Pain as a Barrier to Physical Activity in Severe Obesity and the Alter-G Anti-Gravity Treadmill as a Potential Therapeutic Tool

by

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TABLE OF CONTENTS

ABSTRACT

Obesity is highly prevalent, and more than 36.5% of American adults have obesity. Common barriers to physical activity in people with obesity are pain and low enjoyment, and both may contribute to low levels of activity. The use of the Alter-G Anti-Gravity Treadmill as a therapeutic tool to overcome these barriers is a new area explored in this study. Specific aims explored in this study were to determine if: Aim 1 - pain was associated with physical functioning in obesity, Aim 2 - exercise barriers were reduced by using the unweighting function of the Alter-G Anti-Gravity Treadmill, and Aim 3 - energy expenditure of moderate intensity exercise sessions with self-selected duration was similar in weighted and unweighted groups.

Healthy adults (20- 55 years) with obesity (≥30 BMI) were recruited for this study. Participants were randomized into two groups with the control group exercising at 100% body weight and the experimental group using the unweighting function with self-selection of body weight. This project was an analysis of baseline data from a longer randomized trial of a 12 week walking program. Measurements taken during the baseline visit include physical functioning test (6-minute walk test and Timed Up and Go) and questionnaires (Short-Form McGill Pain Assessment, Physical Activity Enjoyment Scale (PACES), and History of Joint Pain). After baseline measurements, energy expenditure during exercise sessions (calculated by the Alter-G`s Stride Smart system), Physical Activity Enjoyment Scale (after experiencing the Alter-G Anti-Gravity Treadmill for three workouts), and Subjective Pain during exercise sessions (provided by the Alter-G`s Stride Smart system) were measured.

There were sixteen (9 female, 7 male) participants (age *M* = 33.06, *SD* =10.99, weight (kg) *M* = 107.51, *SD* = 13.30, BMI (kg/m²) *M* = 37.94, *SD* = 5.20) that participated in the study. They were randomized into two groups (control *n* = 10, experimental *n* = 6). There was no detectable association between pain and physical functioning. Subjective pain was not statistically different between the two groups (p = .156), and change in PACES scores were not statistically different between groups (p = .947). However the experimental group did have a statistically significant increase in PACES scores from the baseline measurement (*M* = 82.40, *SD* = 14.63) to the measurement taking after the 3rd visit (*M* =92.40, *SD* = 10.71) (p = .043). There was no difference in energy expenditure between groups. The exercise sessions were broken down into average speed, incline, and duration. The average speed (p = .280) and incline (p = .758) was not statistically different between groups, but the duration was significantly higher in the experimental (*M* = 45.64, *SD* = 2.43) group compared to the control (*M* = 37.52, SD = 1.81) group, (p = .020). This study demonstrated that a walking protocol using the unweighting feature of Alter-G Anti-Gravity Treadmill was associated with a significant increase in PACES score, and that using the unweighting feature of the Alter-G Anti-Gravity Treadmill can cause the duration during exercise be higher, leading to similar energy expenditure compared to exercising at 100% body weight.

LIST OF FIGURES

LIST OF ABBREVIATIONS

American College of Sports Medicine (ACSM)

Body Mass Index (BMI)

Centers of Disease Control and Prevention (CDC)

Heart Rate Reserve (HRR)

Lower Body Positive Pressure Treadmill (LBPPT)

Physical Activity Enjoyment Scale (PACES)

Physical Activity Readiness Questionnaire (PAR-Q+)

Rate of Perceived Excretion (RPE)

Timed Up and Go Test (TUG)

CHAPTER I

INTRODUCTION

Obesity is an issue worldwide. According to the Centers for Disease Control and Prevention (CDC) more than 36.5% of American adults have obesity (Centers for Disease Control and Prevention, 2017). The different classifications are Class 1 (body mass index (BMI) $\geq$ 30 kg/m^2), Class 2 (BMI $\geq$ 35 kg/m^2), or Class 3 (BMI $\geq$ 40 kg/m^2) obesity (Ogden, Carroll, Fryar, & Flegal, 2015).

Although exercise is therapeutic for obesity (Chin, Kahathuduwa, & Binks, 2017), people with severe obesity experience many barriers to exercise, including greater joint pain while exercising (Shawn R. Simonson, 2011). Pain is associated with obesity (Hitt, McMillen, Thornton-Neaves, Koch, & Cosby, 2007). Also, pain is predictive of physical inactivity in people with obesity (Sallinen et al., 2009). Physical inactivity has been found to be a significant contributor to metabolic diseases, including obesity, diabetes, hypertension, and cardiovascular disease (Vuori, 2007). As this population continues to grow, the need for interventions and new technology to treat obesity is urgent.

Those with obesity could benefit from moderate physical activity (Faghri P, 2015), such as walking at a self-selected pace on a treadmill. The Alter-G Anti-Gravity Treadmill is unique with features that make it particularly suitable to overcoming physical activity barriers in severe obesity. The Alter-G Anti-Gravity Treadmill has a cockpit surrounded by an air chamber that can create positive pressure to help reduce the subject’s weight and stress on their lower extremities. However, it is unclear if the benefits associated with exercise would diminish using the Alter-G Anti-Gravity

Treadmill due to exercising at a lower percentage of body weight, which would reduce energy expenditure during exercise.

Indeed, using the unweighting feature of the Alter-G Anti-Gravity Treadmill at 80% of body weight reduces oxygen consumption in the last stage of a Bruce stress test by 6.0 ml/kg/min, and it reduces energy expenditure by an average of 173 kcal in a 30 minute exercise session (Figueroa, 2012). However, participants with obesity have never been allowed to self-select their pace and duration in studies previously using an Alter-G Anti-Gravity Treadmill, so it is still unclear if, when using the unweighting feature of the Alter-G Anti-Gravity Treadmill, people engage in longer durations that may still lead to equivalent energy expenditure despite the potentially reduced exercise intensity. If individuals with obesity had access to the Alter-G treadmill, they could exercise at a reduced total body weight, which we hypothesize may in turn reduce the barriers to exercise, since the exercise may be conducted with more comfort.

We had three specific aims in this project. The first specific aim will be to determine if pain is associated with physical functioning in obesity. The second specific aim is to determine if exercise barriers are reduced by using the unweighting function of the Alter-G Anti-Gravity Treadmill. The third specific aim is to determine if energy expenditure of exercise sessions with self-selected duration is similar in weighted and unweighted groups.

CHAPTER II

REVIEW OF LITERATURE

Exercise in Obesity Treatment

According to the American College of Sports Medicine (ACSM) the most recent estimate of the percent of adults in the United States classified as having overweight or obesity is 68% (American College of Sports Medicine, 2018). Obesity is associated with significant increased risk of mortality, reduced quality of life and a greater risk of developing many chronic diseases (Fontaine, Redden, Wang, Westfall, & Allison, 2003). Chronic diseases associated with obesity include diabetes, heart disease, some cancers, sleep apnea, and osteoarthritis (Shawn R. Simonson, 2011).

People with obesity and severe obesity could benefit from increased physical activity in several ways (Baillot et al., 2014). First, exercise can produce small amounts of weight loss (American College of Sports Medicine, 2018). Losing 5-10% of one's body weight has been shown to produce health benefits including reduced risk of diabetes, heart disease, and countless musculoskeletal problems (Look & Wing, 2010). Other benefits include increased energy, better quality of sleep, fewer aches and pains associated with obesity, and making everyday activities less taxing (Warburton, Nicol, & Bredin, 2006).

Obesity and a mostly sedentary lifestyle can have a detrimental effect on an individual’s health (Faghri P, 2015; Jebb & Moore, 1999; Shawn R. Simonson, 2011). On average 17% of adults are inactive and 41% do not get sufficient exercise (Vuori, 2007), and those with obesity are no exception. Less than 150 minutes per week of moderate activity is considered insufficient, where the recommended amount of moderate activity is 180 to 210 minutes per week (Vuori, 2007). The recommended amount of physical activity per week to prevent weight gain is 150 to 250 minutes a week, 200 to 300 minutes of physical activity per week to maintain weight after weight loss, and 225 to 420 minutes of physical activity per week to promote weight loss (Donnelly et al., 2009). There is evidence indicating that an increase of physical activity could reduce the incidence of metabolic and cardiovascular cases (Vuori, 2007).

Even if those with obesity begin an exercise program, adherence to the program may be an issue. Factors that can create obstacles to adhering to exercises are low motivation, negative history with exercise, and low self-efficacy (Dalle Grave, Calugi, Centis, El Ghoch, & Marchesini, 2011). A study of adherence to an exercise-based cardiac rehabilitation program with 12,003 patients reported that 56% of patients with obesity and no diabetes and 59% of patients with obesity and diabetes did not adhere to the cardiac rehabilitation program (Forhan, Zagorski, Marzonlini, Oh, & Alter, 2013).

Pain is a common barrier to physical activity, which can lead to low exercise adherence in those with obesity. High pain levels in this population may be associated with lower quality of life (Jia & Lubetkin, 2005), decreased enjoyment of exercise (Allender, Cowburn, & Foster, 2006), and lower physical functioning (Fontaine & Barofsky, 2001), as has been demonstrated in other populations with chronic pain (Dailey et al., 2016). Individuals with obesity also experience an increased perceived rate of exertion, more skin friction, urinary stress incontinence, low back pain, and hip arthritis compared to the lean population, which may significantly impair their ability to adhere to an exercise regimen (Ekkekakis & Lind, 2006; Hulens, Vansant, Claessens, Lysens, & Muls, 2003). Therefore, individuals with severe obesity could benefit from tools that help to overcome these barriers and enable them to exercise.

Obesity and Pain

Pain can be debilitating in many ways, and physical functioning is just one of many aspects negatively impacted by pain. Pain can influence physical movements as well as the amount of physical behavior (A. Paraschiv-Ionescu, Perruchoud, Buchser, & Aminian, 2012; Anisoara Paraschiv-Ionescu, Perruchoud, Rutschmann, Buchser, & Aminian, 2016). About 100 million Americans suffer from chronic pain (Academies, 2011), where 10% suffer from chronic pain worldwide (Jackson et al., 2016).

