may look at the research records to see that the research is being done in a safe and proper way.

<u>Feedback</u> You will be provided an opportunity to have an individualized walking cadence at the end of the second visit. After receiving this information your results, if 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. A feedback form will be provided and your results will be sent to you if you want through postal service or email as of your preference.

<u>Costs</u>: All research-related procedures, which will be performed as part of this study, are provided at no cost to you.

<u>Compensation</u>: After you have completed the field test, you will receive a pedometer as well as the individualized walking cadence prescription. For example, you will be told how many steps you should do in 15 minutes to walk at the intensity associated with optimal health benefits. If you prefer instead of the pedometer and the prescription you will be given the option to take ten dollars in cash.

<u>Alternative</u>: You do not have to participate in this study to learn how to exercise at the optimal intensity. All trainers at your fitness facility can give you similar exercise services.

<u>Voluntary Participation/Withdrawal From the Study</u>: 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 notice to the research assistant, Fagner Serrano, by phone at (204) 474-7878 or by email at walk.cadence@gmail.com. He will then communicate the information to all research staff by email. However, all data collected before your withdrawal will be kept and analyzed unless you mention to Mr. Serrano that you want all collected data to be destroyed when you communicate your wish to withdraw. All necessary medical treatment or medical care needed as a result of your participation will be available at no additional cost to you. 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.

<u>Questions</u>: 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, or if you have a research-related injury, 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 consent form unless you have had a chance to ask questions and have received satisfactory answers to all of your questions.

<u>Statement of Consent</u>

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 the 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. Consent forms have also been approved by the Reh-Fit Fitness Centre and the Seven Oaks General Hospital Wellness Institute. 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) at 474-7122. A copy of this consent form has been given to you to keep for your records and reference.

Participant signature______________________ Date _________________
Researcher and/or Delegate's Signature: ____________________________ Date______________

Appendix 5: Pictures of the Portable Metabolic Cart

Appendix 6: Walking Cadence Prescription

Based on your results, your minimal walking cadence is ______ (steps/min) to reach moderate intensity which is the one recommended by the Canadian Physical Activity Guideline.

Desired Walking Exercise Time (min.)	Target steps when you walk
5	
10	
15	
20	
30	
45	
60	