

Community-based prehabilitation program: A pilot study exploring
the impact of exercise and education programs on functional mobility
pre-surgery and on length of stay post-total joint arthroplasty

by

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Abstract

The effect of implementing a community-based prehabilitation program prior to total joint arthroplasty (TJA) on mobility and length of stay (LOS) in hospital post-TJA in obese patients was investigated in this quantitative pilot study. Changes in mobility measures from baseline, at 6 weeks and 12-weeks pre-surgery and post-surgery were assessed using: Lower Extremity Functional Scale (LEFS), Visual Analogue Scale (VAS), Timed Up and Go (TUG), Self-Paced Walk Test (SPWT), and Stair Test (ST). A prehabilitation group attended education sessions and underwent a 12-week land and pool-based exercise program before TJA, whereas the control group received the usual preoperative standard of care. The prehabilitation group experienced improved mobility before and after surgery whereas the control group only saw improvements post-surgery. The LOS for the prehabilitation group was marginally lower (0.3 days) than the control group. In conclusion, there is evidence that a prehabilitation program prior to TJA may reduce hospital LOS resulting in potential cost savings and improved patient mobility measures both prior to and post-surgery.

Keywords

Osteoarthritis, Total Joint Arthroplasty, Prehabilitation, Community-Based, Obesity, Exercise, Education, Hospital Length of Stay, Cost Benefit, Mobility Measures, Pain, Surgery.

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“Do not go where the path may lead, go instead where there is no path and leave a trail.” — **Ralph Waldo Emerson**

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List of Abbreviations

2WW	Two-Wheeled Walker
ANOVA	One-Way Analysis of Variance
Assist	Assistant
AVG	Average
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CHHI	Canadian Heart Health Initiative
CVD	Cardiovascular Disease
DVT	Deep Venous Thrombosis
KL	Kellgren and Lawrence
LEFS	Lower Extremity Functional Scale
LOS	Length of Stay
M	Meter
MMPs	Matrix Metalloproteinases
MSCs	Mesenchymal Stem Cells
NPRS	Numeric Pain Rating Scale
OA	Osteoarthritis
OATS	Osteochondral Autograft Transfer System
PATCH	Planned Approach to Community Health
PHD	Doctor of Philosophy
PMR	Physical Medicine and Rehabilitation
ROM	Range of Motion

S	Second
SD	Standard Deviation
SPWT	Self-Paced Walk Test
ST	Stair Test
THA	Total Hip Arthroplasty
TJA	Total Joint Arthroplasty
TKA	Total Knee Arthroplasty
TUG	Timed Up and Go
VAS	Visual Analogue Scale

Introduction

Osteoarthritis (OA) is the most common musculoskeletal disorder and causes debilitating pain and decreased mobility. This degenerative disease affects over 27 million people in North America, with over 5.4 million individuals in Canada alone, placing a burden on the Canadian health care system estimated to cost \$27.5 billion annually (Arthritis Alliance of Canada, 2011; Collins, Chin, Sanmartin, Reimer, Herzog, & Marshall, 2014).

The most common surgical solution to treat OA is a TJA. The average age of a TJA patient in Canada is 63.2 ± 14.9 years (Antoniou et al., 2004). Amongst Canadian TJA patients, approximately 82% are overweight or obese (De Guia, Zhu, Keresteci, & Shi, 2006) and are at increased risk of complications post-surgery. Sudbury, Ontario has the second highest percentage of obese individuals in Canada, with 33.80% of the population falling into this category compared to the provincial average of 18.40% (Statistics Canada, 2014; Twells, Gregory, Reddigan, & Midodzi, 2014). On average, obese patients who undergo a TJA, are 10 to 13 years younger than those with a normal BMI, suggesting a negative correlation between age of primary arthroplasty and rising BMI (Vasarhelyi & MacDonald, 2012).

Furthermore, the majority of patients who undergo TJA are between the ages of 48 and 78 years old and this community also has a higher proportion of aging adults with 16.10% of the total population being older compared to the provincial average of 14.80% (Antoniou et al., 2004; Statistics Canada, 2012). In 2015, 950 TJAs were performed at Health Sciences North in Sudbury, Ontario and the projected annual number is expected to rise to 1100 TJAs within the next two years (Health Sciences North, 2015). Based on

the demographics of the community and on other risk factors (i.e. obesity), the number of such procedures is expected to increase by 50% to 100% in the next 10 years (Health Sciences North, 2015).

Currently, there is no prehabilitation hospital, particularly in the north, which means there is a need for a community-based prehabilitation program. Accordingly, evidence-based strategies such as the *implementation of a community-based prehabilitation program* to improve function in patients with OA (Jamtvedt et al., 2008) and to enhance patient recovery after joint arthroplasty should therefore be carefully considered as a strategic intervention. Previous research has found that a combination of land and pool-based exercise classes benefitted OA patients (Coudeyre, Jardin, Givron, Ribinik, Revel, & Rannou, 2007; Desmeules, Hall, & Woodhouse, 2013; Uthman et al., 2013). In this current study, pilot data is presented to make a case for this intervention.

Chapter 1

1 Review of Literature

1.1 Osteoarthritis

OA is the most common musculoskeletal disorder, but also in general practice, it is one of the most commonly diagnosed diseases. It is expected that by 2020, the prevalence of OA will double due to an aging population and increasing rate of obesity (Johnson & Hunter, 2014). OA is a progressive autoimmune disease that is characterized as the loss of articular cartilage surrounding the joints. This loss of cartilage results in both pain and stiffness around the joint as well as inflammation and rubbing of the two corresponding bones. In association with the degradation of the cartilage, there is also new formation of bone and synovial proliferation resulting in multiplication of cells within the joint space (Abramson & Attur, 2009; Kristjánsson & Honsawek, 2014). This complex interaction of cellular, biochemical, and mechanical factors appears to cause OA in addition to a combination of other risk factors (Johnson & Hunter, 2014).

1.1.1 Types of OA

There are two types of OA: primary OA, where the onset is brought on by risk factors such as age, excessive weight, alignment, injury or overuse of the joint and family history and secondary OA, which is the result of a previous injury. Injury to the joint often results in synovial inflammation to adjacent areas. This leads to the advancement of cartilage degradation due to an increase in the secretion of proteinases, inflammatory cytokines and matrix metalloproteinases (MMPs) (Johnson & Hunter, 2014). It is these inflammatory

mediators in combination with the formation of osteophytes that may also cause pain by irritating the sensory nerve endings.

1.1.2 Diagnosing and predicting OA

The inflammation of the joints associated with OA causes debilitating pain and decreased mobility. The severity of OA is most commonly determined through the analysis of radiography using the Kellgren and Lawrence (KL) grading system. The system uses a scale from 0 to 4, radiographic OA being a number greater than 2 (Johnson & Hunter, 2014). Aside from a combination of clinical (i.e. pain, stiffness, reduced range of motion (ROM), malalignment, swelling) and radiography (i.e. x-ray, magnetic resonance imaging), there is a lack of tools available to diagnose early OA (i.e. Grade I or II). Therefore, early diagnosis continues to rely mainly on a symptomatic approach of the affected joint. Early diagnoses for the disease is important to prevent any further damage.

Accordingly, recent research studies have focused on early diagnosis through identifying specific biological markers for OA (Hawker, 2014). These include interleukins and tumour necrosis factor alpha, which are both pro-inflammatory mediators that can help with early diagnosis and prognosis (Wenham & Conaghan, 2013). This is in alignment with recent data suggesting that OA is an inflammatory illness (Hawker, 2014; Wenham & Conaghan, 2013).

1.1.3 Risk factors/causes of OA

OA affects over 4.6 million Canadians, and by 2040, it is estimated that every one in four Canadians will be affected by OA (Collins et al., 2014). OA affects men and women of different age groups and of all ethnicities, however women are at higher risk, most likely

due to gender differences related to bone and neuromuscular strength, joint alignment, ligament laxity and pregnancy (Johnson & Hunter, 2014). The increased risk of OA for women at the time of menopause has been linked to decreased levels of estrogen. These decreased levels have been linked to accelerated cartilage turnover and an increase in cartilage surface erosion, which may predispose women to OA by unmasking symptoms such as the intensification of pain (Johnson & Hunter, 2014).

Age is one of the most important predictors of OA, yet how it specifically increases the risk of OA is not fully understood. Johnson & Hunter (2014) report that age-related bone turnover and sarcopenia, which is the loss of muscle mass, affect the ability of the joint tissue to repair and to adapt to biological and biomechanical changes. Another risk factor is an increase in wear and tear of the joint, which is likely correlated with age, eventually leading to the degradation of cartilage (Johnson & Hunter, 2014).

Excessive weight has been highly associated with OA in the knees, and as seen in previous studies, it is an important predictor for OA in the hips (Grotle, Hagen, Natvig, Dahl, & Kvien, 2008). Previous research has also considered excessive weight to be the main modifiable factor in the development of OA (Weiss, 2016). In particular, a higher body mass index (BMI) leads to an increase in weight distributed over the weight-bearing joints and inflammation within the joints. This excess weight causes the joint cartilage to wear down, ultimately leading to OA.

Obese individuals are seven times more likely to develop knee OA compared to a nonobese individual (Weiss, 2016). An increase in body fat is also related to increased levels of cytokines and adipokines leading to low-grade systemic inflammation, which

may also contribute to the development of OA (Collins et al., 2014). The World Health Organization has labeled obesity as an epidemic, as it has been estimated to affect 1 billion individuals worldwide (Lementowski & Zelicof, 2008). In 2001, 12.5% of Canadian adults were considered obese and Twells et al. (2014) predict that by 2019, this will increase to 21.0%. Given the close association between excessive weight and OA, it is plausible that the incidence of OA will increase in the coming years.

1.1.4 Prevention of OA

Currently, there is no cure for OA, however there are *preventative measures* that can be adopted. For instance, maintaining a healthy weight and protecting the joints through the avoidance of repetitive tasks or excessive weight bearing activities is key (Lementowski & Zelicof, 2008). Early diagnosis, and the implementation of pharmacological treatment for OA, can help strengthen the surrounding affected area, control pain and inflammation and delay or prevent more damage to the joint thereby preserving functional mobility (Topp, Swank, Quesada, Nyland, & Malkani, 2009). Exercise, including weight training, is an important component in prevention because it helps to manage body weight, which can minimize the load placed on the joints as well as improve joint movement. Physical activity can also strengthen the muscles surrounding the affected joints to help reduce associated pain and improve function (Koepsell et al., 1992).

1.1.5 Treatments of OA

Moderately effective OA treatment options delivered by a variety of professionals in the health care industry are available. These health care professionals include: physiotherapists, occupational therapists, kinesiologists, family physicians, internists,

rheumatologists, and orthopedic surgeons. As OA is incurable, the goal of the treatment is to manage the negative effects of OA through pain management, improved function, and to mitigate both occupational and functional disability (Speerin et al., 2014). Less invasive methods to treat OA are: balanced diet, exercise, physiotherapy, occupational therapy, application of heat and/or cold and relaxation methods. These conventional treatment options aid in managing pain and halt the progression of the disease, but have little impact on stopping the progression of OA.

OA education and exercise are the most common and beneficial OA treatment options and should be easily introduced into a person's lifestyle. Weight loss and an increase in muscle mass achieved through high and low-intensity aerobic exercises have been shown to result in improvements of functional status and gait, as well as a decrease in pain (Ringdahl & Pandit, 2011). Few community-based health promotion programs are currently available within Canada that focuses specifically on OA management.

The use of over the counter medications, such as Acetaminophen, a preferred drug by the American College of Rheumatology (Ringdahl & Pandit, 2011), has also been proven to help relieve pain. Topical creams or gels may reduce pain and swelling without the adverse effects that may occur when ingesting oral medications. Intra-articular steroids, hyaluronic acids, and arthroscopic surgery are more invasive potential options. Both intra-articular steroids and hyaluronic acids help with pain management, but are only short-term methods of treatment (Ringdahl & Pandit, 2011). Patients with OA possess a lower concentration of hyaluronic acid, a naturally occurring glycosaminoglycan found in synovial fluid (Pavelka & Uebelhart, 2011). It is thought

that injecting hyaluronic acid into the joint helps to restore the synovial fluid environment through viscosupplementation, which helps to restore the structure of the joint and its function (Pavelka & Uebelhart, 2011).

There are other exploratory treatment options that have the potential to slow the progression of OA. One of these methods is the modification of the underlying joint structure. It has been recognized that supplements (glucosamine sulphate, chondroitin sulphate, sodium hyaluronan, doxycycline, MMP inhibitors, bisphosphonates, calcitonin) with treatment may help to modify disease progression (Johnson & Hunter, 2014). Interestingly, it has been shown that cartilage degradation is not the only cause of OA symptoms, but drug development strategies continue to focus primarily on ways to manage cartilage health.

Another OA treatment is pathomechanics. Biomechanics of the joint plays a role in OA since alignment affects joint stress. It is the magnitude and dispersion of forces caused by malalignment that cause joint stress and contribute to OA progression (Mills & Hunter, 2014). Progression of the disease results from the disruption in balance of the breaking down and repairing of joint tissues (Mills & Hunter, 2014). By focusing on modifying joint alignment through the use of braces, orthotics and taping, the progression of OA can be altered resulting in reduced OA symptoms and improved joint structure (Johnson & Hunter, 2014).

Recently, regenerative medicine is a potential area of investigation as it relates to OA. The idea is that the regeneration of damaged tissue can be achieved by implementing biomaterials, cell therapy, and bioactive factors such as growth factors, drugs and small

molecules (Hawker, 2014). Recently, the focus has been on less invasive methods that help to regenerate articular cartilage to increase its thickness through the use of mesenchymal stem cells (MSCs). MSCs are progenitor cells that can produce osteocytes, adipocytes, chondrocytes, myoblasts and tenocytes (Kristjánsson & Honsawek, 2014). MSCs contribute to the maintenance and regeneration of connective tissue and help repair injured or inflamed tissue. However, Kristjánsson & Honsawek (2014) found that when MSC's are cultured in vitro in order to yield sufficient quantities for subsequent use, their function is altered, which impacts their therapeutic effectiveness and may even lead to tumorigenesis. Currently the implantation of MSCs either through incision or injection has shown some promise in treating OA by alleviating pain and promoting cartilage regeneration, but the results are still inconsistent (Kristjánsson & Honsawek, 2014).

Surgical options specific to focal defects or single compartment disease related to OA are also available. Focal surgeries include: fresh osteochondral allografts, osteochondral autograft transfer systems (OATS), microfracture surgery and fetal cartilage transplants (juvenile). Fresh osteochondral allografts (from a donor) and OATS (from the patient) are similar procedures where a bone graft is harvested from an unaffected area of a joint and transplanted into the affected area (Rönn, Reischl, Gautier, & Jacobi, 2011). Microfracture surgery is used to repair articular cartilage by creating small fractures in underlying bone, allowing new cartilage to develop (Rönn et al., 2011). A fetal cartilage transplant, like the DeNovo NT Graft, is used to repair damage to articular cartilage by implanting a graft on the affected area (Zimmer, 2014). Osteotomy and realignment procedures (compartmental surgery) include distal femoral and high tibial osteotomies. Distal femoral and high tibial osteotomy is the surgical breaking or

fracturing of the bone to enable realignment of the limb to relieve joint pressure (Rönn et al., 2011).

When other conventional and surgical treatment options are no longer adequate to treat OA, the most common procedure is TJA. TJA is both safe and cost-effective in treating OA and helps to relieve pain while reestablishing mobility (Topp et al., 2009).