The prevalence of pain is 33% in individuals with obesity, which is higher than the general population (Green et al., 2016). Likewise, people with chronic pain commonly have obesity or overweight (Okifuji & Hare, 2015). Chronic pain in obesity can include widespread pain (Yoo, Cho, Lim, & Kim, 2014), pelvic pain (Gurian et al., 2015), headaches (Chai, Scher, Moghekar, Bond, & Peterlin, 2014), abdominal pain (Eslick, 2012), neuropathic pain (Miscio et al., 2005), as well as osteoarthritis of the knee (Hartz et al., 1986). Chronic pain in obesity may also explain higher sleep disturbances that occur with obesity (A. Wachholtz, Binks, Suzuki, & Eisenson, 2009).

Pain may significantly impact an individual`s ability to manage their obesity for several reasons. First, pain can contribute to weight gain from lack of physical activity caused by fear of pain, physical disability, and fear of increasing pain (Arranz, Rafecas,

& Alegre, 2014; Tukker, Visscher, & Picavet, 2009). Tukker et al. (2009) found a strong association between being overweight or obese and osteoarthritis in the lower extremities. Also, obesity can increase the prevalence of musculoskeletal pain (Vincent, Adams, Vincent, & Hurley, 2013). People with severe obesity are at a greater risk of having alterations in biomechanical forces, leading to chronic musculoskeletal pain and impaired mobility, thus leading to physical disability (Vincent et al., 2013). Along with chronic pain, people with obesity have a lower quality of life (Arranz et al., 2014). With a lower quality of life people with obesity may experience depression. Chronic pain and depression interfere with daily functioning (Amy Wachholtz, Binks, Eisenson, Kolotkin, & Suzuki, 2010). Wachholtz et al. (2010) found that increased leg/joint pain and headaches also are associated with a reduction in daily functioning. With musculoskeletal pain leading to reduced mobility, which could also lead to depression, a person with obesity would not be able to be physically active at the level required to manage their obesity.

In addition, pain may inhibit weight loss due to using food as a coping mechanism. Choi et al. (2014) found that people with obesity and reported osteoarthritis pain also had a higher calorie and fat intake compared to osteoarthritis patients with normal weight (Choi et al., 2014). Amy Janke and Kozak (2012) conducted research with 30 adults in a primary care facility with a mean BMI of 36.8. The researchers conducted in-depth interviews with the participants and analyzed the transcripts. They found five themes that emerged from the interviews, the first being that patients with chronic pain and obesity experienced depression which could hinder treatments. Second, hunger was triggered by pain and was associated with depression and shame. They also found that emotional eating was associated with pain, and that pain also altered dietary choices. Lastly, pain was associated with low self-efficacy for physical activity. Importantly, therefore, using food to cope with chronic pain may result in a reduction in weight loss ability (Amy Janke & Kozak, 2012) and increase in caloric intake (Choi et al., 2014).

Physical Functioning in Obesity

Having obesity may also attenuate physical functioning, independent of pain. People with obesity have a lower self-reported score on physical functioning (Hergenroeder, Brach, Otto, Sparto, & Jakicic, 2011) when compared to normal weight.

Hergenroeder et al. (2011) examined the association of body mass index with a self-reported performance-based measure of physical functioning in adult women. The researchers compared 50 sedentary women across five BMI categories (normal weight, overweight, obese class I, obese class II, and obese class III). They performed a 6-minute walk test and found significant difference between normal weight and class I obesity, normal weight and class II obesity, and normal weight and class III obesity. The distance covered by class III could be attributed to slower gait speed (Hergenroeder et al., 2011). They also found that participants categorized as obese felt more limited in life tasks compared to those that were normal and overweight.

Another study by Hulens et al. (2002) performed the 6-minute walk test in 85 people with overweight and obesity, 133 women with severe obesity, and 82 women with normal weight. The results of the 6-minute walk test showed a significant difference in distance covered and speed between women of normal weight and women with severe obesity. Women with severe obesity walked at a slower pace, and covered less distance during the test. They also reported that the rate of perceived exertion (RPE) was significantly higher in women with severe obesity compared to normal weight women.

The Impact of Lower-Body Positive Pressure and Exercise Intensity and Energy Expenditure

Lower-body positive pressure treadmills have an impact on energy expenditure during exercise. The difference in energy expenditure is driven primarily by the reduction in body mass that occurs on a lower-body positive pressure treadmill (LBPPT). Even at 100% body weight, the treadmill reduces an individual's body weight by approximately 3% due to the cockpit set up (Raffalt, Hovgaard-Hansen, & Jensen, 2013). Energy expenditure during exercise has been previously studied while running/walking on a treadmill or LBPPT.

Figueroa et al (2012) conducted research to validate the ACSM metabolic equations using a LBPPT. Their results indicate that the ACSM prediction equations did not accurately predict energy cost at different body weights. Indeed, using the unweighting feature of the Alter-G Anti-Gravity Treadmill at 80% of body weight reduces oxygen consumption in the last stage of a Bruce stress test by 6.0 ml/kg/min, and it reduces energy expenditure by an average of 173 kcal in a 30 minute exercise session (Figueroa, 2012).

Reduced oxygen consumption has been seen in previous research (McNeill, Kline, de Heer, & Coast, 2015; Ruckstuhl, Schlabs, Rosales-Velderrain, & Hargens, 2010; Stucky, Vesin, Kayser, & Uva, 2018; Temple et al., 2017) while using a LBPPT.

Although the populations examined were elite distance runners (McNeill et al., 2015), young healthy male and females (Ruckstuhl et al., 2010), healthy male adults (Stucky et al., 2018), and normal and overweight individuals (Temple et al., 2017) no study has been done using a population with obesity.

Obesity and Alter-G Anti-Gravity Treadmill

The Alter-G Anti-Gravity Treadmill has been used in clinical settings to help patients initiate walking again after knee reconstruction surgery, hip replacement surgery, and other lower body injuries. Also, the Alter-G Anti-Gravity Treadmill is used by populations with osteoarthritis, and in children with cerebral palsy, but little has been done regarding the applications of an anti-gravity treadmill to populations with obesity.

The Alter-G Anti-Gravity Treadmill may reduce joint pain during exercise, which is a common barrier to exercise in obesity. Having obesity can put higher forces on the lower joints (hip 40%, knee 43%, and ankle 48%) when compared to normal weight (Sanford, Williams, Zucker-Levin, & Mihalko, 2014). Using the unweighting (anti-gravity) feature on the Alter-G Anti-Gravity Treadmill, participants are able to reduce their total body weight by increasing the amount of positive pressure in the cockpit. As participants reduce their weight, this leads to less force on the lower joints (Christensen, Bartels, Astrup, & Bliddal, 2007). This could lead to less pain of the joints during exercise, greater exercise enjoyment, and lead to more frequent and prolonged exercise sessions. The effects of the unweighting feature on the Alter-G Anti-Gravity Treadmill may have on perceived exertion, exercise enjoyment, adherence to exercise, and quality of life have not been examined.

The Alter-G Anti-Gravity Treadmill has been compared to a traditional treadmill for weight loss in a population with obesity (Bercier, 2014). This study had 15 participants with 9 using the traditional treadmill and 6 using the Alter-G Anti-Gravity Treadmill during an 18-week, structured, supervised walking program. The protocol for use of the Alter-G Anti-Gravity Treadmill was structured and started (phase 1) at 50-70% of body weight and a speed of 1.5-3.5 mph for 30 minutes. By phase 3, participants using the Alter-G Anti-Gravity Treadmill were instructed to walk/jog at 80-95% of their body weight and speed of 4.0+ mph. Researchers used percentage of heart rate maximum to determine mild/moderate (20-40%) intensity for phase 1, moderate (40-60%) intensity during phase 2, and moderate/vigorous (60-85%) intensity in phase 3. This study demonstrated that adherence to a structured walking program either on a traditional treadmill or the Alter-G Anti-Gravity Treadmill was not significantly different. Weight loss was also similar between the two groups with the Alter-G Anti-Gravity Treadmill participants losing an average of 2.3 kg and the traditional treadmill group losing an average of 2.1 kg. In addition, they demonstrated that moderate intensity could be reached, as verified by percentage of heart rate maximum, while using the Alter-G Anti-Gravity Treadmill while using the unweighting feature.

However, one limitation of the work of Bercier (2014) is that they used set speeds and a very structured walking program that does not allow for self-selection of pace, duration, or frequency of exercise. These results therefore do not reflect what may happen if an individual were to have access to an Alter-G Anti-Gravity Treadmill in a self-guided clinical or gym setting. Any variation that may come from psychological aspects of exercise such as pain, or exercise enjoyment to influence their adherence to the exercise program is not reflected in their findings. This is critical because high levels of pain, and low exercise enjoyment make it significantly more likely for an individual to have poor adherence to an exercise program (Cadmus-Bertram et al., 2014; Jack, McLean, Moffett, & Gardiner, 2010; Jekauc, 2015).

In summary, little research has been done utilizing the unweighting feature of the Alter-G Anti-Gravity Treadmill in people with obesity during a self-guided walking program. Therefore, our objective is to explore the association of pain with physical functioning and exercise outcomes in a population with obesity, and determine the influence of the anti-gravity function of the Alter-G Anti-Gravity Treadmill on exercise enjoyment and energy expenditure during moderate intensity exercise sessions of self-selected duration. Also, we will compare pain and exercise enjoyment between those using the Alter-G Anti-Gravity Treadmill at 100% body weight, to those using the treadmill at a self-selected unweighting. If using the Alter-G Anti-Gravity Treadmill unweighting function reduces these barriers, this could, in turn, lead to increased exercise adherence, weight loss, and health benefits (Baillot et al., 2014; Garnier et al., 2015).

Specific Aims and Rationale

1) Determine if pain is associated with physical functioning in obesity.

   - Previous research has shown that severe obesity is an impairment for physical functioning. However, it is unclear if pain may explain the impaired physical functioning.

2) Determine if exercise barriers are reduced by using the unweighting function of the Alter-G Anti-Gravity Treadmill.

    - Previous research demonstrated that low exercise enjoyment and high levels of pain results in lower adherence to exercise programs. Therefore, we will determine if the Alter-G Anti-Gravity Treadmill alleviates these barriers.

3) Determine if energy expenditure of exercise sessions with self-selected duration is similar in weighted and unweighted groups.

    - Previous research found that energy expenditure at 90% bodyweight and 80% bodyweight, using the ACSM equation, were significantly lower compared to 100% bodyweight during a modified Bruce stress protocol. However, energy expenditure has not been examined when participants are allowed to self-select their duration.

Hypotheses

- Specific Aim 1:

    1. We hypothesized that there would be an inverse relationship between pain and distance during the 6-minute walk test, and a direct relationship between pain and time during the TUG test.

- Specific Aim 2:

1. We hypothesized that during self-select exercise, unweighting via the anti-gravity treadmill may result in increased exercise enjoyment and subjective pain rating may decrease.

- Specific Aim 3:

    1. We hypothesized that during exercise sessions self-selected duration, unweighting via the anti-gravity treadmill may result in increased speed and duration such that energy expenditure is similar.

CHAPTER III

METHODOLOGY

Study Design Overview

The study design involves a baseline visit consisting of an in person screening to confirm eligibility, measurement of body composition, physical functioning tests, questionnaires, and introduction to the Alter-G Anti-Gravity Treadmill. The baseline session is then followed by three separate exercise sessions. Healthy adults with obesity was recruited for the study. First, pain, physical functioning (Timed up and go test and 6-minute walk test), and exercise enjoyment was measured. Individuals were then randomized to two groups for the exercise session. The control group used the Alter G Anti-Gravity Treadmill and walked at a self-selected pace and duration while at their full body weight. The experimental group walked at a self-selected pace and duration on the Alter G Anti-Gravity Treadmill, but was allowed to use the unweighting feature of the treadmill. The only thing that was monitored is the intensity, and both groups were instructed to exercise at a moderate intensity (50-70% HRR).

The participants were blinded about the actual purpose of the study. It is critical to have a control group to control for the placebo effect of using a novel, high-tech treadmill. However, subjects were blinded to the fact that there is a control group because if participants in the control group was aware that the purpose of the study is to determine the effects of the anti-gravity function, but they are not allowed to use it, this may have led to disappointment and had an independent effect that influences their exercise sessions. This unintended effect would influence and bias our results.

Participants

Adults were recruited using the announcement system (Techannounce) at Texas Tech University. For this project, we were conducting an analysis of baseline data from a longer randomized trial of a 12-week walking program. The inclusion and exclusion criteria are specifically designed for the longer trial. Inclusion criteria included body mass index (BMI) of ≥ 30 kg/m² and adults ages 20-55. Participants were excluded if pregnant, recently experienced fluctuations in body weight, have had weight control surgery, and any current medical conditions listed in the PAR-Q+ questionnaire, including diagnosed cardiovascular, renal, and metabolic disease.

Detailed Inclusion/Exclusion Criteria

Inclusion Criteria:

- Between 20-55 years of age
- Not currently participating in high intensity exercise >30 minutes per day
- BMI >30 kg/m²

Exclusion Criteria:

- Swelling of the ankles unrelated to injury
- Pain in the legs that cause them to stop walking
- Serious acute or chronic infections during the past 3 months
- Skin infection/ wounds
- Thyroid medication if not stable dosage and followed up regularly

- Experienced a weight loss in the past 6 months >5%
- Experienced a weight gain in the past 6 months >5%
- Surgery for weight control or liposuction
- Currently taking medication that increase or decrease appetite
- Members of household participating in trial or staff in the trial
- Currently participating or will be participating in another intervention soon
- Less than 3 months after childbirth
- Currently smoking or quit less than 6 months prior
- Has a recent or ongoing problem with drug abuse or addiction
- Consumes on average 3 or more alcohol beverages daily
- Consumed 7 or more alcohol beverages in a 24-hr period in past 12 months
- Any surgery or been diagnosed with any serious illness in past 3 months
- Not passing the PAR-Q AND not receiving physician permission to participate
- Hip circumference needs to be 58 inches or smaller
- Weight of ≥ 400 lbs. (the weight limit of the Alter-G Anti-Gravity Treadmill)

Screening Process

The American College of Sports Medicine has developed a physical activity readiness questionnaire (PAR-Q+), which is meant to screen individuals for any metabolic, renal or cardiovascular disease (Appendix A). Participants are given a screening form online (including the PAR-Q+), and if they meet all inclusion and exclusion criteria, then they were contacted through email for an in-person screening process. If they were found to have any medical condition that may impair the ability to exercise based on their responses to the PAR-Q+, a medical clearance form was given to them, which they could bring to their physician. The participants were also screened in person to verify their eligibility. Their resting blood pressure and heart rate was measured after a 10-minute resting period (the participants were seated during the resting period), and measurements were taken while seated. Anyone with blood pressure exceeding 140/90, and/or anyone who had a resting heart rate over 100 N/m^2 beats per minute, as measured by an Omron Hem-907XL, was excluded. Blood pressure and heart rate were taken twice and the average was used. Hip circumference was taken by placing the measuring tape around the widest part of their hips. Hip circumference needs to be 58 inches or smaller to use the Alter-G Anti-Gravity Treadmill and for the participant to be eligible. Participants were measured for weight (kg) and height (cm) to calculate and verify their BMI. An Omron scale and stadiometer were used, and the weight is corrected for clothing (weight – 1 kg). BMI was calculated by (using the corrected weight) kg/m^2, and if the participant`s BMI was 30 kg/m^2 or above, and their weight was less than 400 lb. (the weight limit of the machine), then they qualified to participate.

Procedures

Once the participants were fully screened and eligible to participate, informed consent was obtained and participants were randomized into either control (weighted) or experimental (unweighted) group. A randomization scheme was created using Excel’s random number generator function, and randomization allocations were specified in sealed, opaque envelopes by study ID number. Those administering the randomization process were blinded to the creation of the scheme and envelopes so that they remained unbiased in the allocation process. Participants remained unaware of the randomization, and were debriefed about the study hypothesis and randomization at the end of the 12-week study.

Outcome Measures

- **6-Minute Walk Test** - The 6-minute walk test was used to measure the distance a participant can walk on a flat, hard surface in a period of 6 minutes ("ATS statement: guidelines for the six-minute walk test," 2002). Participants were given instructions on how the test was conducted (Appendix B). The 6-minute walk test was shortened to 12 meters because of the nature of the lab space. The 6 minute walk test has been used previously in populations with obesity (Hulens et al., 2003).
- **Rate of Perceived Exertion –** The Borg Scale measures rating perceived exertion (Borg, 1998). Instructions were read to the participant regarding what they are rating and what each rating correlates to the first time it is administered during each session (Appendix C). The participant was asked to rate the level of physical excursion during their self-selected exercise sessions. The measurements were taken 5 minutes into the session and every 10 minutes thereafter for the duration of their session, and were measured to monitor exercise intensity in addition to heart rate.
- **Timed up-and-go (TUG) Test** - The TUG was designed to assess mobility and help predict fall risk (Ling, Kelechi, Mueller, Brotherton, & Smith, 2012). A chair was

placed 3m from a cone straight ahead. Participants were instructed to sit in the chair with feet flat on the floor and back against the back of the chair (Appendix D). When the researcher said ‘go’, the participant stood up, without using the arms of the chair or pushing off their legs, walked around the cone and proceeded to come back and sit down in the chair without falling into the chair. Once ‘go’ was said a stopwatch was started then stopped when the participant sat down with feet flat on the floor and back against the chair. Three separate trials were done then the time in seconds was averaged.

- **Energy Expenditure** - The Alter-G Anti-Gravity Treadmill Stride Smart system has the ability to calculate energy expenditure. The Stride Smart system takes into account the treadmill`s speed and the person’s body weight percentage along with duration and incline. When the treadmill is first turned on the Stride Smart system calibrates to the individual on the treadmill. The load cells located under the treadmill belt allow the Alter-G Anti-Gravity Treadmill to measure the individual’s weight. During the calibration the individual will go through a series of enclosed inflations which the Alter-G Anti-Gravity Treadmill uses to derive an algorithm specific to the participant, thus allowing for a precise and effective body weight control. This resulting algorithm is also used to calculate energy expenditure. Energy Expenditure was recorded from the first three exercise sessions. During each exercise session average speed, average incline, duration, and average unweighting was also recorded.

The following questionnaires (physical activity enjoyment, short-form McGill pain assessment, and the history of pain) were given to the participants during a resting period of the first visit.

- **Physical Activity Enjoyment Scale (PACES) –** Physical activity enjoyment scale was used to measure the current level enjoyment of physical activity. The scale consents of 18 questions with a rating of 1-7 (Kendzierski & DeCarlo, 1991) (Appendix F). This measurement was taken at baseline, and again after at least 3 exercise sessions, but some participants were measured later (3 – 23 exercise sessions), specifically in regards to exercising on the Alter-G Anti-Gravity Treadmill.
- **Short-Form McGill Pain Assessment** – The short-form McGill pain assessment was comprised of 15 descriptors which are rated on a scale where 0 = none, 1 = mild, 2 = moderate, and 3 = severe (Melzack, 1987) (Appendix G). The 15 descriptors include 11 sensory and 4 affective, with scoring coming from three different sums: the intensity rank values, the affective, and the total descriptors (Hawker, Mian, Kendzerska, & French, 2011). Hawker et al (2001) found the short-form to be reliable and valid. This measurement was taken at baseline.
- **History of Joint Pain –** The history of joint pain consists of 4 questions (Appendix H). The questions are answered either yes or no. If yes was answered then we ask for the participant to explain further including frequency, severity, and previous injuries and/or surgeries. This will be used to monitor joint pain during the sessions. This measurement was taken at baseline.

- **Subjective Pain Scale -** A subjective pain scale was used during workout sessions to monitor pain levels. The subjective pain scale was rated from 0 -10, where 0 = no pain at all and 10 = worst pain. The measurement was taken at 5 minutes into the exercise sessions, and every 10 minutes after that for the duration of each session. This measurement was taken during the three exercise sessions.