1.2 TJA

TJA, also known as total joint replacement, is an option when other conventional treatments are no longer adequately reducing pain, or when functional movements and quality of life are substantially compromised. The most commonly performed replacements in relation to OA are the hip and knee joints (Johnson & Hunter, 2014).

Before considering total knee arthroplasty (TKA), the following criteria are to be met: radiological proof of joint damage, moderate and severe pain that is not relieved by other treatments and a reduction in functional capabilities that affects quality of life. The surgical procedure involves the implantation of an artificial joint or prosthesis, which replaces the damaged joint. Affected bone and cartilage are removed and the prosthetic typically composed of metal, plastic and ceramic is implanted. In North America, THR's are usually uncemented, and TKR's are cemented. Depending on the strength of the bones in the joint, there are two types of implants available. For weaker bones, the prosthesis is cemented to the remaining bone of the joint to increase its stability and strength. This procedure however is correlated with revision surgery (aseptic loosening, implant failure, infection, etc.), partly because as the plastic wears out over time (McKay, 2011). In comparison, uncemented joints are used for stronger bones. They are designed

to allow the bone to grow around the joint to secure it naturally making this type of implant much more durable. On average, the lifespan of the prosthesis in both cases is 10-20 years, with around an 86% revision rate after 10 years (Health Sciences North, 2015).

1.2.1 Risks of TJA and barriers to recovery post-surgery

Similar to other surgical procedures, there are potential post-operative complications associated with a TJA, some of which lead to dissection or amputation. These include infections, vascular complications (i.e. myocardial infarction), thrombotic complications (deep venous thrombosis-DVT), neurologic complications (i.e. foot drop, intra-operative, post-operative), instability and/or dislocation of the joint and fracture of components of the implant or surrounding bone (Kremers, Visscher, Kremers, Naessens, & Lewallen, 2014). There are measures used to prevent or decrease the occurrence of these post-operative complications, which include prescribed antibiotics for a period of 24 hours post surgery to reduce risk of infection, mobilization, as well as both voluntary and passive movement of the joint following surgery to reduce stiffness.

Individual risk factors, some of which have already been discussed, may also impact pain and function post surgery. These factors include: “age, gender, BMI, ethnicity, psychological distress, baseline pain, functional disability, socioeconomic status, radiographic OA severity” and comorbidity profile (Dowsey & Choong, 2013, p. 1). Patients with a BMI of 30 kg/m² or greater are at increased risk of having at least one other comorbidity such as diabetes, which elevates the risk of TJA post-operative complications (Kremers et al., 2014). The reason for this may be that obese individuals

are unhealthy, deconditioned and predisposed to other medical conditions causing likeliness of post-operative complications.

Possible common risk factors for obese individuals undergoing TJA include: greater loss of blood, an increase in perioperative complications including higher risk of infection and an increased time for the wounds to heal, a higher chance of the implant failing after a minimum of 5 years and lower post-operative functional scores (D'Apuzzo, Novicoff, & Browne, 2014). These risks could be due to surgery being more difficult on patients with increased adipose tissue, which can lead to malalignment of the implants and early implant failure. A high BMI is also associated with obstructive sleep apnea, which is linked with postoperative complications (D'Apuzzo et al., 2014; Twells et al., 2014). The implementation of a community-based prehabilitation program could help mitigate these risks that are partly due to the deconditioning of these TJA candidates (Foran, Mont, Etienne, Jones, & Hungerford, 2004).

Interestingly, Dowsey & Choong (2008) looked at 1,207 total hip arthroplasties (THA), and found that the risk of infection was greater in obese patients, independent of their medical comorbidities. In contrast, other studies have found no relationship between BMI and post-operative complication rates. In particular, Moran and colleagues (2005) found no association between the level of obesity and complication rates post surgery amongst 800 cases of cemented implants. Everhart, Altneu, & Calhoun (2013) found that diabetes mellitus, tobacco use and only patients with an extremely high BMI of 50 kg/m² or greater were linked to risk factors like post-operative infection.

Another possible obstacle to being discharged post surgery included limited overall functioning and mobility, resulting in the need for significant support by other family or community support services. The patients' social situation, represented by any barriers in the patient's home that cannot be accommodated for a safe discharge such as stairs or other ergonomic factors related to the home environment is also an obstacle.

1.2.2 Implementing a prehabilitation program

Rehabilitation programs, significantly impact post-operative outcomes for patients having undergone TJA. In previous studies, patients reported substantial improvements in both mobility and independence within the first three to six month-period following surgery with the help of a post-surgery rehabilitation program (Dowsey & Choong, 2008). An issue with rehabilitation programs is that, although it is already well known that they are effective, in-patient programs can be expensive. Within Canada, there have been cut backs to in-hospital rehabilitation due to the associated costs.

In order to optimize recovery and outcomes following total joint replacement, it is important to implement a community-based exercise program *prior* to TJA as it has been shown that preoperative measures for strength, functional ability and pain are all significant positive predictors for total knee arthroplasty outcomes (Topp et al., 2009). Despite this evidence, the implementation and delivery of prehabilitation programs prior to TJA is not standard practice within the hospital setting. This may be due to the limited empirical evidence of the benefits and risks of such programs for patients with low levels of fitness and presenting with risk factors such as obesity and other health concerns. It may also be due to the costs associated with providing a hospital-based prehabilitation

program prior to OA. This is where a community-based prehabilitation program comes in to play, because not only is it effective in improving mobility and post-operative outcomes, it is cost effective and there currently are no programs like it for OA. However, prior to implementing this type of program, it is desirable to consider program parameters that would optimize its effectiveness and sustainability.

1.2.3 Community-based intervention programs

Currently, there are several community-based programs within the community where the current study was conducted that have been operating with success. These programs include: Cardiac Rehabilitation; Pulmonary Rehabilitation; and Smoking Cessation (Health Sciences North, 2015). The Cardiac Rehabilitation program is currently the most developed three-phase program and is supervised by a medical team whose mandate is aimed at improving both the health and quality of life of individuals with heart problems. The first phase is the eight-week recovery program, which occurs after hospitalization. The second phase is the Maintenance program, which is 4 months in length after recovery. The Passport to Wellness phase is the last phase and is a collaborative initiative with the YMCA, which entails exercise participation three times a week to maintain a healthy and active lifestyle. Each phase is a combination of physical activity, education on a heart healthy lifestyle and counselling to decrease stress and move forward post heart complications (Health Sciences North, 2015). The framework of these established community-based programs could be modelled to develop a community-based prehabilitation program targeting OA.

1.3 Prehabilitation Program

With OA being the most common form of arthritis and the main cause of disability in Canada and the US, it is likely that the rates of TJA will continue to increase overtime as the demographics shift towards an aged population. Accordingly, it will be important to develop effective programs aimed at reducing joint pain and improve one's ability to function when coping with this disease prior to TJA. A prehabilitation program can also reduce the functional limitations due to inactivity, by increasing muscle mass and strength, diminishing joint dysfunction, reducing disabilities related to everyday activities, lessening chronic pain and bettering quality of life (Mathus-Vliegen, 2012). It is standard for a rehabilitation program to be put into place following TJA, but there has been little research conducted on determining the effectiveness of a prehabilitation program *prior* to surgery.

Interestingly, it has been shown that functional task performance prior to surgery is a predictor of functional task performance post surgery (Swank et al., 2011). Although TJA reduces pain, it is linked to a reduction in leg strength up to several years post surgery (Swank et al., 2011). It would therefore seem plausible that strengthening leg muscles prior to surgery may help to mitigate this issue. Therefore, if properly implemented, a prehabilitation program would be anticipated to help maintain both mobility and functional status while patients are awaiting surgery. The program would also potentially enhance physical function, minimize patient anxiety prior to surgery and improve body composition, thereby relieving pressure and strain on the joints, all of which could lead to improved physical outcomes post surgery.

At the present time, there is no standard prehabilitation program that has been adopted widely due to cost and the available data in the literature regarding the effectiveness of such programs are inconsistent and hospital-based. Firstly, prehabilitation programs are uncommon due to budget constraints in outpatient rehabilitation. The lack of clear evidence-based research on the effectiveness of prehabilitation programs related to cost-savings is an obstacle to securing sustained funding to deliver such programs, which is why it is important to implement a community-based program to limit this concern (Desmeules, Hall, & Woodhouse, 2013).

For instance, improvements in muscle strength and increases in functional abilities were found to be minimal in TKA patients subsequent to a 4-8 week hospital-based exercise program in comparison to the control group who received only the usual TKA care (Swank et al., 2011). The exercise program consisted of 3 classes per week of resistance and step training in addition to the usual care (Swank et al., 2011). A previous study done by Rooks et al. (2006) looked at the effects of a 6-week prehabilitation program and found that it did not affect post surgery outcomes, however it did lead to a reduction in inpatient rehabilitation post-surgery.

In comparison, Nunez et al. (2006) found significant improvements in self-reported function in a prehabilitation group who participated in a 3-month prehabilitation program prior to TJA compared to the control group. A faster recovery of physical mobility was reported as a result of a prehabilitation program prior to TJA in combination with a well-structured exercise program post surgery or the implementation of an educational portion with exercise prior to TJA (Coudeyre et al., 2007). Either of these

combinations previously stated prior to TJA has lead to a decrease in patient anxiety prior to surgery, reduced pain and a decreased length of stay in the hospital post TJA for fragile patients (i.e. disabled or with a comorbidity) (Coudeyre et al., 2007). Duration of the exercise programs in these studies may have also attributed to the results.

Exercise programs that are personalized in terms of intensity and duration and that are completed under expert supervision where feedback is provided to the patient appear to be the most effective (Desmeules et al., 2013). Furthermore, a well-rounded prehabilitation program for patients with OA includes: active ROM and stretching exercises, use of contralateral joints in the lower extremities, exercises that increase strength of the muscles that surround the affected joints and passive mobilizations (Desmeules et al., 2013; Lee, Lee, & Kozyreva, 2013). Swimming, a non-weight bearing activity is also beneficial for overweight individuals (Van Baak & Saris, 2005).

Engaging patients who have functional limitations is an obstacle and accordingly these patients are often times the most difficult to enroll in an exercise program. Furthermore, drop out rates also tend to be greater for patients who are overweight or obese (Van Baak & Saris, 2005). In order to properly implement an effective exercise program, it is important to take into account specific barriers to exercise and the specific needs for a population affected by OA. By tailoring the prehabilitation program to the needs of this group, drop out rates may be minimized. This is an important consideration because optimizing preoperative physical function via a well-designed prehabilitation program is likely to improve postoperative physical function (Desmeules et al., 2013).

Developing an effective program can be accomplished by using previous studies in hospital care (i.e. physiotherapy programs) for groups with similar needs and relating them to the needs of individuals with OA to standardize the provided care. Therefore, creating a community-based program that is effective and easy to run, while accounting for the appropriate needs and barriers would be of value. Determining the effectiveness of the program post surgery is then required in order to secure health care funding to deliver such programs in a consistent and sustainable manner.

1.4 Cost Benefit Analysis of implementing a TJA prehabilitation program

OA affects over 27 million people in North America placing a burden on the Canadian health care system with an estimated annual cost of \$16-23 billion (Badley & Wang, 1998). A significant portion of health care costs are also expensed to treat our aging population and in treating individuals that are obese, as both groups have higher rates of co-morbidities (Mathus-Vliegen, 2012). In the United States, \$200 billion are spent for the treatment of illnesses related to obesity. Worldwide, it is estimated that 2%-7% of total medical costs are allocated to treat obesity-related illnesses (Vasarhelyi & MacDonald, 2012). In Canada, the health care system is mainly publicly funded and regulated by the government. Due to this budget structure that is government-mandated, there are limitations placed on the post-acute-care services as well as restrictions of access to these services, which ultimately leads to increases in length of stay (LOS) at the hospital post surgery (Antoniou et al., 2004).

Within Canada and the United States, the Transition cost accounting system is a well used “comprehensive database including demographic, clinical, resource utilization,

and cost of treatment data for each patient admitted to a hospital” (Antoniou et al., 2004). The Canadian hospitals are also obliged to follow the Management Information System Guidelines, which are a set of national standards on how to manage both financial and statistical data in relation to the Canadian health services organizations. Data are extracted from the hospital medical records system and go into one database that is controlled by the Transition system software. Examples of the data gathered include: discharge summary of patient LOS, clinical diagnosis and the procedures put into place. Data related to resources are then extracted such as: operating room time, pharmacy records and laboratory use. Each of these services or products are then given an associated unit cost, which is combined to represent the total hospital cost of a patient’s treatment.

The actual treatment cost of TJA is broken up into two categories; the direct cost and the overhead cost. Direct costs come from hospital departments that give the patients direct treatment, such as direct labour costs or material fees. The overhead costs are from overhead departments within the hospital, for example housekeeping or administrative costs. In Canada, the direct cost represents 68.90% of the total treatment cost for TJA (Antoniou et al., 2004). A significant factor in relation to total cost of TJA is postoperative complications as determined when using multivariate regression analyses. Postoperative complications lead to an increase of 36.50% in total cost. The cost of the TJA implant can also significantly impact the total cost of TJA. In Ontario, the estimated average cost of the implant is \$2000.00 (Health Sciences North, 2015). In 2015, there were 950 TJAs performed in Sudbury, Ontario, which would be an estimated annual cost of approximately \$1, 900 000.00 for the implants alone.

Finally, Kremers et al. (2014) found that those with a BMI in the lowest or highest percentiles exhibited longer stays in the hospital post TJA and for every five unit increase in BMI greater than 30 kg/m^2 , there was an associated increase in hospitalization costs of approximately \$421/patient (U.S. currency), adjusting for sex, age, and surgery type.

In order to perform a cost benefit analysis, the following variables need to be taken into account: the cost of a prehabilitation program, the effect of a prehabilitation program on LOS post surgery and the hospital cost per day including salary costs of physicians and nurses, medication, food, laundry and so forth. In relation to the prehabilitation program, determining the costs to design the program, to deliver the program as well as the cost of equipment, supplies and location fees will need to be considered. Demonstrated hospital cost savings as well as evidence of improvements in patient quality of life post-surgery (i.e. functional mobility, pain management) would make the resourcing and implementation of a community-based prehabilitation program justifiable and more manageable.

Chapter 2

2 Study Rationale and Hypotheses

2.1 Statement of the Problem

A positive relationship between prehabilitation exercise programs and TJA outcomes has been reported previously in the literature (Coudeyre et al., 2007; Desmeules et al., 2013). *There is currently a lack of empirical data demonstrating the health benefits and cost-effectiveness of a prehabilitation exercise program in a community-based setting.* What makes the current proposed study different from previous studies is that the subject population is from an aging community. Also obesity rates are higher than the provincial average. The community also comes with a unique set of challenges. Some of these challenges include: unique health profile (i.e. higher BMI and no prehabilitation program available), available services (reduced funding and quality based procedures) and accessibility to services. Because there is limited access to preoperative programs in the community where this study was conducted, the implementation of a community-based prehabilitation program is critical to improve function in patients with OA (Jamtvedt et al., 2008) and prepare patients for optimized recovery from TJA. There is a need for empirical data demonstrating the cost-effectiveness of a community-based prehabilitation program prior to TJA in order for budgetary resources to be permanently allocated to such an initiative.

2.2 Research questions

In this thesis, the following three research questions will be addressed:

1. Will the implementation of a community-based prehabilitation program prior to TJA of the hip or knee lead to a decreased LOS in the hospital post-surgery?