Participants were asked to put on a heart rate monitor (625x Polar Electro Oy) around their chest and place the paired watch on their left wrist to monitor heart rate during the baseline visit and all exercise sessions. The 6-minute walk test was performed first during the baseline visit. While the participant was answering the questionnaires the researcher calculated the total walking distance walked during the 6-minute walk test. Once the questionnaires were answered and checked then the Time-Up-Go (TUG) test was administered. Participants were given instructions on how the TUG test would be conducted and given one practice try if wanted. The TUG test was performed 3 times and the average time in seconds was taken.

Once finished with testing, the participant was introduced to the Alter-G Anti-Gravity Treadmill. Instructions were given on how the treadmill works and how to get in and out of the treadmill. Participants were shown the shorts they would be wearing to use the Alter-G Anti-Gravity Treadmill and instructed on how to correctly wear the shorts. Participants select the shorts that they felt comfortable walking in, and proceed to get in the treadmill and zip into the cockpit. Once zipped in, the participants were given the instructions how to use the treadmill again to reinforce how to use the Alter-G Anti-Gravity Treadmill, and on selection of a moderate intensity walking pace. Moderate intensity was determined by calculating 50% and 70% of heart rate reserve. Predicted heart rate max was calculate by using 220 – age. The heart rate reserve was used to calculate 50% [.5(HRmax - HRrest) + HR rest] and 70% [.7(HRmax - HRrest) + HRrest] (American College of Sports Medicine, 2018). The instructions were scripted and standardized to ensure that the instruction process does not vary between groups as much as possible. Instructions were specific depended on which group the participant were randomized to, since this was determined how they can use the different features.

The individuals assigned to the control group were given the instructions on how the treadmill works, but they were specifically told that they would not be using the unweighting feature of the Alter-G Anti-Gravity Treadmill. The participants were asked to press start and stand still while the treadmill calibrates their weight and inflates the cockpit. They were asked to self-select a pace that was "somewhat challenging but no to challenging that cannot be maintain for at least 20 minutes". Once they self-select a pace, a 2-minute timer was started and heart rate was monitored to see if they fell within the 50-70% of HRR (moderate intensity). During the 2-minute time period participants were shown the pain scale on the Alter-G Anti-Gravity Treadmill. This was done to familiarize the participants with the different measurements taken during their exercise sessions After 2 minute's heart rate was checked, if heart rate was lower than 50% then participants were instructed to either increase speed or incline to bring heart rate into the range and another 2-minute timer was started. If heart rate was too high after the first 2-minute timer, then participants were instructed to either decrease speed or incline to reduce heart rate and another 2 minute timer was started. Once the heart was in the moderate intensity range the participants were told that this will be their starting point for their first exercise session.

The experimental group was instructed similarly to the control group but participants were using the unweighting feature provided by the Alter-G Anti-Gravity Treadmill. They were given specific instructions to allow them to experience and become familiar with the anti-gravity function before self-selecting a pace. Participants were asked to first walk for 30 seconds at normal weight at a comfortable pace, then asked to drop the unweighting feature from 100 to 80%. The cockpit uses positive air pressure to support the participants and reduce body weight. They then were asked to reduce their weight from 80 to 60% for 30 seconds followed by 60 to 40% for another 30 seconds. Participants were allowed to increase speed and/or incline while experiencing the different unweighting level, as needed, to be comfortable while walking. After the different levels were experienced, the participants were then asked to self-select the speed, incline, and unweighting. They were asked to self-select a pace that is “somewhat challenging, but no so challenging that it cannot be maintain for at least 20 minutes”. Once they self-select this pace, then a 2-minute timer was started and heart rate was monitored to see if they fell within the 50-70% of HRR (moderate intensity). During the 2-minute timer participants were shown the pain scale on the Alter-G Anti-Gravity Treadmill. After 2 minutes heart rate was checked, if heart rate was lower than 50% then participants were instructed to either increase speed, incline, or increase body weight to bring heart rate into the range and another 2 minute timer was started. If heart rate was too high after the first 2 minute timer then participants were instructed to either decrease speed, incline, or decrease body weight to reduce heart rate and another 2 minute timer was started. Once the heart rate was in the moderate intensity range the participants were told that this would be their starting point for their first exercise session. Afterward the participants were shown the calendar that the exercise sessions were scheduled on, and were asked to schedule their exercise sessions. Participants were given a verbal recommendation of 30 minutes for 3 times a week as a starting point goal for the first two weeks.

The three exercise sessions were scheduled at the end of the baseline visit. The moderate intensity pace that was identified in the first visit was recommended to the participant as a starting place to set the pace of the three exercise sessions. Participants were asked to stop if their systolic blood pressure during the exercise session exceeds 200 mmHg (blood pressure will be monitored by using the Omron Hem-907XL) or if their subjective pain scale exceeds 7, which was monitored after 5 minutes, and every 10 minutes thereafter. Rate of perceived exertion was also measured at those same time points. Also, participants were monitored during exercise sessions for symptoms of a cardiovascular event. The Alter-G Anti-Gravity Treadmill has a data recording system built in that recorded exercise speed, incline, unweighting, duration, and the subjective pain scale ratings. The actual duration, speed, incline, and unweighting (for the unweighted group) was entirely self-guided and up to the participant, as long as they maintained a moderate intensity. The supervision was only to record data and monitor the safety of the participant, and no other feedback was given to influence their exercise session.

Statistical Analysis

1) To determine whether pain was associated with physical functioning in obesity. The 6-minute walk test distance and the timed up and go test (average of three trials) were the outcomes measures. The assumptions for a Pearson`s partial correlation were examined as a method to assess the relationship between distance in the 6-minute walk test and McGill pain score after adjusting for body mass index (BMI). BMI was positively skewed, and therefore was transformed using square root function. The McGill pain score distribution was also non normal, and was transformed using the LOG10 (positively skewed) function in SPSS. Despite the transformations, the relationships between each variable were not linear and violated the assumptions for the Pearson`s Partial Correlation. Therefore, a nonparametric partial correlation (Spearman rank-order correlation) was conducted using total distance in the 6-minute walk test vs. McGill pain score while adjusting for BMI.

   A Pearson`s Partial correlation was run to assess the relationship between mean TUG time and McGill pain score after adjusting for age. There was univariate normality, as assess by Shapiro-Wilk`s test ($p > .05$), and there were no univariate or multivariate outliers, as assess by boxplots and Mahalanobis Distance. There was a linear relationship between mean TUG time, McGill pain score, and age as assessed by scatterplots and partial regression plots. The assumptions for the Pearson`s Partial correlation where not violated, thus the test was performed. Alpha is set at 0.05.

A Pearson`s Partial correlation was run to assess the relationship between total distance in the 6-minute walk test and McGill pain score while adjusting for age. There was a linear relationship between distance, McGill pain score, and age as assessed by scatterplots and partial regression plots. There was univariate normality, as assess by Shapiro-Wilk`s test ($p > .05$), and there were no univariate or multivariate outliers, as assess by boxplots and Mahalanobis Distance. The assumptions for the Pearson`s Partial correlation were not violated, thus the test was performed. Alpha is set at 0.05.

2) To determine whether exercise barriers are reduced by using the unweighting function of the Alter-G Anti-Gravity Treadmill, a Wilcoxon Sign Rank test was run, excluding any participant that didn't have a score for the pre and 3rd visit Physical Activity Enjoyment Scale (PACES) (n = 14). Distributions of the PACES scores for the control and experimental groups were similar, as assessed by visual inspection.

To determine if subjective pain during exercise would decrease by using the unweighting function of the Alter-G Anti-Gravity Treadmill, the highest subjective pain rating was taken from each exercise session and those were averaged. A one-way ANOVA was run to using subjective pain as the dependent variable, group as the factor. No outliers where observed in boxplots, and Shapiro-Wilk test ($p > .05$) showed a normal distribution for the control and experimental groups. Homogeneity of variance was assessed by Levene`s (p =

.116). Therefore, all the assumptions of one-way ANOVA were met and the test was conducted. Alpha was set a 0.05.

3) To determine whether energy expenditure of self-selected duration was similar in control and experimental groups, differences in speed, incline, duration and weight were also examined. The mean of the first three exercise session energy expenditures was used for the dependent variable.

A one-way ANCOVA was run, with the mean energy expenditure as our dependent variable, the group as our fixed factor, and age as the covariate, to determine if energy expenditure was different between the control (n = 9) and experimental groups (n = 5). Slopes were in the same direction, and not perfectly parallel. Also, the relationship between age and energy expenditure was small, and there was no need to adjust for age. Therefore, we proceeded without age as a covariate, and preformed a one-way ANOVA.

A one-way ANOVA was run with mean energy expenditure was the dependent variable and group as the factor. There were no outliers, as determined from boxplots. A Shapiro-Wilk test ($p > .05$) determined a normal distribution of data and a Levene`s test ($p = .153$) determined homogeneity of variances. All assumptions were met to continue with the one-way ANOVA.

A one-way ANOVA was run with mean speed at the dependent variable and group as the factor. Speed was used from the first three exercise sessions and the mean was used for the calculations. There were no outliers, determined from boxplots. A Shapiro-Wilk test ($p > .05$) determined normal distribution of data and a Levene`s test (p = .493) determined homogeneity of variances. All assumptions were met to continue with the one-way ANOVA.

A one-way ANOVA was run with mean incline as the dependent variable and group as the factor. Incline was used from the first three exercise sessions and the mean was used for calculations. There were no outliers, as determined from boxplots. A Shapiro-Wilk test ($p > .05$) determined a normal distribution of data and a Levene`s test (p = .493) determined a homogeneity of variances. All assumptions were met to continue with the one-way ANOVA.

A one-way ANOVA was run using mean duration as the dependent variable and group as the factor. Duration was used from the first three exercise session and the mean was used for calculations. There were no outliers, determined from boxplots. A Shapiro-Wilk test ($p > .05$) determined a normal distribution of data and a Levene`s test (p = .059) determined homogeneity of variances. All assumptions were met to continue with the one-way ANOVA.

A one-way ANOVA was run using mean workout weight as the dependent variable and group as the factor. Weight during exercise for the control group was 100% their body weight, and weight for the experimental group was calculated by multiplying the participant's body weight by the percentage of unweighting during the three exercise session. The mean from the three weights (ex. 100kg participant at 50% unweighting = 50kg weight during exercise) was examined. There were no outliers, determined from boxplots. A Shapiro-Wilk test

($p > .05$) determined a normal distribution of data and a Levene`s test ($p = .460$) determined homogeneity of variance. Alpha was set a 0.05.

CHAPTER IV

RESULTS

Descriptive Statistics

There were 16 participants (age *M* = 33.06, *SD* =10.99, weight (kg) *M* = 107.51, *SD* = 13.30, BMI (kg/m^2) *M* = 37.94, *SD* = 5.20) that participated in the study. They were randomized into two groups (control *n* = 10, experimental *n* = 6). All participants went through the first visit, although one participant dropped out after going through the first exercise session and another participant dropped out after the first visit. Therefore, for the first aim data was analyzed from all sixteen participants, but for aims 2 and 3 complete data was only available for 14 participants. The groups were similar as displayed in Table 1.

Table 1 Descriptive measures of the different groups.

	Experimental (*n* = 6)	**Control (*n* = 10)**	**P value**
Age (years)	36.33 (14.15)	31.10 (8.86)	.157
Weight (kg)	112.34 (10.78)	104.62 (14.33)	.521
BMI (kg/m^2)	39.25 (4.46)	36.99 (5.61)	.607
Fat Mass (%)	46.74 (8.80)	42.36 (10.67)	.552
Fat Free Mass (%)	60.01 (13.44)	60.01 (11.53)	.690

Mean (*SD*)

Aim 1

Sixteen participants had complete data for this test. Mean distance in the 6-minute walk test was 392.94m (*SD* = 49.48), mean McGill pain score was 1.94 (*SD* = 1.88), and mean BMI was 37.94m/kg² (*SD* = 5.20). There was a weak positive correlation between distance and pain score, r_s (13) = .167, p = .551, but the correlation was not significant. There was no detectable association between pain score and distance walked during the 6-minute walk test when adjusting for BMI.

A Pearson`s partial correlation was run to assess the relationship between distance (6-minute walk test) and McGill pain score while adjusting for age. Mean distance was 392.94m (*SD* = 49.48), mean McGill pain score was 1.94 (*SD* = 1.88), and mean age was 33 years (*SD* = 11). A bivariate Pearson's correlation established that there was a negative, non-statistically significant linear relationship between total distance in the 6-minute walk test and McGill pain score, *r* (14) = -.011, p = .968.

The Spearman rank-order correlation was also used to examine timed-up and go (TUG) time vs. McGill pain score while adjusting for BMI. Mean TUG time was 9.43s (*SD* = 1.37), mean McGill pain score was 1.94 (SD = 1.88), and mean age was 33 years (*SD* = 11). . There was a negative correlation between mean TUG time and McGill pain score, r_s (13) = --.108, p = .703, but this correlation was not significant.

Person`s partial correlation was then conducted to determine the association of mean TUG time with McGill pain score while adjusting for age. A bivariate Pearson`s correlation established that there was a moderate, non-statistically significant linear relationship between mean TUG time and McGill pain score, r_s (14) = .326, p = .218.

Pearson`s partial correlation showed that the strength of this linear relationship was less when age was controlled for, $r_{partial}$ (13) = .313, and was not statistically significant, p = .256. McGill pain score and age had a strong positive correlation that was statistically significant, r_s (14) = .514, p = .042 (Figure 1.1).

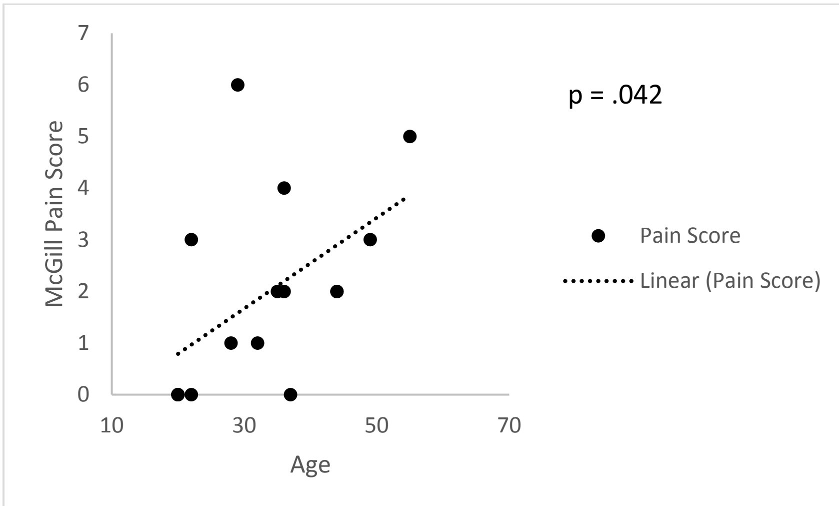

Figure 1.1 McGill pain score and age association in our sample population.

Aim 2

Determining if there were group differences in the change in physical activity enjoyment scale over time, 14 participants had complete data for analysis. Of the 14 participants, 11 had a PACES score from pre to the 3rd visit increase, whereas 3 participants had a reduction in the PACES score. A Wilcoxon Sign Rank test was run for each group, control (weighted, *n* = 9) or experimental (unweighted, *n* = 5). In the control group, six of the nine participants had an increase in PACES, whereas three of the nine had a decrease in PACES. There was no statistically significant change in PACES score in the control group from the prePACES (*M* = 83.33, *SD* = 26.31) and the 3rd visit PACES score (*M* = 94.67, *SD* = 19.88, z = -1.24, p = .214). Whereas in experimental group, all five participants had a positive increase in PACES score, which was found to be a statistically significant change in PACES scores from the prePACES (*M* = 82.40, *SD* = 14.36) and the 3rd visit PACES score (*M* = 92.40, *SD* = 10.71, z = -2.02, p = .043). A Mann-Whitney U test was run to determine if there were differences in the change in PACES score between the control and experimental groups. However, change in PACES score was not significantly different between the control and experimental groups (*M* = 10.86, *SD* = 20.61, U = 22.00, z = -.067, p = .947).

Subjective pain was examined during the first three exercise sessions. A one-way ANOVA was conducted to determine the effect of control and experimental groups on subjective pain during exercise. There was no statistically significant difference in subjective pain between groups (F (1, 11) = 2.086, p = .177, partial η^2 = .159). The experimental group had a higher mean subjective pain (*M* = 1.67, *SD* = .97) compared to the control group (*M* = .81, *SD* = 1.03), but this difference was not significant.

Aim 3

Energy expenditure was obtained from the Stride Smart system on the Alter-G Anti-Gravity Treadmill and a one-way ANOVA was run to determine if energy expenditure was different between the control and experimental groups. Energy expenditure was slightly lower in the experimental group (M = 472.40, SD = 197.21) compared to the control group (M = 485.85, SD = 129.69), but the difference between the groups was not statistically significant, F (1, 12) = .024, p = .879 (Figure 1.2).

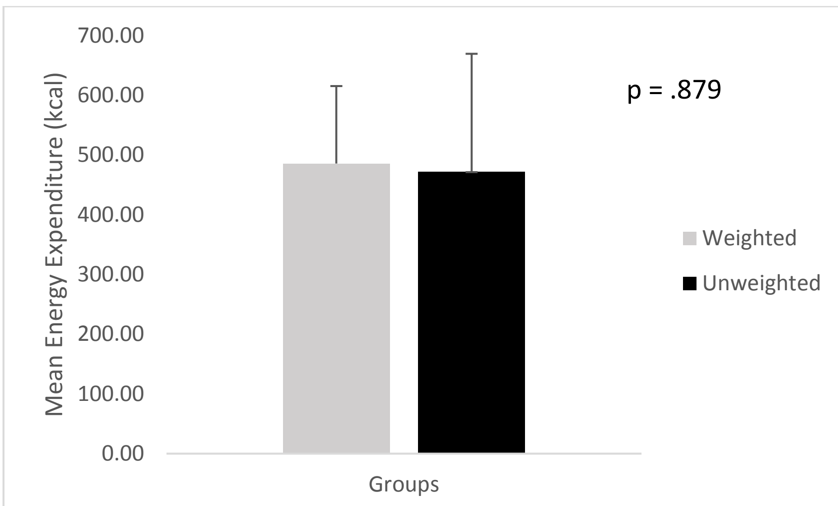

Figure 1.2 Mean energy expenditure between groups calculated from three exercise sessions.

Differences in exercise sessions that may explain how energy expenditure could be similar between the two groups, despite exercising at a lower body weight in the experimental group, were examined. A one-way ANOVA was run for each of the following variables: mean incline, mean speed, mean duration, and mean weight (kg) taken from their first three exercise sessions.

A one-way ANOVA was conducted to determine if mean speed (mean was taken from the participants first three exercise sessions) was different between the control and experimental groups. Mean speed was higher in the experimental group (*M* = 2.90, *SD* = .50) compared to the control group (*M* = 2.48, *SD* = .73). However, the difference was not statistically significant different (*F* (1, 12) = 1.28, p = .280) (Figure 1.3).

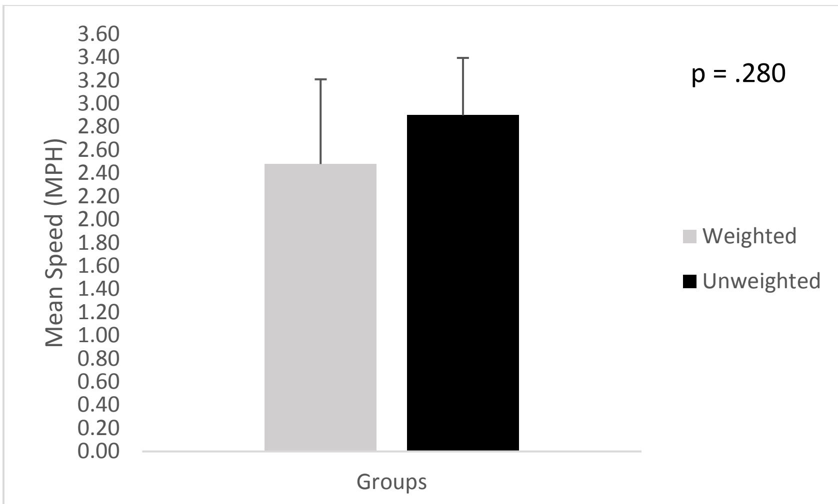

Figure 1.3 Mean speed between groups.