2. Will the implementation of a community-based prehabilitation program lead to overall reduced medical costs in relation to treating OA through TJA?
3. Will the implementation of a community-based prehabilitation program prior to TJA of the hip or knee lead to improved patient mobility prior to surgery and better mobility post-surgery?

2.3 Hypotheses

Hypothesis 1 – A prehabilitation program prior to TJA will decrease the LOS in the hospital post-surgery.

Hypothesis 2 – The implementation of a prehabilitation program will reduce overall health care costs in relation to treating OA through TJA.

Hypothesis 3 - The implementation of a prehabilitation program will lead to improved patient mobility outcomes prior to TJA.

Hypothesis 4 – The implementation of a prehabilitation program will lead to improved patient mobility outcomes six to twelve weeks post TJA surgery.

Chapter 3

3 Methodology

3.1 Participant Recruitment

The recruitment process involved matching the patient charts with the criteria of the study (see next section). While matching the charts, the assessment results collected at a local joint assessment center and also collected by four orthopedic surgeons whose practices were located within the same catchment area, were taken into account. Patients meeting the inclusion criteria were then informed of the study and if interested, came back to meet with the research coordinator. At this meeting, the participants were given the recruitment form (see Appendix A) and were provided the opportunity to ask any questions related to the study and how their participation would potentially affect their surgery. Upon receiving consent, participants were randomly assigned to either the control or the prehabilitation group (Mathematica 8.0). Participants assigned to the prehabilitation group were then given a copy of the recruitment form along with the exercise program schedule. The control group had the standard care options and exercises given to them following their joint assessment to follow at their own discretion. Registered Kinesiologists took the baseline measures (see below) for both groups at a local health and wellness center prior to the start of the program.

3.1.1 Participants

A total of 63 participants were recruited, 29 in the control group and 34 in the prehabilitation group. Of the 63 participants, 50 participants had completed the study or were enrolled in the study when this thesis was written. Thirteen participants dropped out

of the program, ten prior to beginning the study due to an earlier surgery date, one due to a brain injury sustained outside of the program, one due to a muscle strain sustained outside of the program and one due to new onset osteomyelitis. Of the 50 that completed the study or were enrolled in the prehabilitation program at the time of writing, there were 34 females and 16 males between the ages of 44 and 83 (average (AVG) = 63.83 years \pm 8.28). The inclusion criteria of the study were 1) a BMI equal to 30 kg/m² or greater, which is the obesity threshold (Yeung, Jackson, Sexton, Walter, & Zicat, 2011) 2) residing within a 40-kilometer radius of the regional hospital and 3) having had no history of cognitive issues (i.e. Alzheimer, Stroke, etc.) or neurologic disorders (i.e. Polio). BMI was measured using the Health o meter Professional 500KL Digital Beam Scale (Health o meter; McCook, IL).

3.2 Outcome Measures

A total of five measures were used to best predict a patient's function and pain prior to and during the prehabilitation program as well as post surgery. These included two self-reported measures, which were LEFS and VAS and three performance measures, which were TUG, SPWT and ST.

Two of the performance measures were taken using a standard chair with arm rests. The height of the chair seat was 0.48 meters from the floor and the armrest height was 0.18 meters from the seat. A standard locked wheelchair was used as well in the hospital when the standard chair was not available, with the seat being 0.48 meters from the floor and the arm rests 0.24 meters from the seat. The stopwatches used to time the participants for all three-performance measures were the Sportline (SPORTLINE;

Elmsford, NY) and the Ekho. (EKHO; Dallas, TX). The time was measured to the nearest 1/100th of a second. The stairs used for the ST were 0.20 meters in height/step. The measures were taken by one of the two Kinesiologists at the local wellness center or by one of their interns. Both Kinesiologists were familiar with the tests, but nevertheless they rehearsed along with the interns prior to taking the measures during the study to ensure consistency and reliability.

3.2.1 Self-reported measures

The first measure was the LEFS, which is a 20-item questionnaire to determine an individual's ability to perform everyday activities/tasks (see Appendix B1). This test was used to determine the participant's functional impairment related to OA. The test was scored out of 80 then the score was converted to percentages. LEFS was chosen because it is both widely used and user friendly, and has proven to be reliable, valid and a good indicator of functional ability (Hoozeboom, de Bie, Broeder, & van den Ende, 2012; Kennedy, Stratford, Riddle, Hanna, & Gollish, 2008). The second measure was the VAS, which is a continuous scale ranging from one to ten. VAS is a valid and reliable measure for chronic pain intensity (Bijur, Silver, & Gallagher, 2001). For this test, the participant places a mark along a line from one to ten in relation to where their level of pain is at that moment. There are also six faces below the line that correspond to the scale that associate their pain with one of the following categories: no pain, mild, discomforting, distressing, horrible, or excruciating (see Appendix B2). The patient circles the emotion that best represents their pain at that moment.

3.2.2 Performance measures

For the TUG test, the participant is timed from the moment they stand up from a sitting position in a standard armchair, walk three meters, turn around and until they sit back down. This test is repeated (two times in total) and the test results are averaged (see Appendix B3). The TUG test is reliable, inter-rater reliable, reproducible and sensitive to change (Dobson, Hinman, Hall, Terwee, Roos, & Bennell, 2012; Kennedy, Stratford, Wessel, Gollish, & Penney, 2005). Next, the participant does the SPWT. They are timed (to the nearest 1/100th of a second) from when they leave the starting mark to when they walk two, 20-meter lengths (see Appendix B4). If the participant walks the two lengths consecutively, the stopwatch is not stopped, however if the participant walks 20 meters, turns around and walks back 20 meters, the stopwatch is paused during the turn around and resumed once the patient starts walking the second half of the 40 meters. SPWT is reliable, inter-rater reliable, sensitive to change, and has a good interpretability (Dobson et al., 2012).

ST is the final measure with the option of using a handrail. Participants are timed from the moment they touch the first step until they have climbed nine stairs, turned around and come back down, touching the main platform they started on (see Appendix B5). Again, this test is measured to the nearest 1/100th of a second. The ST is reliable, reproducible and responsive to change whether it is improvement or degradation, particularly for patients undergoing a primary TJA of the hip or knee (Kennedy et al., 2005). For all of the tests, footwear is recommended for comfort and stability and aids are permitted and recorded when used. Aids include: a two-wheeled walker ((2WW), ranging from 0.84-0.97 meters in height), a cane, with 1 assistant (assist) and/or with 2 assists.

3.3 Prehabilitation Program

The prehabilitation program in the current study was a 12-week community-based exercise program prior to TJA surgery that was comprised of three classes per week: one land-based class with an additional education portion for the first three weeks and two pool-based classes. The surgery was to be scheduled no later than two weeks after the end date of the program. There were three levels of progression throughout the program. Level one was weeks one to three, level two was weeks four to six and level three was weeks seven to twelve.

3.3.1 Land-based program

The land-based program was designed by a registered Kinesiologist and a Human Kinetics graduate student (refer to Table I; Appendix C1) and was reviewed by an external panel comprised of physiotherapists, physicians and exercise specialists (i.e. Doctor of Philosophy (PhD)). It was based on previous studies and guidelines established for participants who are physically inactive, affected by OA and obese. It was designed so that the interns who run the classes present different levels of progression for each exercise, to allow the participants to select the alternative that best suits their abilities. A qualified physician who specializes in educating arthritis patients, created the education portion of the land-based program (refer to Appendix C2).

The administrators of the prehabilitation classes were assigned prior to the start of the program. The land-based exercises (see Appendix C1) were managed by interns (minimum of one, but commonly two) who were University students selected and trained by a registered Kinesiologist prior to the beginning of the program. A minimum of one

registered Kinesiologist and/or a Human Kinetics graduate student supervised the exercise classes. The education portion, organized and delivered by a local qualified physician, took up the last half of the land-based class during the first three weeks.

Table I: Land-Based Exercise Program Outline

	Level 1		Level 2		Level 3	
Time Frame	Weeks 1-3		Weeks 4-6		Weeks 7-12	
Class Breakdown						
Education	30 min		-		-	
Exercise	20-30 min		40-50 min		60 min	
Progressions	<ul style="list-style-type: none"> - Low impact - ROM - Isometric exercises - Flexibility 		<ul style="list-style-type: none"> - Resistance bands: yellow and green - Cardio: treadmill, cycle ergometer, arm ergometer - Balance training 		<ul style="list-style-type: none"> - Resistance bands: blue and black - Weight bearing dynamic exercises - Gait exercises 	
Program	<u>Exercise</u>	<u>Time (min)</u>	<u>Exercise</u>	<u>Time (min)</u>	<u>Exercise</u>	<u>Time (min)</u>
	Warm up	5	Warm up	5	Warm up	5
	Circuit	5-10	Circuit	30	Circuit	30-35
	Stretching	10	Balance	5	Cycle	10
			Stretching	5-10	Gait	1
					Balance	5
					Stretching	5-10

Level 1

Weeks one to three of the land-based program were 20 to 30 minutes in length with the addition of a 30-minute education period. The exercise was low impact, focused on ROM, isometric exercises and total body flexibility. The program began with a five-minute warm-up focusing on ROM, followed by a five to ten minute strengthening circuit in both standing and sitting positions. After the circuit and while the participants were

sitting on chairs in a circle, there was a general discussion between the interns and the participants. The discussion was in regards to pain level, thoughts and/or recommendations for the program and overall energy level since the commencement of the program. During that time a whole body, ten minute stretching session began. After stretching, the participants met in a separate room with the qualified physician for the education session.

Level 2

Level 2 was from weeks four to six, and was 40 to 50 minutes in length and was considered higher impact than level one based on increased duration and intensity of exercises. Level 2 included aerobic exercises (see below) and exercises using resistance bands. The session began with a five minute warm up followed by a circuit comprised of three stations, each station lasting between three to five minutes and attended twice within a 30-minute period. Station one was aerobic exercises, where the participants alternated between a treadmill, stationary bike and arm ergometer working at a level they felt comfortable. Station two was seated and/or standing resistance band exercises for the upper extremities, with eight to ten reps for each exercise. Station three was seated and/or standing resistance band exercises for hips and knees, with eight to ten reps for each exercise. The use of different coloured resistance bands was also implemented to accommodate different levels of difficulty. Yellow was light resistance, green was medium resistance, blue being heavy resistance and black being the most resistance. During level 2, participants most commonly used the yellow and green bands. The stations were followed by an open discussion and stretching period similar to level 1, with the addition of a three to five minute exercise dedicated to balance.

Level 3

Level 3 was from weeks seven to twelve and was 60 minutes in length and exercises were of greater intensity. For instance, the resistance band exercises were completed with the blue and black bands and weight bearing dynamic exercises were added to the program. The exercise sessions began with a five-minute warm up period, followed by the same three stations as described for level 2. This section was 30 to 35 minutes in duration and each station was to be attended only once for seven to ten minutes each. The aerobic station remained the same as level 2, however the upper and lower extremity resistance band stations introduced more difficult exercises, with the use of more resistant bands. Next the participants did a more fast-paced circuit for approximately ten minutes including wall push-ups, step-ups and side step-outs, where the number of repetitions progressed each week. This moved into gait exercises for 30 seconds to one minute, including: tandem walking, walking on toes, walking on heels and then long strides. The exercise class ended with a balance exercise with highest progression (reaching forward and to the sides on one leg while holding a chair if necessary), then an open-discussion and the five to ten minute stretching program similar to levels 1 and 2 (refer to Appendix C1).

3.3.2 Education component

The education component, which was presented at the end of the land-based class from weeks one to three, was 30 minutes in length. The participants were presented a slideshow. It included information related to the prevalence of OA, the physiological changes that occur and the TEAM approach to treatment: Teach Equipment Alternatives

Medications. Topics covered were the importance of exercise and the best types, the use of heat and cold therapy and an increase in activity. The education component also addressed common patient concerns regarding pain and inability to perform daily tasks and then the importance of weight loss and the development of support systems (See Appendix C2).

3.3.3 Pool-based program

The pool-based program was designed by an individual who specializes in hydrotherapy classes and the director of Health, Fitness and Aquatics at the YMCA (local recreational center). An external panel later reviewed the pool program. The pool-based classes (see Appendix C3) were managed and delivered by a designated instructor at the local recreational center, who had been trained by the center to lead hydrotherapy fitness classes for this study.

The hydrotherapy program was 45 minutes in length and was offered three times a week, however the participants were asked to attend a minimum of two classes per week. The program was held in the therapy pool and the instructor engaged with the participants by running through the program with them, while also being in the pool. Participants performed all exercises 12 to 15 times. The pool-based program was consistent for all 12 weeks, however three levels of progression were put into place. Level 1 (weeks one to three) required participants to use water resistance without weights. Level 2 (weeks four to six) required participants to increase the repetitions and to use water dumbbells. Level 3 (weeks seven to twelve) required participants to further

increase the repetitions, to use water bottles for resistance and to increase movement speed.

The program began with a ten minute warm up including gentle range of motion exercises. It then moved into a 15-minute cardio session involving a series of exercises performed while moving from one length of the therapy pool to the other. The session included plyometric exercises performed while the group was in a circle. This was followed by ten minutes of exercises dedicated to muscular development, using the water as resistance. The program ended with a ten minute cool down that included stretching and ROM exercises.

3.4 Hospital Involvement

The TJA surgeries were performed at the regional hospital, by four orthopedic surgeons who agreed to partake in the study. The artificial joint used was either a Zimmer (Zimmer Biomet; Warsaw, IN) or Smith and Nephew (smith&nephew; Memphis, TN) and standard protocols and surgical techniques were used. Both implants are widely used with a proven track record. The techniques used during TJA include a lateral approach for the hip and a standard medial parapatellar approach for the knee.

Both the physiotherapists and the nurses on the Orthopedic floor at the hospital were informed of the study prior to the participants being taken into their care post TJA. The physiotherapists and physiotherapist assistants were taken through the measures to ensure they were administered in the same manner as at the local wellness center to ensure reliability and consistency of results. The nurses were informed of the discharge criteria and were briefed of the procedure and their role in the study.

An effort was made to keep the physicians, physiotherapists and nursing staff blinded in regards to whether the participants were in the prehabilitation group or control group. Once the participants were placed into a group, they were asked not to say which group they were in to any of the TJA medical or therapy staff in relation to the study.

The physiotherapists were given a list of participants in the study prior to the group being on the floor and then the discharge criteria were placed on the front of the patient's charts. An orange form used to help flag the patient-participants was also placed on the front of each patient's binder in addition to the discharge criteria. The orange form described what was expected of the nurses and physiotherapists along with a checklist to ensure all necessary information was collected. Prior to a new set of subjects undergoing TJA, a member of the research team attended the Orthopedic floor 'morning huddle' to remind the staff of the study and to answer any outstanding questions. This was implemented to ensure that all data was collected.

3.4.1 Hospital discharge criteria

The discharge criteria included: absence of wound problems, pain control (through oral analgesics), awareness of procedures for safely ending medication, awareness of precautions and restrictions, a stable hemoglobin, being able to safely walk, ability to perform home exercise, ability to perform personal care and having a ROM greater than 70 degrees (irrelevant for hips)(see Appendix D). Once the nurses and physiotherapists checked off all of the discharge criteria for a participant, that particular day was set as the temporal reference point to determine LOS. The orthopedic surgeon also oversaw the

patient's status to ensure discharge criteria were met. Subsequently, the physiotherapists collected data for the five functional tests: LEFS, VAS, TUG, SPWT, and ST, prior to participants being officially discharged from the hospital. The LOS and the date of hospital discharge did not necessarily align perfectly due to other variables such as availability of staff to collect the functional test measures, particularly on weekends.