A one-way ANOVA was conducted to determine if mean incline between groups was different. Mean incline was higher in the experimental group (*M* = 4.75, *SD* = 3.55) compared to the control group (*M* = 4.11, *SD* = 3.60). There was no statistically significant difference in mean incline between groups, F (1, 12) = .100, p = .758 (Figure 1.4).

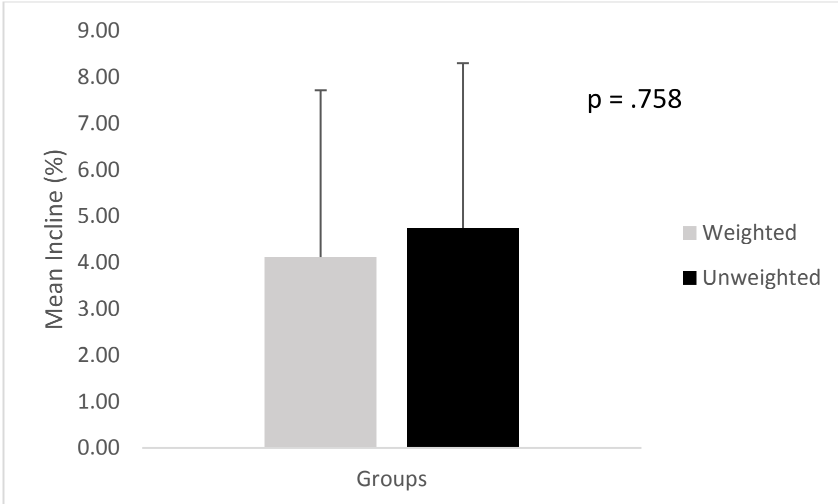

Figure 1.4 Mean incline between groups.

A one-way ANOVA was conducted to determine if mean duration between groups was different. Mean duration was higher in the experimental group (*M* = 45.64, *SD* = 2.43) compared to the control group (*M* = 37.52, SD = 1.81). There was a statistically significant difference in mean duration between groups, F (1, 12) = 7.15, p = .020) (Figure 1.5).

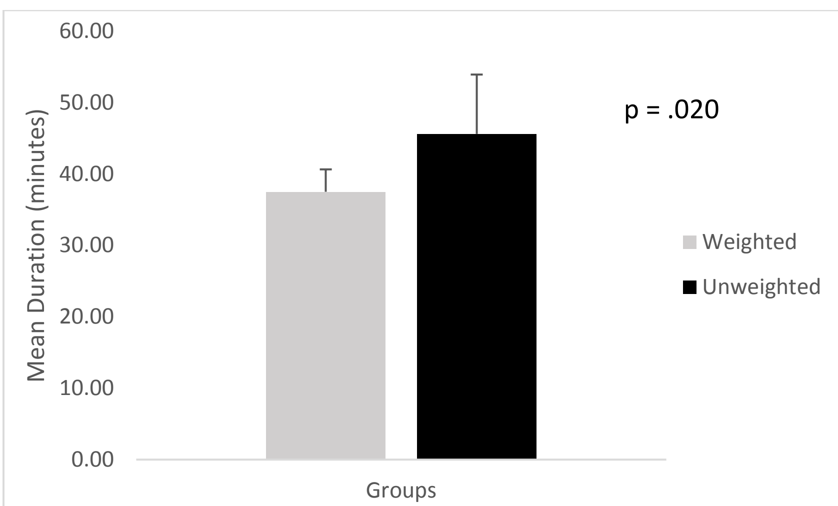

Figure 1.5 Mean duration between groups.

A one-way ANOVA was conducted to determine if mean weight during workouts was different between groups. Mean workout weight was higher in the control group (*M* = 101.99, *SD* = 4.63) compared to the experimental group (*M* = 68.83, *SD* = 6.21).There was a statistically significant difference in mean weight during workouts between groups, F (1, 12) = 18.31, p = .001 (Figure 1.6).

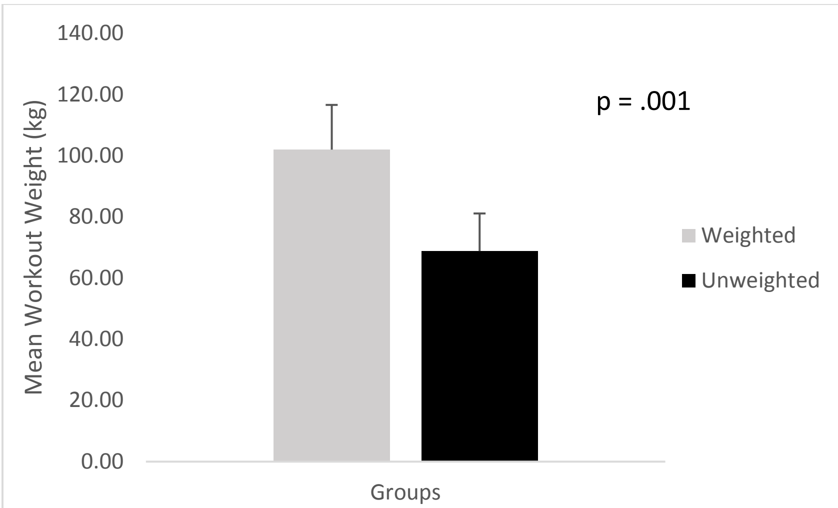

Figure 1.6 Mean weight during workout.

A Paired t-test was conducted to compare the 1st exercise session and the 3rd exercise session for energy expenditure, incline, speed, duration, and workout weight. Duration in the control group was significantly different from exercise session 1 to session 3, and increased over time. Energy expenditure, incline, speed, and workout weight were similar from exercise session 1 to 3 in both groups as displayed in Table 2.

Table 2 Difference between exercise sessions (ES) 1 and 3 for each group.

	Control (n = 9)			**Experimental (n = 5)**		
	ES1	ES3	p-value	ES1	ES3	p-value
Energy Expenditure (kcal)	465.44(122.33)	522.67(177.97)	.260	441.20(164.41)	483.60(221.19)	.234
Incline (%)	4.40(3.59)	4.041(3.61)	.427	3.82(2.52)	5.08(4.28)	.407
Speed (mph)	2.43(.69)	2.58(.87)	.472	2.80(.42)	2.94(.54)	.206
Duration (minutes)	35.24(3.5)	40.37(5.96)	.031	44.69(9.53)	46.33(8.85)	.485
Workout weight (kg)	100(0)	100(0)	.347	61.32(4.79)	59.82(7.46)	.592

Mean (SD)

CHAPTER V

DISCUSSION

People with obesity do not engage in physical activity, and experience pain and low physical activity enjoyment as barriers to physical activity (Baillot et al., 2014). The objective of this study was to see if using the Alter-G Anti-Gravity Treadmill can be a therapeutic tool to overcome pain and low physical activity enjoyment as barriers, and to determine if energy expenditure would be impacted by using the unweighting feature, which is a common criticism of using the Alter-G for obesity treatment. Both groups were asked to exercise at a moderate intensity, but the control group walked was able to self-select their incline, and duration while staying at 100% of their body weight and maintaining a moderate intensity. The experimental group also walked at a self-selected incline, and duration but was allowed to use the unweighting feature of the treadmill, while staying in a moderate intensity range. The study had three aims; aim 1 was to assess the association of pain with physical functioning, aim 2 was to assess if using the unweighting feature of the Alter-G Anti-Gravity Treadmill would increase the physical activity enjoyment and decrease subjective pain during exercise, and aim 3 was to assess if energy expenditure between the control and experimental groups were similar.

Results of the first aim did not support our hypothesis that there was an association between pain and physical functioning test outcomes (TUG and 6-minute walk test). Our results contradict a previous study done by Hulens et al. (2002) that walking ability was hampered by pain. Researchers asked participants (n = 218) if they experienced friction from skin, foot static problems or pain, and knee or lower back pain to assess the conditions that might interfere with walking capacity in a population of women (18 – 65 years) with a BMI of > 27.5 kg/m², and they found walking ability in women with obesity was hampered by sedentary lifestyle and pain compared to women of normal weight. Wachholtz et al. (2010) also found an association between pain and interference with daily functioning. The researchers in this study asked participants (n = 386) if they experienced leg pain, back pain, joint pain, muscle pain, and chest pain regarding cardiac or respiratory to assess pain regarding interference with daily function and short-term weight loss. Both studies did not use standardized physical functioning tests as our experiment did, and the questions used during both studies were targeted at specific pain during daily functioning whereas the Short-Form McGill Pain Assessment was designed to capture pain using 15 descriptors (11 sensory; 4 affective), and is typically used for post-surgery, obstetrical wards, physiotherapy, and dental pain. It is possible that there was no significant association between pain and physical functioning in our study because during our screening process, we screened for healthy people with obesity without high levels of pain. There was very little variation in pain to detect any association. The use of a joint pain specific questionnaire or a questionnaire such as the Physical Activity Acceptance Questionnaire may have been a better measure of pain that would be associated with obesity and the specific tasks participants were asked to perform.

The results from aim 2 suggest that using the unweighting feature of the Alter-G Anti-Gravity Treadmill may increase PACES scores. We did not see between group differences, perhaps because of our small sample size, but a within-groups comparison demonstrated that the experimental group experienced an increase in PACES scores, while the control group did not experience any change in PACES scores. Research done by Nagle et al. (2007) used the PACES scale on two groups of women with obesity and also found the experimental group (walking plus aquatic exercise) compared to their control group (walking only) experienced a significant increase in PACES scores. Both our study and Nagle et al. (2007) had interventions that used a form of weight reduction (unweighting feature of the treadmill or aquatic) along with a walking protocol, so such technologies may lead to significant increases in PACES scores. Importantly, physical activity enjoyment may significantly contribute to improvements in exercise adherence (Dalle Grave et al., 2011). Several studies (Leslie et al., 1999; Trost, Owen, Bauman, F Sallis, & Brown, 2003; Wanda, 2002) have found that low levels of physical activity is associated with low physical activity enjoyment.