3.5 Cost Benefit Analysis

A cost benefit analysis was performed to determine if the implementation of a prehabilitation program prior to TJA would reduce overall hospital costs. The costs were broken up into three sections: costs to deliver the prehabilitation exercise program, hospital costs associated with TJA and comparative analyses of hospital expenses incurred by the control and the prehabilitation exercise groups.

The prehabilitation exercise program costs were determined by calculating the total expenses associated with running the program. The expenses included the facility costs to deliver the land and pool based exercise program, the salaries of staff to administer the program, the equipment, licensing and administration supplies.

The hospital costs were determined by evaluating the resources used during the patient's hospital stay post TJA and determining the mean cost per patient, then multiplying the mean by the average number of TJA procedures performed per year. The hospital expenses included medications, salaries of health care staff, linens, food and fees related to readmission due to post-surgery complications.

The hospital cost for the control and for the prehabilitation exercise group was calculated based on the LOS for each group (defined as days post-surgery when

discharge criteria were met). The final cost benefit analysis took into account the expenses to administer the prehabilitation exercise program and potential hospital cost savings resulting from shorter hospital stay post-surgery for the prehabilitation exercise program group. A cost neutral program yielding positive health outcomes for the participants could be considered as adequate criteria to implement a community-based prehabilitation exercise program.

3.6 Statistical Analyses

The data were analyzed using IBM SPSS 22.0. The Friedman test was used to determine if there were any differences between the mobility measures collected from the control and the prehabilitation exercise groups. One-way analysis of variance (ANOVA) was performed to determine any differences in LOS between the two groups. Pearson's chi-squared test was performed to compare the frequency that the participants declined surgery post prehab program in the control versus the prehab group. For all data analyses, p was set at <0.05 . Student t-tests were also performed to determine the differences in total hospital cost for the control group and the prehabilitation group.

Chapter 4

4 Results

4.1 Participants

Table IIA represents the demographic data of the control and prehabilitation groups and Table IIB breaks down the demographic data of the control and prehabilitation groups into TKA and THA. There were no differences between the control and prehabilitation groups' demographic data. The average age for the control group (n=21) was 64.38(\pm 9.32) years, their average BMI was 42.37(\pm 6.93) kg/m² and their average level of OA was 4.00(\pm 0.00), which is the highest possible OA rating on a scale of 1-4. The average age for the prehabilitation group (n=29) was 63.28(\pm 7.24) years, their average BMI was 41.02(\pm 6.91) kg/m² and their average level of OA was 3.97(\pm 0.13). For the control group, 67% were women and 33% were men and for the prehabilitation group the distribution of women and men was 69% and 31% respectively. On average, participants in the prehabilitation group attended 85% (10/12) of classes during the 12-week period. Approximately 81% and 72% of the control group and prehabilitation group underwent TKA respectively and 19% (control) and 28% (prehabilitation) underwent THA.

4.2 Prehabilitation Program Effects

4.2.1 Effects on self-reported measures

Table IIIA summarizes the averages and standard deviations for both the control and prehabilitation groups' baseline, 12-week (end of prehabilitation program) and 12-week post-operative scores for LEFS and VAS. Despite efforts to randomly assign the participants into the control and prehabilitation groups, the baseline LEFS scores were not

similar between the two groups. Tables IIIB and IIIC break down the averages for the LEFS and VAS measures of the control and prehabilitation groups into TKA and THA respectively. The sample sizes displayed in Tables IIIA-IIIC for the control and prehabilitation groups (n= 16 each) are different from the sample size reported in Tables IIA and IIB because the study was still ongoing at the time of thesis submission. More specifically, the data reported in Tables IIIA-IIIC and in the Figures are from participants that had reached the 12-week post-operative mark. Figures 1 and 2 represent the LEFS scores and the VAS scores are displayed in Figures 3 and 4. The LEFS scores were not significantly improved by the end of the 12-week exercise program for the control ($p = 0.317$) and prehabilitation ($p = 0.134$) groups as seen in Figure 1, despite their baseline scores not being similar. Figure 3 shows that there was also no improvement in the VAS self-reported measure after the 12-week exercise program for either the control ($p = 0.782$) or the prehabilitation groups ($p = 0.285$).

Table IIA: Overview of the control and prehabilitation group profiles (age, BMI, level of OA).

<i>Profile</i>	Control Group, n=21	Prehabilitation Group, n=29
	<i>M: n=7, W: n=14</i>	<i>M: n=9, W: n=20</i>
<i>Age (years)</i>	64.38(9.32) <i>M: 61.43(8.87)</i> <i>W: 65.86(9.51)</i>	63.28(7.24) <i>M: 63.44(8.04)</i> <i>W: 63.20(7.08)</i>
<i>BMI (kg/m²)</i>	42.37(6.93) <i>M: 38.41(4.22)</i> <i>W: 44.35(7.29)</i>	41.02(6.91) <i>M: 37.75(3.41)</i> <i>W: 42.24(7.77)</i>
<i>Level of OA (1-4)</i>	4.00(0.00) <i>M: 4.00(0.00)</i> <i>W: 4.00(0.00)</i>	3.97(0.13) <i>M: 4.00(0.00)</i> <i>W: 3.95(0.15)</i>

Data presented as the mean (±SD).

M: Men, W: Women, BMI: Body Mass Index, OA: Osteoarthritis.

Table IIB: Overview of the control and prehabilitation group profiles (age, BMI, level of OA) for total knee arthroplasty (TKA) and total hip arthroplasty (THA).

<i>Profile</i>	Control Group, n= 21		Prehabilitation Group, n= 29	
	TKA, n=17	THA, n=4	TKA, n=21	THA, n=8
	<i>M: n=7, W: n=10</i>	<i>M: n=0, W: n=4</i>	<i>M: n=7, W: n=14</i>	<i>M: n=2, W: n=6</i>
<i>Age (years)</i>	64.59(9.42) <i>M: 61.43(8.87)</i> <i>W: 66.80(9.60)</i>	63.50(10.25) <i>M: N/A</i> <i>W: 63.50(10.25)</i>	61.90(6.48) <i>M: 62.71(9.05)</i> <i>W: 61.50(4.80)</i>	66.88(8.32) <i>M: 66.00(2.83)</i> <i>W: 67.17(9.75)</i>
<i>BMI (kg/m²)</i>	43.16(7.25) <i>M: 38.41(4.22)</i> <i>W: 46.49(7.19)</i>	39.00(4.63) <i>M: N/A</i> <i>W: 39.00(4.63)</i>	42.03(7.13) <i>M: 38.80(3.78)</i> <i>W: 43.75(5.13)</i>	38.38(5.88) <i>M: 36.70(0.42)</i> <i>W: 38.93(6.85)</i>
<i>Level of OA (1-4)</i>	4.00(0.00) <i>M: 4.00(0.00)</i> <i>W: 4.00(0.00)</i>	4.00(0.00) <i>M: N/A</i> <i>W: 4.00(0.00)</i>	3.95(0.15) <i>M: 4.00(0.00)</i> <i>W: 3.93(0.18)</i>	4.00(0.00) <i>M: 4.00(0.00)</i> <i>W: 4.00(0.00)</i>

Data presented as the mean (±SD)

M: Men, W: Women, TKA: Total Knee Arthroplasty, THA: Total Hip Arthroplasty, BMI: Body Mass Index, OA: Osteoarthritis.

Table IIIA: Summary of the control and prehabilitation groups' baseline, 12 week post-prehabilitation program, and 12 week post-operative self-reported measures (LEFS, VAS) and mobility measures (TUG, SPWT, ST).

<i>Measure</i>	Control, n=16 <i>M: n=5, W: n=11</i>			Prehabilitation, n=16 <i>M: n=5, W: n=11</i>		
	Baseline	12-Weeks	12-Weeks Post-Op	Baseline	12-Weeks	12-Weeks Post-Op
<i>LEFS</i>	23.25(9.00) <i>M: 24.00(9.92)</i> <i>W: 22.91(9.04)</i>	21.81(11.43) <i>M: 26.20(9.78)</i> <i>W: 19.82(11.98)</i>	46.81(17.99)⁺ <i>M: 49.60(22.88)</i> <i>W: 45.55(16.44)⁺</i>	35.00(15.40)* <i>M: 47.80(16.59)*</i> <i>W: 29.18(11.25)</i>	36.44(10.30)* <i>M: 41.20(6.69)</i> <i>W: 34.27(11.16)*⁺</i>	46.88(11.53)⁺ <i>M: 53.00(14.16)</i> <i>W: 44.09(9.59)⁺</i>
<i>VAS</i>	5.03(2.09) <i>M: 4.80(3.11)</i> <i>W: 5.14(1.61)</i>	5.09(2.81) <i>M: 4.00(3.39)</i> <i>W: 5.59(2.52)</i>	1.56(1.66)⁺ <i>M: 1.40(2.04)⁺</i> <i>W: 1.64(1.57)⁺</i>	4.22(2.91) <i>M: 3.90(1.75)</i> <i>W: 4.36(3.38)</i>	3.72(1.46) <i>M: 4.20(1.10)</i> <i>W: 3.50(1.60)</i>	1.34(2.01)⁺ <i>M: 2.40(3.21)</i> <i>W: 0.86(1.05)⁺</i>
<i>TUG (sec)</i>	11.87(2.56) <i>M: 11.07(1.90)</i> <i>W: 12.23(2.82)</i>	12.98(4.17) <i>M: 10.81(2.29)</i> <i>W: 13.96(4.54)</i>	10.72(3.45) <i>M: 9.55(1.36)⁺</i> <i>W: 11.25(4.01)⁺</i>	11.61(3.97) <i>M: 9.63(1.80)</i> <i>W: 12.51(4.41)</i>	9.80(3.07)*⁺ <i>M: 8.04(1.73)⁺</i> <i>W: 10.60(3.26)</i>	10.27(2.94) <i>M: 8.95(3.53)</i> <i>W: 10.87(2.59)⁺</i>
<i>SPWT (sec)</i>	37.85(7.88) <i>M: 33.35(5.05)</i> <i>W: 39.89(8.27)</i>	40.78(12.97) <i>M: 32.19(6.71)</i> <i>W: 44.68(13.45)</i>	36.32(10.67) <i>M: 31.86(4.49)</i> <i>W: 38.35(12.18)</i>	37.26(16.48) <i>M: 27.87(5.99)</i> <i>W: 41.52(18.14)</i>	32.16(10.13)*⁺ <i>M: 24.88(5.20)⁺</i> <i>W: 35.47(10.22)⁺</i>	35.15(8.59) <i>M: 30.31(8.40)</i> <i>W: 37.35(8.09)</i>
<i>ST (sec)</i>	24.31(7.31) <i>M: 20.04(6.31)</i> <i>W: 26.25(7.13)</i>	27.45(10.01) <i>M: 19.31(7.47)</i> <i>W: 30.41(9.36)</i>	20.01(11.71) <i>M: 12.99(2.48)</i> <i>W: 23.20(12.94)</i>	22.43(11.63) <i>M: 12.35(3.15)</i> <i>W: 27.01(11.19)</i>	16.52(7.27)*⁺ <i>M: 10.15(3.04)⁺</i> <i>W: 19.42(6.78)*⁺</i>	17.52(7.20)⁺ <i>M: 12.00(5.72)</i> <i>W: 20.02(6.52)⁺</i>

Data presented as the mean (\pm SD).

M: Men, W: Women, LEFS: Lower Extremity Functional Scale, VAS: Visual Analogue Scale, TUG: Timed Up and Go Test, SPWT: Self-Paced Walk Test, ST: Stair Test.

*denotes significant differences between the control and prehabilitation groups at each time point.

⁺denotes significant within group differences from baseline.

Table IIIB: Summary of the control group's baseline, 12 week post-prehabilitation program, and 12 week post-op self-reported measures (LEFS, VAS) and mobility measures (TUG, SPWT, ST) categorized by total knee arthroplasty (TKA) and total hip arthroplasty (THA) participants.

Measure	TKA, n=12 <i>M: n=5, W: n=7</i>			THA, n=4 <i>M: n=0, W: n=4</i>		
	Baseline	12 Weeks	12 Weeks Post-Op	Baseline	12 Weeks	12 Weeks Post-Op
LEFS	24.00(9.47) <i>M: 24.00(9.92)</i> <i>W: 24.00(9.93)</i>	21.67(10.18) <i>M: 26.20(9.78)</i> <i>W: 18.43(9.85)</i>	46.33(16.18)⁺ <i>M: 49.60(22.88)</i> <i>W: 44.00(10.77)⁺</i>	21.00(8.21) <i>M: N/A</i> <i>W: 21.00(8.21)</i>	22.25(16.50) <i>M: N/A</i> <i>W: 22.25(16.50)</i>	48.25(25.57)⁺ <i>M: N/A,</i> <i>W: 48.25(25.57)⁺</i>
VAS	4.58(2.23) <i>M: 4.80(3.11)</i> <i>W: 4.43(1.62)</i>	4.67(2.87) <i>M: 4.00(3.39)</i> <i>W: 5.14(2.61)</i>	1.50(1.77)⁺ <i>M: 1.40(2.04)⁺</i> <i>W: 1.57(1.72)⁺</i>	6.38(0.48) <i>M: N/A</i> <i>W: 6.38(0.48)</i>	6.38(2.50) <i>M: N/A,</i> <i>W: 6.38(2.50)</i>	1.75(1.50)⁺ <i>M: N/A,</i> <i>W: 1.75(1.50)⁺</i>
TUG	11.87(2.45) <i>M: 11.07(1.90)</i> <i>W: 12.44(2.78)</i>	12.02(2.89) <i>M: 10.81(2.29)</i> <i>W: 12.88(3.12)</i>	10.15(1.31)⁺ <i>M: 9.55(1.36)⁺</i> <i>W: 10.58(1.18)</i>	11.85(3.28) <i>M: (N/A)</i> <i>W: 11.85(3.28)</i>	15.86(6.47) <i>M: (N/A)</i> <i>W: 15.86(6.47)</i>	12.42(6.92) <i>M: (N/A)</i> <i>W: 12.42(6.92)</i>
SPWT	37.46(7.91) <i>M: 33.35(5.05)</i> <i>W: 40.40(8.57)</i>	37.54(9.43) <i>M: 32.19(6.71)</i> <i>W: 41.36(9.61)</i>	34.91(4.62) <i>M: 31.86(4.49)</i> <i>W: 37.09(3.53)</i>	38.99(8.90) <i>M: (N/A)</i> <i>W: 38.99(8.90)</i>	50.51(18.64) <i>M: (N/A)</i> <i>W: 50.51(18.64)</i>	40.55(21.43) <i>M: (N/A)</i> <i>W: 40.55(21.43)</i>
ST	24.16(7.51) <i>M: 20.04(6.31)</i> <i>W: 27.10(7.26)</i>	24.81(8.78) <i>M: 19.31(7.47)</i> <i>W: 27.96(8.29)</i>	18.79(6.29) <i>M: 12.99(2.48)⁺</i> <i>W: 22.94(4.50)</i>	24.77(7.71) <i>M: (N/A)</i> <i>W: 24.77(7.71)</i>	34.71(10.75)^{*+} <i>M: (N/A)</i> <i>W: 34.71(10.75)⁺</i>	23.66(22.75) <i>M: (N/A)</i> <i>W: 23.66(22.75)</i>

Data presented as the mean (\pm SD).

M: Men, W: Women, TKA: Total Knee Arthroplasty, THA: Total Hip Arthroplasty, LEFS: Lower Extremity Functional Scale, VAS: Visual Analogue Scale, TUG: Timed Up and Go Test, SPWT: Self-Paced Walk Test, ST: Stair Test.

**denotes significant differences between the TKA and THA groups at each time point.*

⁺denotes significant within group (TKA, THA) differences from baseline.

Table IIIC: Summary of the prehabilitation group's baseline, 12 week post-prehabilitation program, and 12 week post-op self-reported measures (LEFS, VAS) and mobility measures (TUG, SPWT, ST) categorized by total knee arthroplasty (TKA) and total hip arthroplasty (THA) participants.

<i>Measure</i>	TKA, n=11 <i>M: n=4, W: n=7</i>			THA, n=5 <i>M: n=1, W: n=4</i>		
	Baseline	12 Weeks	12 Weeks Post-Op	Baseline	12 Weeks	12 Weeks Post-Op
<i>LEFS</i>	35.55(15.12) <i>M: 47.50(19.14)</i> <i>W: 28.71(6.92)</i>	38.18(9.85) <i>M: 41.00(7.70)</i> <i>W: 36.57(11.12)</i>	50.64(10.14)⁺ <i>M: 58.75(6.85)</i> <i>W: 46.00(8.89)⁺</i>	33.80(17.77) <i>M: 49.00(N/A)</i> <i>W: 30.00(18.02)</i>	32.60(11.33)* <i>M: 42.00(N/A)</i> <i>W: 30.25(11.59)</i>	38.60(10.81) <i>M: 30.00(N/A)</i> <i>W: 40.75(11.18)</i>
<i>VAS</i>	3.95(2.80) <i>M: 4.38(1.60)</i> <i>W: 3.71(3.40)</i>	3.50(1.47) <i>M: 4.00(1.15)</i> <i>W: 3.21(1.63)</i>	0.77(0.98)⁺ <i>M: 1.00(0.82)</i> <i>W: 0.64(1.11)</i>	4.80(3.40) <i>M: 2.00(N/A)</i> <i>W: 5.50(3.49)</i>	4.20(1.48) <i>M: 5.00(N/A)</i> <i>W: 4.00(1.63)</i>	2.60(3.13) <i>M: 8.00(N/A)</i> <i>W: 1.25(0.96)⁺</i>
<i>TUG</i>	10.74(2.06) <i>M: 9.52(2.06)</i> <i>W: 11.44(1.85)</i>	9.05(1.91)⁺ <i>M: 7.83(1.92)⁺</i> <i>W: 9.74(1.63)</i>	8.90(1.59)⁺ <i>M: 7.38(0.28)⁺</i> <i>W: 9.76(1.33)⁺</i>	13.53(6.45) <i>M: 10.08(N/A)</i> <i>W: 14.39(7.11)</i>	11.46(4.60) <i>M: 8.90(N/A)</i> <i>W: 12.10(5.04)</i>	13.29(3.06) <i>M: 15.25(N/A)</i> <i>W: 12.81(3.30)</i>
<i>SPWT</i>	33.90(6.85) <i>M: 28.71(6.57)</i> <i>W: 36.86(5.32)</i>	29.73(5.13)⁺ <i>M: 25.50(5.79)⁺</i> <i>W: 32.15(2.91)</i>	30.57(4.07)⁺ <i>M: 26.67(2.36)</i> <i>W: 32.79(2.98)⁺</i>	44.64(28.33) <i>M: 24.50(N/A)</i> <i>W: 49.68(30.02)</i>	37.51(16.33) <i>M: 22.38(N/A)</i> <i>W: 41.29(16.13)</i>	45.23(7.10) <i>M: 44.88(N/A)</i> <i>W: 45.32(8.20)</i>
<i>ST</i>	21.21(8.69) <i>M: 12.11(3.58)</i> <i>W: 26.41(5.72)</i>	15.29(6.34)⁺ <i>M: 10.51(3.38)⁺</i> <i>W: 18.02(6.11)⁺</i>	14.73(5.87)⁺ <i>M: 9.49(1.31)</i> <i>W: 17.73(5.26)⁺</i>	25.12(17.48) <i>M: 13.34(N/A)</i> <i>W: 28.06(18.69)</i>	19.24(9.18)* <i>M: 8.70(N/A)</i> <i>W: 21.88(8.12)</i>	23.64(6.34) <i>M: 22.03(N/A)</i> <i>W: 24.04(7.24)</i>

Data presented as the mean (\pm SD).

M: Men, *W*: Women, *TKA*: Total Knee Arthroplasty, *THA*: Total Hip Arthroplasty, *LEFS*: Lower Extremity Functional Scale, *VAS*: Visual Analogue Scale, *TUG*: Timed Up and Go Test, *SPWT*: Self-Paced Walk Test, *ST*: Stair Test.

*denotes significant differences between the TKA and THA groups at each time point.

⁺denotes significant within group (TKA, THA) differences from baseline.

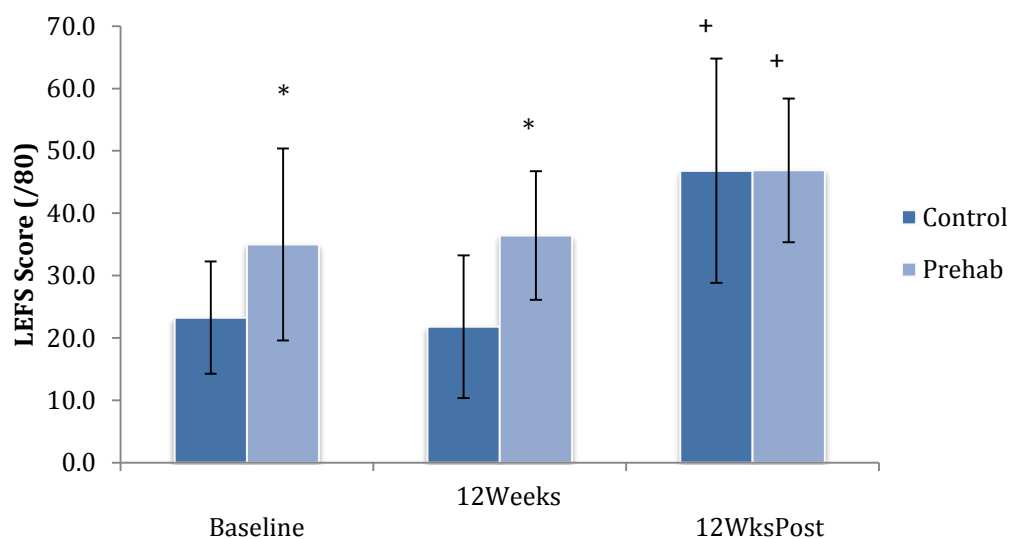


Figure 1: LEFS scores prior to program (baseline), end of 12 week prehabilitation program (12 weeks), and 12 weeks post surgery (12 Weeks Post-Op). *denotes significant differences between the control and prehabilitation groups at each time point. +denotes significant within group differences from baseline. Data are presented as the mean (\pm SD).

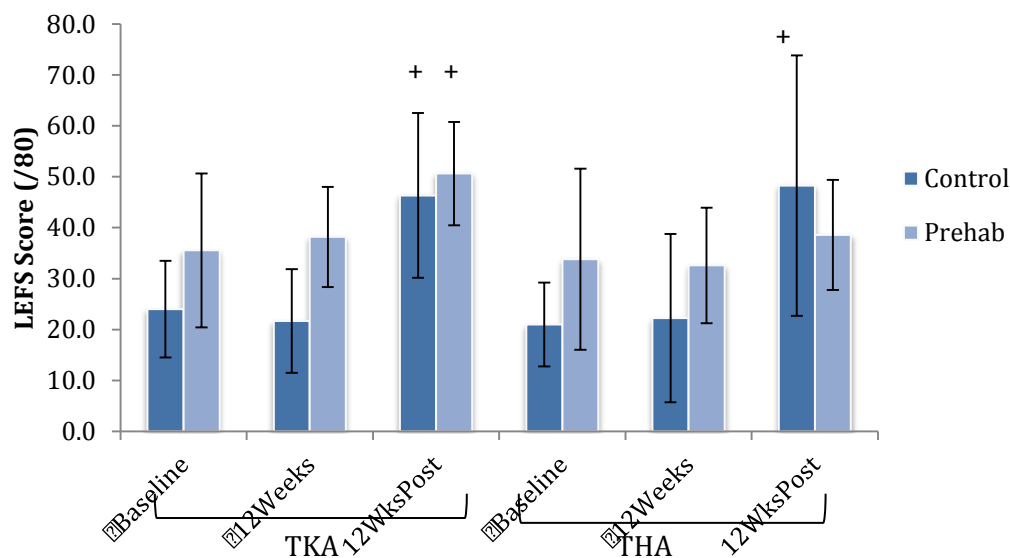


Figure 2: LEFS scores for both TKA and THA prior to program (baseline), end of 12 week prehabilitation program (12 Weeks), and 12 weeks post surgery (12 Wks Post). *denotes significant differences between the control and prehabilitation groups at each time point. +denotes significant within group (TKA, THA) differences from baseline. Data are presented as the mean (\pm SD).

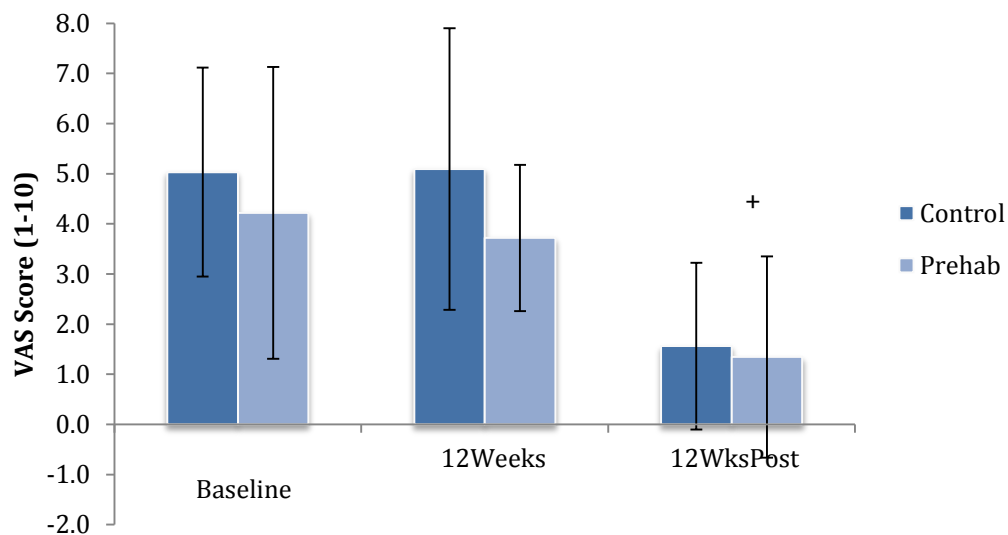


Figure 3: VAS scores prior to program (baseline), end of 12 week prehabilitation program (12 weeks), and 12 weeks post surgery (12 Weeks Post-Op). ⁺denotes significant within group differences from baseline. Data are presented as the mean (\pm SD).

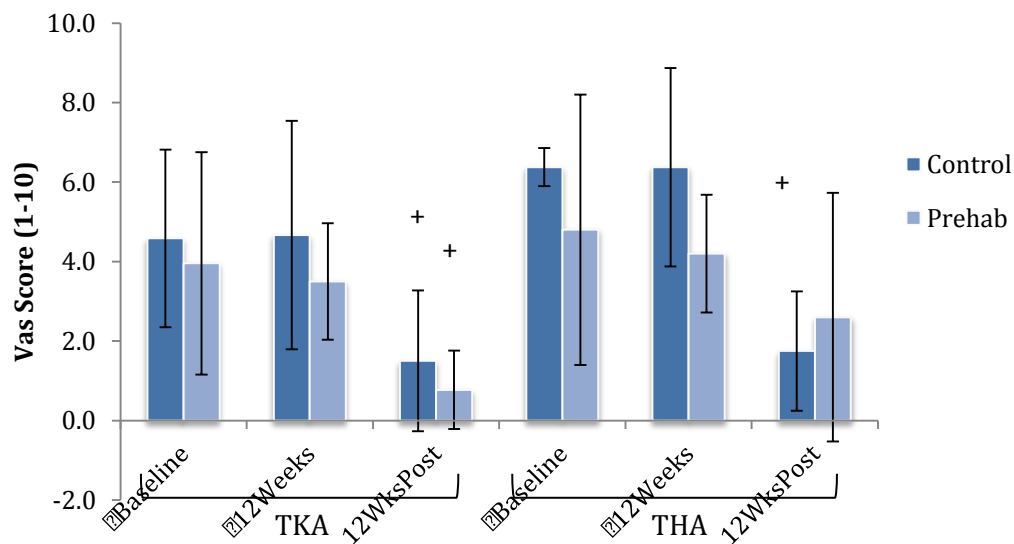


Figure 4: VAS scores for TKA and THA prior to program (baseline), end of 12 week prehabilitation program (12 weeks), and 12 weeks post surgery (12 Wks Post). ⁺denotes significant within group (TKA, THA) differences from baseline. Data are presented as the mean (\pm SD).

4.2.2 Effects on mobility measures

Table IIIA summarizes the data for both the control and prehabilitation groups' baseline, 12 week (end of prehabilitation program) and 12 week post-operative scores for TUG, SPWT and ST. Tables IIIB and IIIC break down the averages for the TUG, SPWT and ST of the control and prehabilitation groups into TKA and THA respectively. As depicted in Figure 5, the TUG scores were similar at baseline between the two groups, however at the end of the 12 week exercise program, the participants in the prehabilitation group showed a significant improvement ($p=0.012$) of 15.60%, whereas the control group remained the same ($p=0.317$). For the SPWT, the prehabilitation group improved ($p=0.003$) by 13.67% from baseline, while the control group showed no improvement ($p=1.000$) as seen in Figure 7. Figure 9 shows that the ST yielded the same pattern as the prior two tests, where the prehabilitation group improved ($p = 0.000$) by 26.35% from baseline, whereas there was no change for the control group ($p = 0.439$). The percent changes for the self-reported and performance measures between baseline and the end of the prehabilitation program (i.e. 12 weeks) for the control and prehabilitation groups are displayed in Figure 11A. All together, the prehabilitation group showed improvements in all three-mobility measures at the end of the program while the control group showed no change.

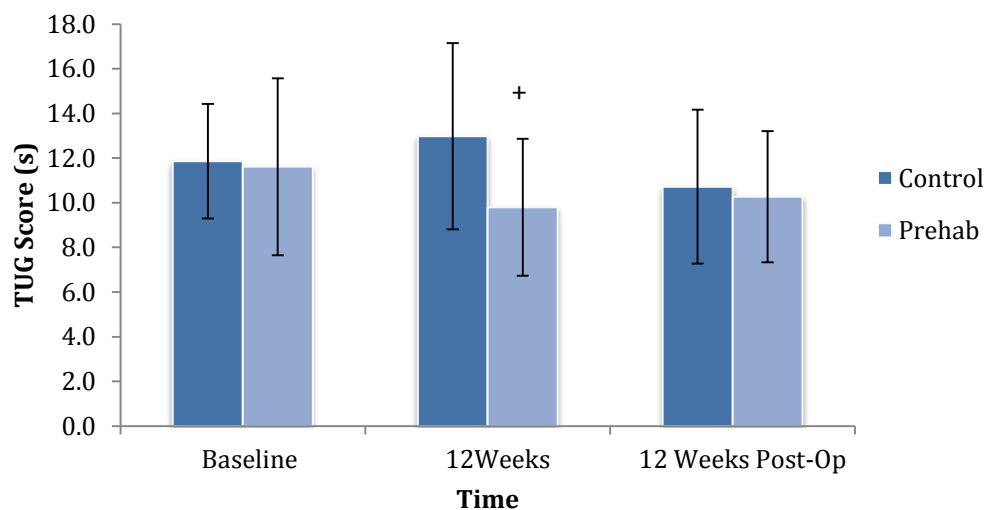


Figure 5: TUG scores prior to program (baseline), end of 12 week prehabilitation program (12 weeks), and 12 weeks post surgery (12 Weeks Post-Op). *denotes significant differences between the control and prehabilitation groups at each time point. ⁺denotes significant within group differences from baseline. Data are presented as the mean (\pm SD).