The physical activity questionnaire was administered after finishing at least three of their exercise sessions. Although some aspects of the novel experience of using the Alter-G Anti-Gravity Treadmill, such as the fall-safe environment, was experienced by all participants, only the participants in the experimental group were able to experience the unweighting feature. Therefore, it is unclear if any effect of novelty on exercise enjoyment would persist over long-term use, and our findings are only applicable to the early stages of an exercise program.

Our results regarding subjective pain during exercise did not support our hypothesis that using the unweighting feature would decrease subjective pain during exercise. This could be because the population recruited for this study were healthy individuals, other than their obesity, with little to no pain. Also, participants were allowed to adjust the speed and incline to suit their level of comfort throughout the exercise session, which could have alleviated any pain they were experiencing from moderate intensity exercise.

The results from aim 3 did support our hypothesis that self-selecting duration while using the unweighting feature would allow energy expenditure to be similar to that of the group not using the unweighting feature. The aspects of the exercise sessions that were self-selected included incline, duration, and weight during the workout (for the experimental group only). The experimental group's exercise sessions were significantly longer in duration compared to the control groups, whereas speed and incline were the same, but workout weight was also significantly different. Specifically, duration was lower in the control group during the first session and increased over time, whereas the duration for the experimental group was high initially and stayed high. The long-term effects of the unweighting feature are unclear, and it is possible that over more sessions, the duration of the control group would match those using the unweighting feature over time. However, in the first three sessions, the similar energy expenditure of the experimental group compared to the control group despite exercising at a lower body weight was likely driven by increased duration. Our results indicate that if a patient with obesity were to use the Alter-G unweighting feature during a moderate intensity exercise session, their energy expenditure and benefit to their weight loss may be similar to walking at 100% body weight if they are allowed to self-select their durations.

Limitations

This study consisted of a small sample size of 16 participants, and this could have limited our power to detect associations like those in aim 1 and detect significant group differences in aim 2 and 3. Future studies with larger sample sizes should be conducted to verify findings from this preliminary study.

This study was limited in that the time allotted for each exercise session was not completely flexible. Allowing more flexibility in duration could have allowed for greater differences in energy expenditure. There was only one Alter-G Anti-Gravity Treadmill and scheduling was done in one-hour time slots. However, during scheduling, we made participants aware that they could schedule longer sessions if they were ready to do so. No participant expressed desire to go longer than one hour. However, it is still possible that the one-hour time slots on the scheduling calendar biased participant's expectations for their exercise session duration. Similarly, the study started with a verbal recommendation of 30 minutes for 3 times a week as a starting point goal for the first two weeks, which may have also biased the duration they had as a goal. Despite these limitations, we still detected a longer duration by those in the unweighted group that resulted in similar energy expenditure overall between groups. Finally, using the Alter-G`s Stride Smart system to predict energy expenditure and not a more accurate technique such as indirect calorimetry may have allowed more precision to detect differences in energy expenditure.

Strengths

This study consisted of a randomized design for aims 2 and 3 allowing us to determine causation, along with a single-blinded design. Therefore, decreasing the selection of bias in a chosen population, along with decreasing bias from participants and observer. A strong control group compared to previous weight-related studies that used a traditional treadmill instead of the same treadmill to control for novelty. Having a strong control group allowed for stronger internal validity. Also using highly standardized measures of physical functioning for aim 1 allowed for findings that can be generalized and represents our study population.

Future Research

Future research should explore subjective pain during exercise using the Alter-G Anti-Gravity Treadmill in a high pain population with obesity to determine if the Alter-G Anti-Gravity Treadmill may be therapeutic for a population with obesity that experience lower body joint pain, specifically knee and hip pain. This study had a population with little to no pain, which may not have the same change in experience while exercising with the unweighting feature as a high pain population.

In addition, future studies should measure energy expenditure a truly self-selected exercise program that does not require participants to exercise at a moderate intensity, without a verbal recommendation of 30 minutes 3 times a week, and without 1 hour time slots. Also, measuring energy expenditure at multiple sessions over a longer time period would strengthen the results and determine if the effect lasts over time. In addition, determining the effect of the unweighting feature on energy expenditure could be measured with more accurate energy expenditure measurement devices such as indirect calorimetry to verify the reliability and validity of the Stride Smarts calculations in future studies.

Finally, a longer-term study should be conducted to determine if the increase in PACES scores from using the Alter-G Anti-Gravity Treadmill produces improved clinical outcomes that extend beyond the study setting. The study could follow up on participants after one year, for example, and examine if they have continued to exercise after the program. Also, a longer program would allow for detection of clinical outcomes such as weight loss and improvements in cardiometabolic risk factors, and through long-term follow up, if weight loss was maintained.

Conclusion

This study demonstrated that a walking protocol using the unweighting feature of Alter-G Anti-Gravity Treadmill was effective in producing a significant increase in PACES score, while also demonstrating that using the unweighting feature of the Alter-G Anti-Gravity Treadmill can cause the duration of exercise to be higher leading to similar energy expenditure compared to 100% body weight. This was the first study to compare two groups using the same Alter-G Anti-Gravity Treadmill. Further research is needed to determine the extent the Alter-G Anti-Gravity Treadmill can be used as a therapeutic tool in people with obesity.

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APPENDIX A

PAR-Q+

2014 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	**YES**	**NO**
1) Has your doctor ever said that you have a heart condition ☐ OR high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** ______	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it ***does not limit your current ability*** to be physically active. **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Go to Page 4 to sign the PARTICIPANT DECLARATION. <u>You do not need to complete Pages 2 and 3.</u>

- Start becoming much more physically active – start slowly and build up gradually.
- Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at **www.eparmedx.com** before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

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 1 / 4
08-01-2014

Figure 2.1 The Physical Activity Readiness Questionnaire + (PAR-Q+). Reprinted with permission from the PAR-Q+ Collaboration and the authors of the PAR-Q+ (3). (*continued*)

2014 PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. **Do you have Arthritis, Osteoporosis, or Back Problems?** If NO ☐ go to question 2
If the above condition(s) is/are present, answer questions 1a-1c

1a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES ☐ NO ☐

1b. Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)? YES ☐ NO ☐

1c. Have you had steroid injections or taken steroid tablets regularly for more than 3 months? YES ☐ NO ☐

2. **Do you have Cancer of any kind?** If NO ☐ go to question 3
If the above condition(s) is/are present, answer questions 2a-2b

2a. Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and neck? YES ☐ NO ☐

2b. Are you currently receiving cancer therapy (such as chemotheraphy or radiotherapy)? YES ☐ NO ☐

3. **Do you have a Heart or Cardiovascular Condition?** *This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm* If NO ☐ go to question 4
If the above condition(s) is/are present, answer questions 3a-3d

3a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES ☐ NO ☐

3b. Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction) YES ☐ NO ☐

3c. Do you have chronic heart failure? YES ☐ NO ☐

3d. Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months? YES ☐ NO ☐

4. **Do you have High Blood Pressure?** If NO ☐ go to question 5
If the above condition(s) is/are present, answer questions 4a-4b

4a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES ☐ NO ☐

4b. Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure) YES ☐ NO ☐

5. **Do you have any Metabolic Conditions?** *This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes* If NO ☐ go to question 6
If the above condition(s) is/are present, answer questions 5a-5e

5a. Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies? YES ☐ NO ☐

5b. Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness. YES ☐ NO ☐

5c. Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet? YES ☐ NO ☐

5d. Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)? YES ☐ NO ☐

5e. Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future? YES ☐ NO ☐

 2 / 4
08-01-2014

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Figure 2.1 (*Continued*)

2014 PAR-Q+

6. Do you have any Mental Health Problems or Learning Difficulties? *This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome*

If the above condition(s) is/are present, answer questions 6a-6b — If **NO** ☐ go to question 7

6a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
6b.	Do you **ALSO** have back problems affecting nerves or muscles?	YES ☐ NO ☐

7. Do you have a Respiratory Disease? *This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure*

If the above condition(s) is/are present, answer questions 7a-7d — If **NO** ☐ go to question 8

7a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
7b.	Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	YES ☐ NO ☐
7c.	If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	YES ☐ NO ☐
7d.	Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	YES ☐ NO ☐

8. Do you have a Spinal Cord Injury? *This includes Tetraplegia and Paraplegia*

If the above condition(s) is/are present, answer questions 8a-8c — If **NO** ☐ go to question 9

8a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
8b.	Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	YES ☐ NO ☐
8c.	Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	YES ☐ NO ☐

9. Have you had a Stroke? *This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event*

If the above condition(s) is/are present, answer questions 9a-9c — If **NO** ☐ go to question 10

9a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
9b.	Do you have any impairment in walking or mobility?	YES ☐ NO ☐
9c.	Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	YES ☐ NO ☐

10. Do you have any other medical condition not listed above or do you have two or more medical conditions?

If you have other medical conditions, answer questions 10a-10c — If **NO** ☐ read the Page 4 recommendations

10a.	Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months?	YES ☐ NO ☐
10b.	Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	YES ☐ NO ☐
10c.	Do you currently live with two or more medical conditions?	YES ☐ NO ☐

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE: ______________________

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

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Figure 2.1 (*Continued*)

2014 PAR-Q+

If you answered NO to all of the follow-up questions about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered **YES** to **one or more of the follow-up questions** about your medical condition:
You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+ at www.eparmedx.com** and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ **at www.eparmedx.com** before becoming more physically active.
- Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that a Trustee (such as my employer, community/fitness centre, health care provider, or other designate) may retain a copy of this form for their records. In these instances, the Trustee will be required to adhere to local, national, and international guidelines regarding the storage of personal health information ensuring that the Trustee maintains the privacy of the information and does not misuse or wrongfully disclose such information.

NAME ____________________ DATE ____________________

SIGNATURE ____________________ WITNESS ____________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ____________________

For more information, please contact
www.eparmedx.com
Email: eparmedx@gmail.com

The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

Citation for PAR-Q+
Warburton DER, Jamnik VK, Bredin SSD, and Gledhill N on behalf of the PAR-Q+ Collaboration. The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). Health & Fitness Journal of Canada 4(2):3-23, 2011.