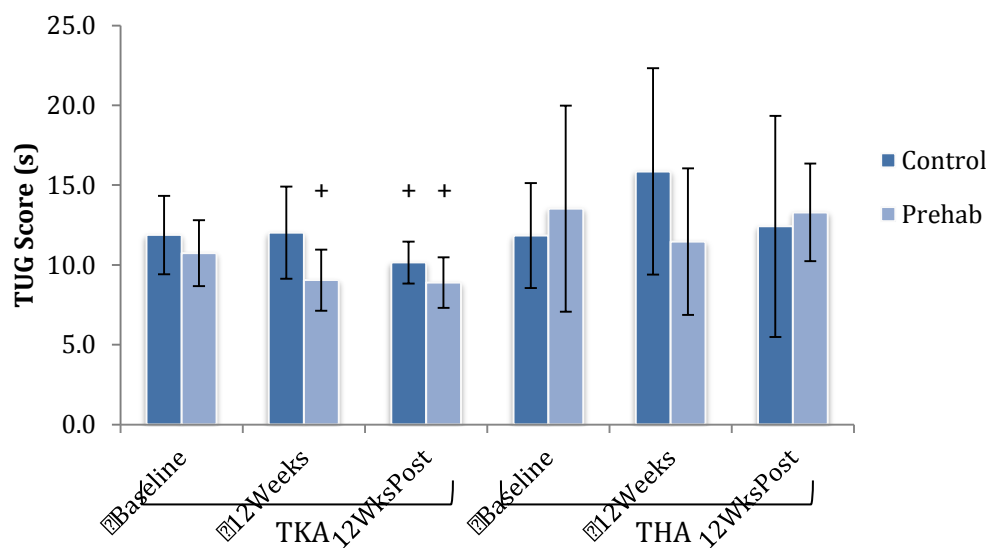


Figure 6: TUG scores for TKA and THA prior to program (baseline), end of 12 week prehabilitation program (12 weeks), and 12 weeks post surgery (12 Wks Post). ⁺denotes significant within group (TKA, THA) differences from baseline. Data are presented as the mean (\pm SD).

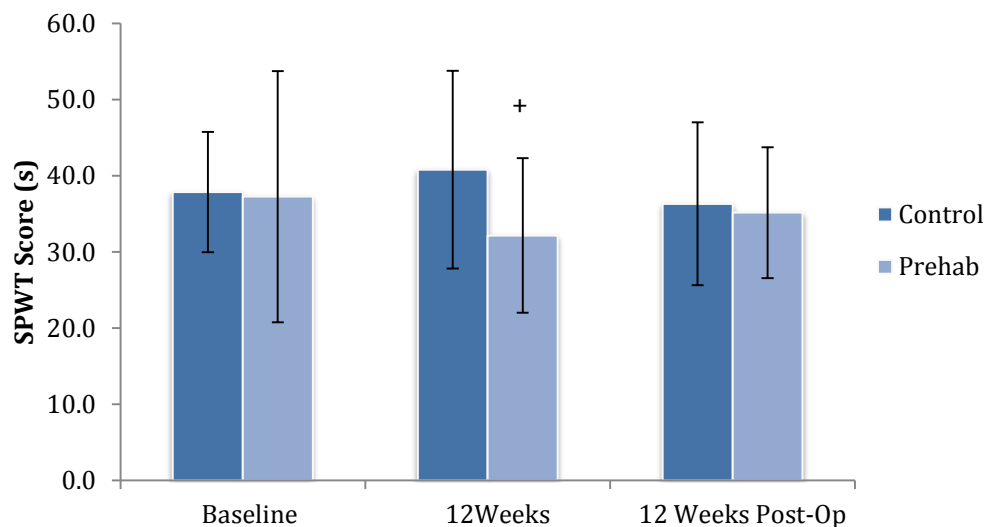


Figure 7: SPWT scores prior to program (baseline), end of 12 week prehabilitation program (12 weeks), and 12 weeks post surgery (12 Weeks Post-Op). *denotes significant differences between the control and prehabilitation groups at each time point. ⁺denotes significant within group differences from baseline. Data are presented as the mean (\pm SD).

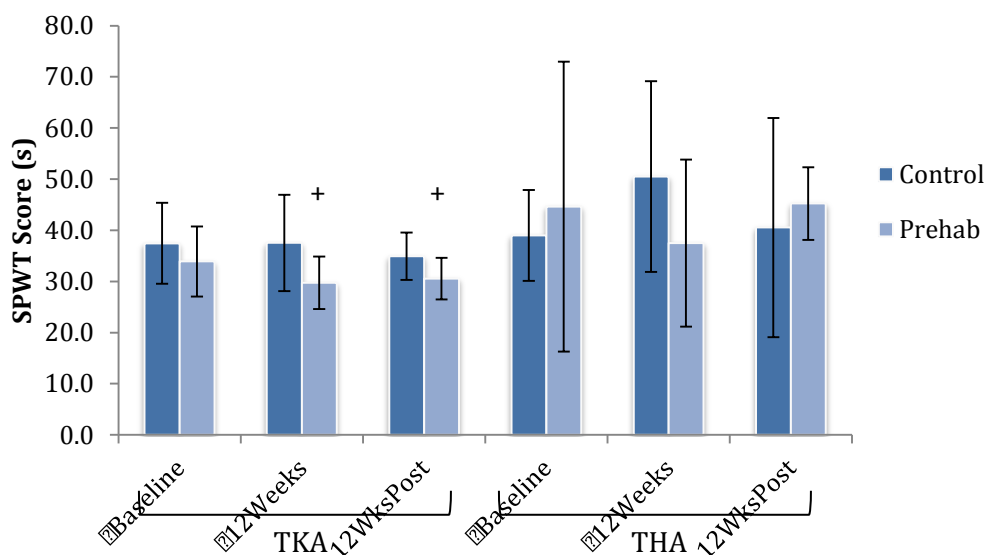


Figure 8: SPWT scores for TKA and THA prior to program (baseline), end of 12 week prehabilitation program (12 weeks), and 12 weeks post surgery (12 Wks Post). ⁺denotes significant within group (TKA, THA) differences from baseline. Data are presented as the mean (\pm SD).

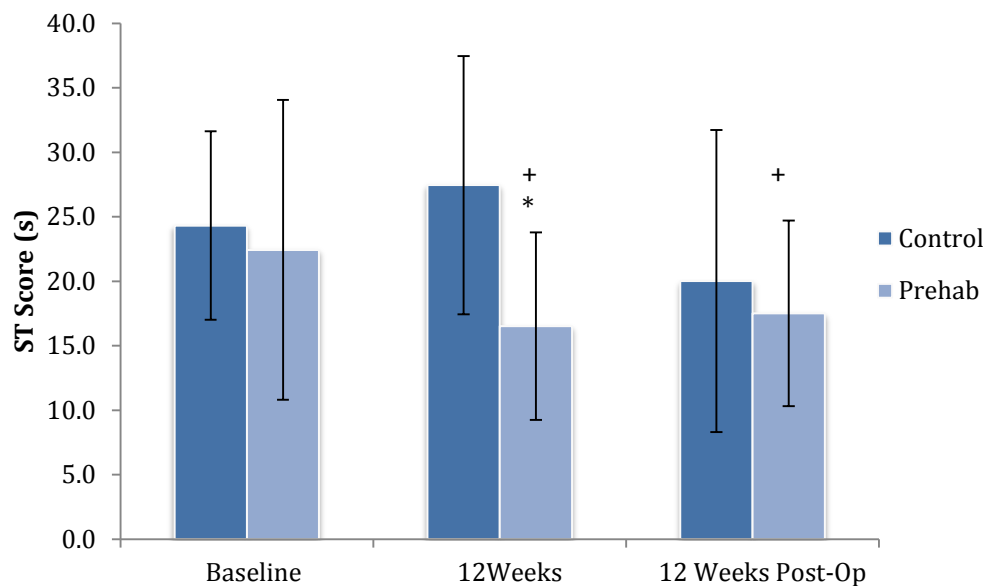


Figure 9: ST scores prior to program (baseline), end of 12 week prehabilitation program (12 weeks), and 12 weeks post surgery (12 Weeks Post-Op). *denotes significant differences between the control and prehabilitation groups at each time point. +denotes significant within group differences from baseline. Data are presented as the mean (\pm SD).

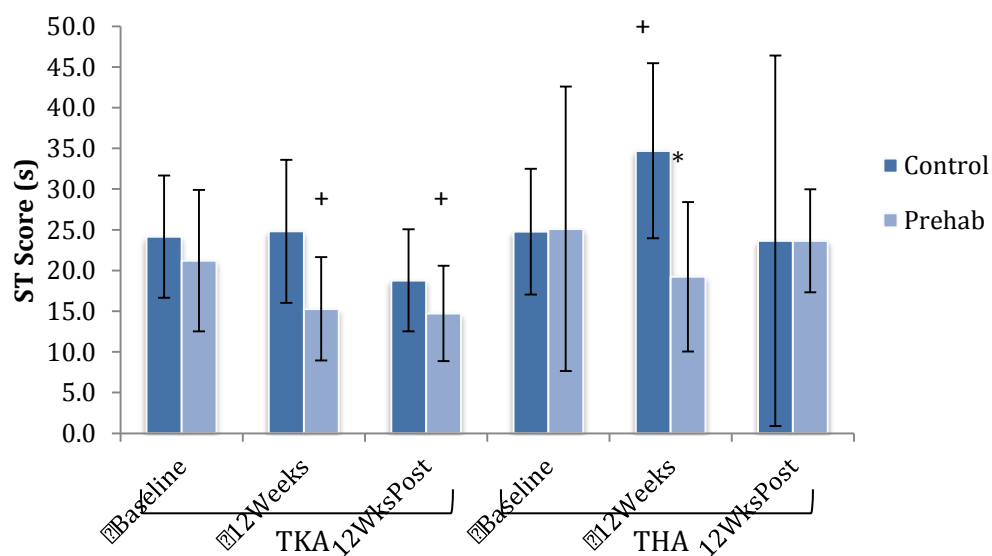


Figure 10: ST scores for TKA and THA prior to program (baseline), end of 12 week prehabilitation program (12 weeks), and 12 weeks post surgery (12 Wks Post). *denotes significant differences between the control and prehabilitation groups at each time point. +denotes significant within group (TKA, THA) differences from baseline. Data are presented as the mean (\pm SD)

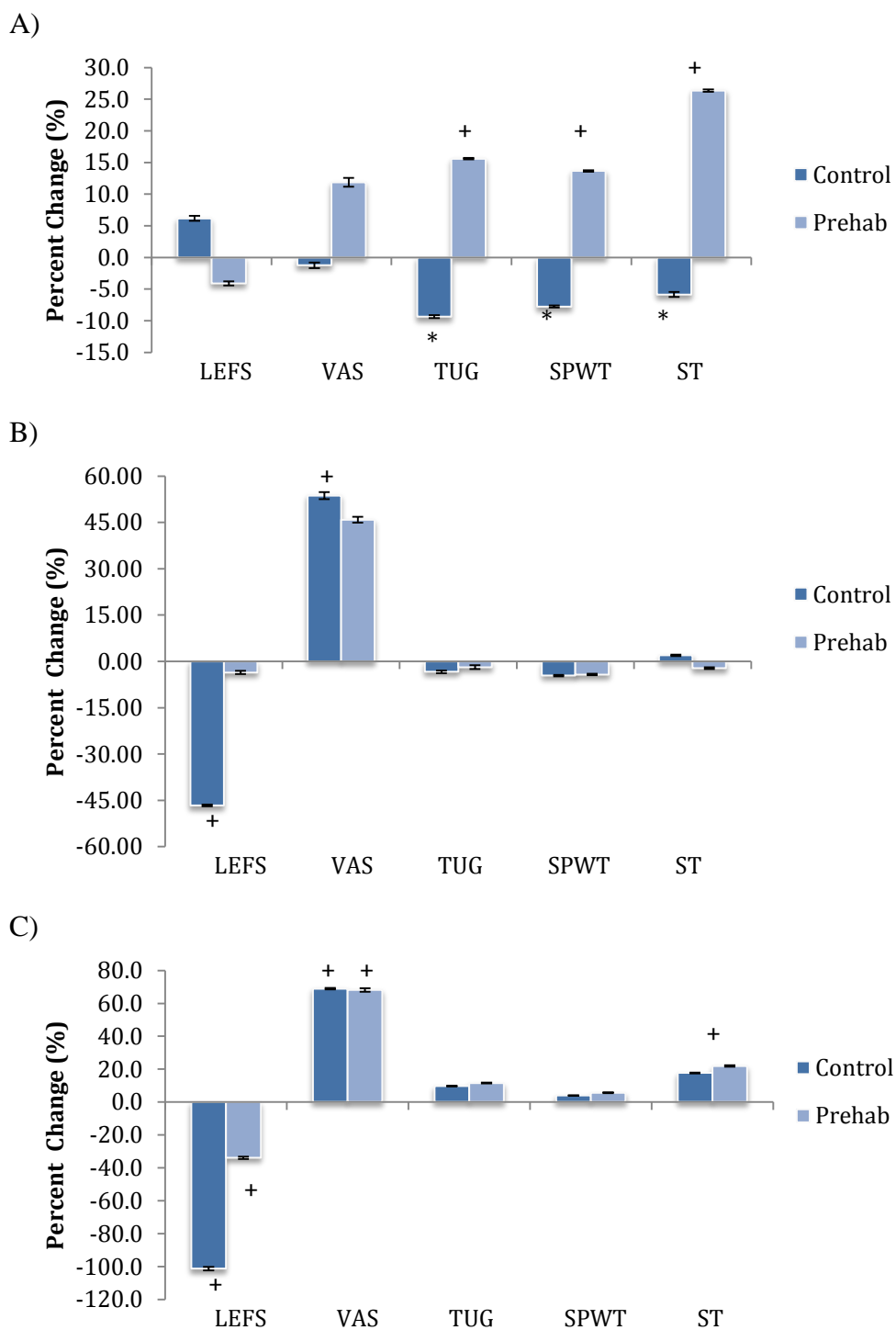


Figure 11: A) Percent changes for measures between baseline and 12 weeks (end of prehabilitation program), B) between baseline and 6 weeks post-surgery, and C) between baseline and 12 weeks post-surgery. Please note that the y-axis scales are different for each graph to make the data more visible. *denotes significant differences between the control and prehabilitation groups. +denotes significant within group differences from baseline. Data are presented as the mean (\pm SD).

4.2.3 Postponed surgeries post prehabilitation program

The number of instances where patients elected to postpone surgery because they experienced improvements in their perceived health was noted. The number of participants from the control (n=21) and the prehabilitation (n=29) groups that declined surgery at the end of the 12-week pre-surgery period was therefore analyzed. The frequency of participants from the prehabilitation group that declined the surgery was greater than the control group (X^2 value = 3.94, $p = 0.05$). 100% of the participants from the control group underwent TJA, whereas 82.80% of the prehabilitation group underwent TJA after the prehabilitation program. Therefore 17.20% of the prehabilitation group (n=5) postponed their surgery post prehabilitation program. Looking at both groups as a whole, 10% of patients from the study postponed their TJA post prehabilitation program.

Overall, the self-reported mobility and pain measures were substantially improved at the 6 and 12-week post-surgery mark for the control group (LEFS 46.69-101.34%, VAS 53.69-68.94%) and the prehabilitation group (LEFS 3.57-33.93%, VAS 45.93-68.15%). However, the functional mobility measures six weeks after surgery were no different from baseline and improvements in only one of three mobility measures (ST) was observed after 12-weeks post-surgery for the prehabilitation group (21.92% increase) (refer to Figures 11B and 11C). No significant differences in the functional mobility measures were observed for the control group at the 6 or 12-week mark.

4.2.4 Analysis of LOS

LOS as seen in Figures 12A and 12B, was calculated as the time interval between the date of surgery and the date when predetermined discharge criteria were met (see Appendix D). No differences were observed between the groups. A permutation test revealed no significant difference in LOS between participants in the control (2.89 ± 0.76 days, $n=18$) and prehabilitation (2.60 ± 0.82 days, $n=20$) groups ($p = 0.314$). The actual LOS post surgery, including the extra time spent in the hospital until actual discharge, was not different between the two groups (control; 3.44 ± 0.86 days, prehab; 3.30 ± 0.73 days, $p = 0.284$) as depicted in Figure 12B. The sample size for both the control and prehabilitation groups reflect the data that was collected at the time of thesis submission, as the study was still ongoing. The LOS was further divided into TKA and THA for both the control and prehabilitation groups, which can be found in Figure 12C. No difference in LOS was noted between the TKA and THA participants of the control and prehabilitation groups.

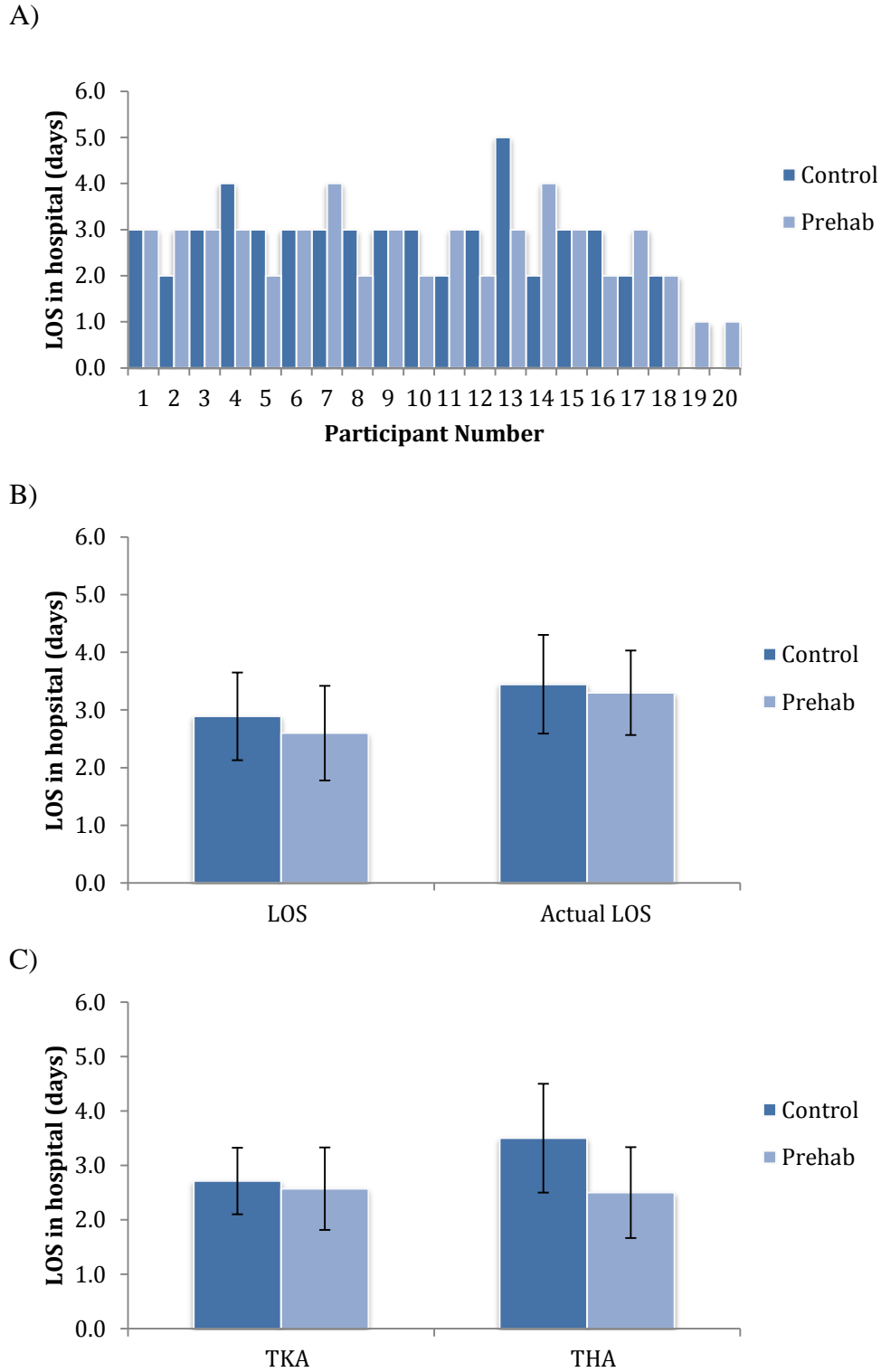


Figure 12: A) LOS for each participant in the control (n=18) and prehabilitation (n=20) groups, B) Average LOS (discharge criteria met) and actual LOS (leaving hospital), C) Average LOS for TKA and THA. Data in panels B and C are presented as the mean (\pm SD).

4.2.5 Twelve week follow up post TJA

Changes in self-reported and mobility measures were also analysed from baseline to 12-weeks post surgery between the control and prehabilitation groups. The changes between the measures are shown in Table IIIA, and Figures 1 to 10. An additional analysis of the percent changes between baseline and six-week post surgery measures was done to determine whether any changes had occurred between six and 12 weeks post surgery. The results are depicted in Figure 11B. The percent changes between the baseline and 12 weeks post-op measures are represented in Figure 11C. The changes between baseline and 12 weeks post-op are also depicted for both TKA and THA of the control and prehabilitation groups in Tables IIIB and IIIC.

4.2.5i Self-reported measures

Although the LEFS scores for the control and prehabilitation groups were not similar at baseline and showed no improvement after the 12-week exercise program, they both showed an improvement of 101.34% ($p= 0.000$) and 33.93% ($p= 0.046$) respectively at 12-weeks post-op, which can be seen in Figure 1. For the self-reported measure (VAS), although there were no changes from baseline and the end of the exercise program, both the control ($p = 0.000$) and the prehabilitation ($p = 0.008$) groups improved from baseline at 12-weeks post-op by 68.94% and 68.15% respectively as seen in Figure 3 and Figure 11C. Both the LEFS and VAS data collected 12-weeks post-surgery can be found in Table IIIA and the percent changes in Figure 11C.

4.2.5ii Mobility measures

Both the control group ($p = 0.150$) and the prehabilitation group ($p = 0.150$) showed no significant improvements in TUG scores between baseline and 12-weeks post-op, as seen in Figure 5 and Figure 11C. For the SPWT, as seen in Figure 7, there were no changes between baseline and 12-weeks post-op for either the control ($p = 0.134$) or prehabilitation ($p = 0.317$) groups. For the ST, there was an improvement between baseline and 12-weeks post-op for the prehabilitation ($p = 0.046$) group of 21.92%, while no changes were observed for the control group ($p=0.070$), as shown in Figure 9 and Figure 11C.

4.3 Cost Benefit Analysis of the Prehabilitation Program

As presented above, the LOS was not significantly shorter for the participants that undertook the prehabilitation program compared to the control group. The cost benefit to run this program can therefore not be made based solely on the LOS data. Therefore a total cost breakeven point was determined. This was the point where the cost of the prehabilitation program would not be an additional expense to the hospital; neither would there be a cost benefit for the hospital. The total cost breakeven point was found using the following formula:

$$\begin{aligned}
 \text{Breakeven point} &= \text{Recovery cost per day} \times \text{LOS difference between control and prehab} \\
 &\text{group} \\
 &= \$1,144.01 \text{ per day} \times .29 \text{ days} \\
 &= \$331.76.
 \end{aligned}$$

The recovery cost per day (i.e. fees incurred during the hospital stay) (\$1,144.01) includes both the direct and indirect hospital costs (not including OR costs= \$4719.04) associated with the recovery phase post TJA as seen in Table IVA. Based on these calculations, a prehabilitation program of equal to or lesser value than \$331.76 per patient would neither cost nor benefit the hospital from a financial perspective. However, the other potential benefits of a prehabilitation program are improvements in patient mobility/performance measures with anticipated impacts on quality of life, which are difficult to quantify from a cost perspective but are nevertheless important to consider in the broader context of the hospital's strategic objectives. The prehabilitation program cost implemented in the study was \$157.80 (cost broken down below), which falls within the breakeven point; therefore there would not be an additional cost to the hospital to run the exercise program prior to TJA.

$$\begin{aligned}
 \text{12-Week prehabilitation program cost} &= \text{pool-based classes} + \text{land-based classes} \\
 &= \$67.80 + \$90.00 \\
 &= \$157.80
 \end{aligned}$$

The 12-week pool-based classes fee of \$67.80 included: two, forty-five minute classes per week, with the option of a third class. The \$90.00 fee for the 12-week land-based class included one class per week that ranged from thirty to sixty minutes under the supervision and direction of two qualified Kinesiologists. There was also a one-time start up cost (not included in the program fee per participant) of \$375.00 for a registered Kinesiologist to design the land-based program. This fee is broken up into the \$75.00/hour Kinesiologist rate multiplied by the 5 hours spent on the development of the

program. This cost did not apply to the pool-based classes, because a hydrotherapy program geared toward individuals with low mobility, had already been developed by the local pool. The reason that the start up cost for the land-based program was not included in the prehabilitation 12-week program cost was because the fee would be minimal in the long run.

Table IVA: Direct, indirect and total hospital costs of TJA per participant.

	Control, N=11	Prehab, N=5
<i>Average Hospital Cost</i>	<i>M: n=3, W: n=8</i>	<i>M: n=2, W: n=3</i>
<i>Direct (\$)</i>	6,541.89(784.05) <i>M: 6293.14(844.20)</i> <i>W: 6635.17(798.82)</i>	6,439.98(421.09) <i>M: 6345.25(801.92)</i> <i>W: 6503.13(134.66)</i>
<i>Indirect (\$)</i>	1,356.84(297.78) <i>M: 1402.33(279.42)</i> <i>W: 1339.78(321.17)</i>	1,351.02(62.29) <i>M: 1332.62(73.29)</i> <i>W: 1363.29(67.16)</i>
<i>Total (\$)</i>	7,898.73(1004.83) <i>M: 7695.47(1122.93)</i> <i>W: 7974.95(1028.49)</i>	7,791.00(458.24) <i>M: 7677.87(875.21)</i> <i>W: 7866.42(125.09)</i>

Data are presented as the mean \pm (SD).

M: Men, W: Women.

Table IVB: Direct, indirect and total hospital costs of TJA per participant categorized by total knee arthroplasty (TKA) and total hip arthroplasty (THA).

	Control, N=11		Prehab, N=5	
	TKA, n=7	THA, n=4	TKA, n=2	THA, n=3
<i>Average Hospital Cost</i>	<i>M: n=3, W: n=4</i>	<i>M: n=0, W: n=4</i>	<i>M: n=1, W: n=1</i>	<i>M: n=1, W: n=2</i>
<i>Direct (\$)</i>	6,301.99(776.84) <i>M: 6293.14(844.20)</i> <i>W: 6308.62(855.40)</i>	6,961.72(687.65) <i>M: N/A</i> <i>W: 6961.72(687.65)</i>	6,138.43(509.44) <i>M: 5778.21(N/A)</i> <i>W: 6498.66(N/A)</i>	6,641.00(270.77) <i>M: 6912.29(N/A)</i> <i>W: 6505.36(190.36)</i>
<i>Indirect (\$)</i>	1,298.45(210.39) <i>M: 1402.33(279.42)</i> <i>W: 1220.53(132.63)</i>	1,459.03(430.31) <i>M: N/A</i> <i>W: 1459.03(430.31)</i>	1,358.22(109.48) <i>M: 1280.80(N/A)</i> <i>W: 1435.64(N/A)</i>	1,346.22(41.00) <i>M: 1384.45(N/A)</i> <i>W: 1327.11(34.21)</i>
<i>Total (\$)</i>	7,600.43(891.63) <i>M: 7695.47(1122.93)</i> <i>W: 7529.16(856.47)</i>	8,420.75(1097.58) <i>M: N/A</i> <i>W: 8420.75(1097.58)</i>	7,496.65(618.92) <i>M: 7059.01(N/A)</i> <i>W: 7934.30(N/A)</i>	7,987.23(289.90) <i>M: 8296.74(N/A)</i> <i>W: 7832.47(156.16)</i>

Data are presented as the mean \pm (SD).

M: Men, W: Women, TKA: Total Knee Arthroplasty, THA: Total Hip Arthroplasty.

The total average hospital cost during recovery post-TJA was also determined for both groups (refer to Table IVA) and was found to be similar between the control (n=11) and prehabilitation (n=5) group (Control = \$7,898.73 \pm 1,004.83, Prehabilitation = \$7,791.00 \pm 458.24, $p = 0.954$). However, when taking into account the participants who chose to become nonsurgical after participating in the prehabilitation program, the effect was marginal ($p = 0.068$). The sample size for the total average hospital cost was smaller than the sample size of TJA patients due to time restraints on receiving hospital costs data at the time of thesis submission. Although there was no difference in overall hospital costs between the control and prehabilitation groups, in terms of potential cost savings, if ten percent of TJA patients postponed their TJA, there would be a potential cost savings for the hospital of \$38,955.00 as seen below.

$$\begin{aligned} \text{Potential cost savings} &= \# \text{ of prehab postponed TJA} \times \text{AVG total cost/prehab participant} \\ &= 5 \times \$7,791.00 \\ &= \$38,955.00 \end{aligned}$$

The average hospital cost for a prehabilitation participant can be found in Table IVA. Annually, the hospital cost savings would be estimated at \$740,145.00 when taking into account the number of TJA procedures performed annually (950 in 2015, see calculations).

$$\begin{aligned}\text{Annual cost savings} &= [\text{Estimated \# of postponed TJA annually} \times \text{\# of annual TJA} \\ &\quad \text{patients at local hospital}] \times \text{AVG total cost for a prehab participant} \\ &= [10\% \times 950] \times \$7,791.00 \\ &= \$740,145.00\end{aligned}$$

With a total cost break even point of \$331.76, the prehabilitation program fee of \$157.80 would not result in additional charges to the hospital to run the program, and could potentially benefit the participants' quality of life and physical capabilities. Taking into account the participants who postponed their TJA after the prehabilitation program, there is other potential hospital cost savings of \$740,145.00 annually for the local hospital.

The direct, indirect and total hospital costs per TJA patient was also categorized into TKA and THA as seen in Table IVB. No differences were observed between the control and prehabilitation groups.