Key References
1. Jamnik VK, Warburton DER, Makarski J, McKenzie DC, Shephard RJ, Stone J, and Gledhill N. Enhancing the effectiveness of clearance for physical activity participation; background and overall process. APNM 36(S1):S3-S13, 2011.
2. Warburton DER, Gledhill N, Jamnik VK, Bredin SSD, McKenzie DC, Stone J, Charlesworth S, and Shephard RJ. Evidence-based risk assessment and recommendations for physical activity clearance; Consensus Document. APNM 36(S1):S266-s298, 2011.

Figure 2.1 (*Continued*)

APPENDIX B

6-MINUTE WALK TEST PROTOCOL

Guidelines for the six-minute walk test

Performing the 6MWT

1. **Have the participant put on the Polar watch and HR strap before starting the test**

"The 6-minute walk test is designed to test your muscular endurance. The object of this test is to see how far you walk at your normal pace in 6 minutes. You will walk back and forth in this room. Six minutes is a long time to walk, so you may be exerting yourself. You may become out of breath or become tired. You may slow down, stop, and rest as necessary. You may sit on the chair while resting, but resume walking as soon as you are able. You will be walking back and forth around the 2 cones. You should walk around the cone and continue back the other way without hesitation. Now I'm going to show you. Please watch the way I turn without hesitation. Keep in mind that you want to cover as much distance as possible. Walk as if you are walking from the car to a store, every two minutes I will ask you for your heart rate".

Demonstrate by walking one lap yourself.

"Are you ready to do that? *Position the participant at the starting line*. ***"Start now, or whenever you are ready."***

1. **At 6 mins, or the time they stopped walking if they stop before 6 mins, Have the participant sit down and take their blood pressure**
2. **Then do the borg scale.**
3. Congratulate the patient on good effort and offer a drink of water

Note: Repeat testing should be performed about the same time of day to minimize intraday variability.

- 12 meter course (39ft 4in)

6MWT Pre/ Post -intervention

Start Time: ___________ End of Test Time ____________

Full lap counter: __

__

Half laps: __________ Extra distance: ___________ Number of rests : _ _

Beginning HR:________ HR at 4 minutes left: _____ HR at 2 minutes left:

_____

HR after test: ______ Blood pressure after test: ____/_____

Borg scale____ Total distance: ______ meters

Other symptoms :____

Stopped or paused before 6 minutes? No Yes, Reason: ________________

5 minutes remaining	*"You are doing well. You have 5 minutes to go".*
4 minutes remaining	*"Keep up the good work. You have 4 minutes to go. Can I get your heart rate".*
3 minutes remaining	*"You are doing well. You are half way done".*

2 minutes remaining	*“Keep up the good work. You have only 2 minutes left. Can I have your heart rate”.*
1 minute remaining	*“You are doing well. You have only 1 minute to go”.*
20 seconds remaining	*“In a moment I’m going to tell you to stop. When I do, just stop right where you are and I will come to you.”*
After 6 minutes (when the timer rings)	*Say “Stop!. Can I get your heart rate”* *Walk over to the patient. Consider taking the chair if they look tired. Mark the spot where they stopped using a piece of tape on the floor or similar.*

APPENDIX C

INSTRUCTIONS FOR BORG SCALE (RPE)

Instructions for Borg Rating of Perceived Exertion (RPE) Scale

- This is to rate your perception of exertion about the 6-minute walk test.
- This feeling should reflect how heavy and strenuous the exercise feels to you, combining **all** sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion.
- Look at the rating scale below while you are engaging in an activity; it ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion."
- Choose the number from below that best describes your level of exertion. This will give you a good idea of the intensity level of your activity.
- Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is.
- Your own feeling of effort and exertion is important, not how it compares to other people's. Look at the scales and the expressions and then give a number.

Level of Exertion		
6	No exertion at all	
7		
7.5	Extremely light	
8		
9	Very light	For a healthy person, it is like walking slowly at his or her own pace for some minutes
10		
11	Light	
12		
13	Somewhat hard	"somewhat hard" exercise, but it still feels OK to continue.
14		
15	Hard (heavy)	
16		
17	Very hard	Very strenuous. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired.
18		.

19	Extremely hard	Extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced
20	Maximal exertion	

APPENDIX D

TIMED UP AND GO PROTOCOL

Protocol and form for the Timed Up and Go (TUG) Test

This test is to assess your mobility and balance

- Instructions to the subject**:**
  "When I say "Go," I want you to:
  1. Stand up from the chair (without using the hands on the arms of the chair or on your body)
  2. Walk to the cone on the floor at your normal pace
  3. Turn
  4. Walk back to the chair at your normal pace
  5. Sit down again. Please do not fall on to the chair"
  "We'll do this three separate times today and again at the end of the last session. Then we will look to see if you have progressed. If you wish, you may walk through the test once before being timed in order to become familiar with the test."
- Demonstrate the test for the participants if needed. Answer any questions the participant may have.
- Allow the participants a practice test before being timed if they feel they need it.
- After each test tell them they did the test correctly.

Note: The subject wears their regular footwear, and may not be assisted by another person. There is no time limit. They may stop and rest (but not sit down) if they need to.

Pre/ post -intervention- Timed up and go test (TUG test) form

Researcher ID: _________ Date: __________

Patient ID# ___________ Patient name: ___________________________________

Average = ………….+…………….+……………./ ……….. = …………..

	TUG Test 1	**TUG Test 2**	**TUG Test 3**	**Average Time**
Time (minutes: seconds)				
Stopped (Yes/No)				

Difficulties (Yes/No)				
Reason if Difficulties				

APPENDIX F

PHYSICIAL ACTIVITY ENJOYMENT QUESTIONNAIRE

Physical Activity Enjoyment Scale

Patient ID# ___________ Date: -
____

Please rate how you feel at the moment about the physical activity you have been doing.

1. * I enjoy it I hate it

   1 2 3 4 5 6 7

2. I feel bored I feel interested

   1 2 3 4 5 6 7

3. I dislike it I like it

   1 2 3 4 5 6 7

4. * I find it pleasurable I find it
   unpleasurable

   1 2 3 4 5 6 7

5. * I am very absorbed I am not at all
   absorbed
   in this activity in this activity

   1 2 3 4 5 6 7

6. It's no fun at all It's lot of fun

   1 2 3 4 5 6 7

7. * I find it energizing I find it tiring

   1 2 3 4 5 6 7

8. It makes me depressed It makes me happy

   1 2 3 4 5 6 7

9. * It's very pleasant It's very unpleasant

1 2 3 4 5 6 7

10. * I feel good physically while
while doing it — I feel bad physically doing it

1 2 3 4 5 6 7

11. * It's very invigorating — It's not at all invigorating

1 2 3 4 5 6 7

12. I am very frustrated — I am not at all frustrated
by it — by it

1 2 3 4 5 6 7

13. * It's very gratifying — It's not at all gratifying

1 2 3 4 5 6 7

14. * It's very exhilarating — It's not at all exhilarating

1 2 3 4 5 6 7

15. It's not at all stimulating — It's very stimulating

1 2 3 4 5 6 7

16. * It gives me a strong a
sense of accomplishment — It does not gives me strong sense of accomplishment at all

1 2 3 4 5 6 7

17. * It's very refreshing — It's not at all refreshing

1 2 3 4 5 6 7

18. I felt as though I would was — I felt as though there

rather be doing something else be							nothing else I would rather doing
	1	**2**	**3**	**4**	**5**	**6**	**7**

Note : "*" items are reverse scored (i.e., 1=7, 2=6,…….., 6=2, 7=1)

APPENDIX G

SHORT-FORM MCGILL PAIN QUESTIONNAIRE

ID______ **Short-Form McGill Pain Questionnaire**

Date__________

Directions: Choose a number of intensity that best describes **your pain rating at this moment** for the following 13 descriptors. 0 = ‘none’, 1 = ‘mild’, 2 = ‘moderate’, 3 = ‘severe’.

	NONE	MILD	MODERATE	SEVERE
THROBBING	0)_______	1)_______	2)_______	3)_______
SHOOTING	0)_______	1)_______	2)_______	3)_______
STABBING	0)_______	1)_______	2)_______	3)_______
SHARP	0)_______	1)_______	2)_______	3)_______
CRAMPING	0)_______	1)_______	2)_______	3)_______
GNAWING	0)_______	1)_______	2)_______	3)_______
HOT-BURNING	0)_______	1)_______	2)_______	3)_______
ACHING	0)_______	1)_______	2)_______	3)_______
HEAVY	0)_______	1)_______	2)_______	3)_______
TENDER	0)_______	1)_______	2)_______	3)_______
SPLITTING	0)_______	1)_______	2)_______	3)_______
TIRING-EXHAUSTING	0)_______	1)_______	2)_______	3)_______
SICKENING	0)_______	1)_______	2)_______	3)_______
FEARFUL	0)_______	1)_______	2)_______	3)_______
PUNISHING-CRUEL	0)_______	1)_______	2)_______	3)_______

Directions: Rate your overall pain intensity on the line below with a vertical line.

NO |——————————————| WORST POSSIBLE

Directions: Choose a number that best describe **your overall pain intensity at this moment**.

0	NO PAIN	_______
1	MILD	_______
2	DISCOMFORTING	_______
3	DISTRESSING	_______

4	HORRIBLE	________
5	EXCRUCIATING	________

APPENDIX H

HISTORY OF JOINT PAIN FORM

History of Joint Pain

The following questionnaire will cover your history of joint pain throughout your lifetime.

1. Have you ever experienced lower back pain?
   a. No
   b. If yes, explain including frequency, severity, previous injuries and/or surgeries.

____
____
____
____
____

2. Have you ever experienced hip joint pain?
   a. No
   b. If yes, explain including frequency, severity, and previous injuries and/or surgeries.

____
____
____
____
____

3. Have you ever experienced knee joint pain?
   a. No
   b. If yes, explain including frequency, severity, and previous injuries and/or surgeries.

____
____
____
____
____

4. Have you ever experienced ankle joint pain?
   a. No
   b. If yes, explain including frequency, severity, and previous injuries and/or surgeries.

____
____
____
____
____