Chapter 5

5 Discussion

5.1 Overview of study objectives, hypotheses and summary of findings

The short-term objective of this study was to develop a prehabilitation program designed to reduce LOS post-surgery for TJA patients and improve mobility measures prior and post-surgery. The long-term objective was to develop and implement a community-based prehabilitation exercise program for individuals undergoing TJA with two desired outcomes: (1) cost savings on the health care system, (2) short and long-term health and wellness benefits for TJA patients.

It was hypothesized that the implementation of a prehabilitation program prior to TJA would: (1) lead to a decrease in LOS in the hospital post surgery, (2) reduce overall health care costs associated with treating OA through TJA and (3) improve patient mobility measures prior to and (4) 6 to 12 weeks post TJA. Although LOS post-surgery was marginally lower for the prehabilitation group (approximately one third of a day), this outcome was not significantly different from the control group (hypothesis 1, refuted). However, participants undergoing the program did experience improved mobility both before and after surgery (hypothesis 3 and 4 accepted), whereas the control group only saw improvements in mobility post-surgery. Unexpectedly, we found that 17% of participants from the prehabilitation group postponed their TJA surgery whereas none from the control group postponed their surgery, which translated into cost savings (hypothesis 2 partially accepted).

The results of this pilot study demonstrate that a 12 week exercise program prior to TJA of the hip or knee effectively improved scores for all three performance measures: TUG by 15.60%, SPWT by 13.67% and ST by 26.35% prior to surgery for the prehabilitation group in comparison to the control group where no changes were observed within the 12-week period as seen in Table IIIA. However, 12-weeks post surgery, the percent changes in the performance measures from baseline was similar for both the control group and prehabilitation group as seen in Figure 11C. Both groups saw no significant improvements in their TUG scores and only the prehabilitation group saw improvements in their ST scores by 21.92%. For the SPWT, there were no changes between baseline and 12-weeks post-op for either the control or prehabilitation groups. As for LOS, although there was no significant difference in days in the hospital between the control (2.89 ± 0.76 , n=18) and prehabilitation (2.60 ± 0.82 , n=20) groups, the prehabilitation group on average, met discharge criteria 0.29 days before the control group. In terms of cost benefit for the hospital, it is estimated that 0.29 days per TJA patient that follow a 12-week exercise program prior to surgery could lead to substantial cost savings when considering the volume of patients who undergo this procedure on a yearly basis (over 900/year in local hospital). A final point is that only one participant in the prehabilitation group was readmitted post-TJA for a stiff knee, which is considered a minor complication.

5.2 Prehabilitation Exercise-Program

5.2.1 Characteristics of prehabilitation programs

Coudeyre et al. (2007) used the French Physical Medicine and Rehabilitation Society (SOFMER) methodology to develop clinical practice guidelines regarding preoperative

TJA rehabilitation of the hip and knee. Ten publications related to prehabilitation were reviewed, six of which focused only on the preoperative period. The analysis determined that a program comprised of both education and exercise showed the most benefit in regards to patients with a major disability (i.e. OA) and other comorbidities. These improvements included, but were not limited to: enhanced ROM; reduced pain following TJA; and better preparation for home recovery (Coudeyre et al., 2007).

Wallis & Taylor (2011) performed a meta-analysis on preoperative interventions prior to THA and also found evidence that a program consisting of education and exercise prior to surgery led to a quicker and improved performance on functional tasks during their LOS in the hospital. Since previous research reported improved outcomes post TJA when education and exercise were used in combination, the prehabilitation program in this study included three education sessions that discussed: OA; management methods for OA; the effects of exercise and diet on the severity of the side effects of OA; and expectations for TJA and the recovery period (see Appendix C2). The education sessions were combined with a 12-week exercise program. Because the experimental design did not include a group only receiving the education component, we are unable to determine the effectiveness of the education component on its own.

The premise of the community-based prehabilitation exercise program used in the current study was to provide the necessary tools to participants to enhance OA awareness and increase mobility prior to TJA through a combination of education and exercise sessions. The exercise program developed for this study was designed based on a combination of prior programs meant for a population with reduced mobility. For

instance, Desmeules et al. (2013) and Swank et al. (2011) used one form of exercise modality (land-based) as opposed to a combination of both land and water-based classes. Although both studies yielded similar improvements in performance measures compared to the current study, feedback from our participants was consistent in that the pool-based classes provided less strain on the joints while exercising, and reduced overall perceived pain.

In the current study, the exercise portion consisted of one 30-60 minute land-based class and two 45-minute pool-based classes per week for a duration of 12 weeks. The program was comprised of a standard warm-up and cool-down in combination with aerobic exercise, circuits and upper and lower body resistance training. Previous research has shown that exercise interventions have been proven to effectively reduce pain and improve function and endurance for those with OA in the lower limbs. Uthman et al. (2013) found evidence that individuals with OA benefited most from a combination of strength training, flexibility and aerobic exercise (land-based and pool-based). Strength training is an important component in an exercise program for individuals affected by OA. When developing the program, it was intended that by strengthening the muscles around the damaged joint, less stress and pressure would be placed on the joint and the joint would become more stable. To assist in post-TJA recovery (i.e. lifts, etc.), strengthening of muscles in the upper body was also considered important.

Pool-based classes in this study provided a therapeutic approach to effectively manage OA and other conditions due to its' benefits. These benefits include easy

administration, minimal adverse effects, reduced stress on the joints and minimal associated costs (Uthman et al., 2013). Pool-based classes provide a non-weight bearing environment, which allows individuals suffering from joint pain to strengthen muscles and improve endurance without the associated pain (Uthman et al., 2013).

Due to a lack of research in the area of prehabilitation programs prior to TJA, there is little evidence as to whether land or pool-based classes provide better outcomes alone or in combination with each other. However, in 2012, the American College of Rheumatology strongly recommended a combination of either or both cardiovascular and resistance land-based training with pool-based classes (Bennell, Dobson, & Hinman, 2014).

In terms of anecdotal information provided by the participants in the current study, it was unanimous that the pool-based classes were preferential. The participants felt that there was less pain following pool-based classes. Participants were also less likely to miss a pool-based class if an OA ‘flare up’ was present whereas land-based classes were more likely to be missed with a ‘flare up’. The once weekly land-based class however, was beneficial to increase the participants’ endurance using a treadmill, stationary bike and arm ergometer, and to provide an environment where the participants could interact and discuss their experience related to the program, that otherwise would be difficult to do in the pool due to background noise.

Some exercise program characteristics to consider are program duration and whether exercises are supervised or home-based. For instance, the lack of improvements reported in the study by Desmeules et al. (2013) is likely because the

program duration or intensity was insufficient. Indeed, to achieve improvements in strength and fitness, programs lasting six to eight weeks are typically recommended. However, an individual's baseline fitness level, frequency of the program and intensity of the program play a large effect on the outcome (Topp et al., 2009). It is prolonged engagement in exercise that allows patients to achieve optimal benefits including improved endurance, increased muscle mass and reduced pain (Topp et al., 2009). Indeed, the benefits can likely extend into the recovery period following TJA. Furthermore, the longer an individual participates in exercise, the more likely they are to adopt a physically active lifestyle, which leads to continued and longer-term health benefits (Bennell et al., 2014).

Furthermore, it is possible that greater benefits may be achieved via supervised exercise sessions versus those completed at home (Topp et al., 2009). In terms of pain management and improved function, home-based exercise programs may result in smaller improvements than supervised exercise regimens (Topp et al., 2009). The cost effectiveness of home-based exercises may also be lesser compared to supervised exercises because home-based exercisers are more likely to use other health-care system services, for example physiotherapy and pharmaceuticals (Bennell et al., 2014). Adherence to an exercise program is facilitated via supervised exercise programs compared to home-based programs where adherence may be challenging (Bennell et al., 2014). One of the big factors that affects adherence to a program is the social environment, for example encouragement from the physiotherapist and training partners, which is provided mainly through supervised exercise sessions (Bennell et al., 2014).

In summary, it is important to consider the length of the exercise intervention program, the types of exercises (land-based vs. pool-based), the intensity and to consider the appropriateness of supervised versus unsupervised exercise programs to maximize health benefits.

5.2.2 Prehabilitation program effectiveness prior and post-surgery

Self-reported and performance measures were used to evaluate the effectiveness of the prehabilitation exercise program on functional mobility and pain. As noted above, the improvements seen in the performance measures at the end of the 12-week exercise program prior to surgery for those who partook in the prehabilitation group, suggest that the short-term objective to improve mobility measures before TJA was achieved with our exercise program. Various other studies that have used a combination of education and exercise or each component alone have reported similar outcomes (Desmeules et al., 2013; Santa Mina et al., 2014; Swank et al., 2011, Topp et al., 2009).

In the current study, improvements in mobility and pain were recorded for both the control and prehabilitation groups 12-weeks post-surgery. This outcome would suggest that 1) the TJA was equally effective in both groups, 2) that the mobility gains observed in the prehabilitation group may have rapidly dissipated owing to the deconditioning effects of the surgery and post-surgery process and 3) that the prehabilitation program may not have been sufficiently challenging (i.e. relative intensity) to maximize fitness gains prior to surgery leading to sub-optimal long-term improvements. Although the program was effective in improving performance measures after 12-weeks (pre-surgery), the starting intensity and subsequent

progressions may not have been optimal for all participants. This limitation could be mitigated by dividing the TJA candidates into tiers depending on their baseline mobility, which would allow the intensity of the program to be tailored according to the capabilities of each group of patients (i.e. low, medium, high functioning patients).

5.3 Outcome Measures: Prioritizing mobility measures over self-reported measures to determine effectiveness of a prehabilitation program

The self-reported measures used in the current study were VAS and LEFS whereas the performance measures were TUG, SPWT and ST. The levels of perceived pain measured using the VAS were no different before and after the prehabilitation program for both the control and the prehabilitation groups. However, the prehabilitation group verbally reported more frequently an improvement in pain after the 12-week program. When completing the VAS, participants were asked to describe their pain level on the day the instrument was filled out, as opposed to describing their overall pain experienced during the program. The pain experienced by the prehabilitation group could also be due to the after effects of exercise (i.e. muscle soreness, joint stiffness), especially for those who have reduced mobility prior to starting the program. On occasion, external causes such as illness, fatigue and weather may have played a role on the participants' perceived pain levels reported on that day. Although other self-reported pain measures are available, for example the numeric pain rating scale (NPRS) and the McGill pain questionnaire, all three tests are comparably effective at gauging pain and are deemed reliable (Kahl & Cleland, 2013). In order to better comprehend the self-reported pain measures, it may be recommended that these measures be used in combination with a quality of life scale.

LEFS scores in the current study did not improve by the end of the prehabilitation program compared to the performance measures. In contrast, Desmeules et al. (2013) found a significant improvement in LEFS scores for the prehabilitation group in comparison to the control group. The reason for this discrepancy could be that the prehabilitation group in Desmeules et al.'s (2013) study was divided into three streams depending on participants' baseline abilities, allowing the comparisons to focus more on participants with similar comorbidities. Another theory by Yeung et al. (2009) is that even though the LEFS scale is both responsive and reliable, changes in LEFS scores are not always correlated with other measures, for example the TUG test. The reason for this may be the ceiling effect. This is the inability of a measure to provide a large enough scale to record further improvement (Yeung et al., 2009). The ceiling effect has been raised as a potential limitation, however when looking at our data, our averages are within the range of 20-50, which does not border either end of the scale for LEFS. It may be that because LEFS is self-reported, it may not capture the whole picture. Also, Yeung et al. (2009) reported that previous studies found a low correlation between self-reported and performance measures. Both the control and prehabilitation group did however experience significant improvements in their VAS and LEFS scores from baseline to 12-weeks post-op, which may be solely attributed to the success of the TJA.

5.3.1 Overall benefits of exercise for TJA patients

The primary focus of this study was to determine the effects of exercise prior to surgery and on post-operative outcomes. However, the benefits of participating in a

prehabilitation exercise program prior to TJA on the adoption of exercise behaviours post-surgery is another important consideration for future research. The introduction of a supervised exercise program to participants who rarely engage in regular physical activity either due to personal choice, or OA mobility restrictions (i.e. pain and reduced movement) offers an ideal opportunity to educate, to orient and to guide these participants towards a more active lifestyle. Surprisingly, physician-prescribed physical activity to patients with OA is not standard practice because practitioners are uncertain of the correct types and dosages of exercise to administer to patients and may lack knowledge on the clinical guidelines and resources available (Bennell et al., 2014). Furthermore, patients with OA are themselves unsure of participating in regular physical activity, as they often perceive that exercise and physical activity will worsen their condition. Although this may be the case for some individuals, *restricting* physical activity may more often than not worsen disease symptoms and decrease quality of life (Bennell et al., 2014).

In this study, there were no measures put in place to observe the effects of a prehabilitation program on the psychological and mental wellness of participants. Future studies could include mental wellbeing measurements to understand the impact of the prehabilitation program in a more holistic manner. There were however, informal written records kept of verbal discussions between the prehabilitation team and the participants and comments from the prehabilitation group regarding the program. There was an overall consensus that the prehabilitation group was extremely pleased and satisfied with the program. It was noted that immediately following surgery, the prehabilitation group felt that the benefits from improving their endurance and muscle

strength allowed for a smoother and less eventful recovery. In only one case, a participant felt that the program intensified the joint pain already experienced due to OA prior to surgery. This is where having different groups based on baseline ability will allow the program to cater to individual needs, as opposed to having a standard program with set progressions for all participants.

Another observation made was in regards to the participant's demeanor and attitude. Previous research has found that older adults who suffer from OA commonly have higher levels of depression due to reduced mobility and increased pain levels (Bennell et al., 2014; Wang, Jayasuriya, Man & Fu, 2015). Although, we did not systematically measure the mental wellbeing of our participants, the following cursory observations were made. When the participants first began the program, many kept to themselves and displayed more negative attitudes regarding their abilities. In comparison, towards the end of the 12-week program, the participants exhibited a more comfortable, positive and happy attitude regarding themselves and the others around them. Several of the participants in the prehabilitation group even developed ongoing relationships with others from their group. It is worth noting that these observations are anecdotal, may not be generalizable and should be followed up in a more systematic manner.

In regards to maintaining regular physical activity following surgery, participants were asked on several occasions, "if a community-based exercise program was available following surgery, would they be interested in participating" and approximately 94% of the prehabilitation participants answered "yes". Therefore

having a standard community-based prehabilitation/rehabilitation program available would aid in improving adherence to exercise.

5.4 Cost savings of implementing the prehabilitation program

The viability of a community-based prehabilitation program prior to TJA is contingent on demonstrating its effectiveness to reduce overall costs associated with treating OA and/or its ability to substantially benefit patients undergoing the procedure by improving quality of life and recovery time, with minimal costs to the health care system.

5.4.1 LOS as a measure

One of the main focuses for reducing health care costs associated with the treatment of OA through TJA is cutting down the LOS in the hospital following surgery. In the current study, a preliminary difference of LOS between the control (2.89 ± 0.76 , $n=18$) and prehabilitation (2.60 ± 0.82 , $n=20$) participants approaching 0.30 days was noted, which is not statistically different owing to the small sample size. The average LOS for TJA in Ontario is currently reported to be 3.50 days, in comparison to the 2.75 days (i.e. when discharge criteria were met) or 3.37 days (i.e. actual LOS in the hospital) determined within the current study (Canadian Institute for Health Information, 2015). The LOS for a TKA and THA were also analysed separately to parcel out whether the prehabilitation program would have a different impact on these distinct types of joint replacement procedures. As illustrated in Figure 12C, no difference was found for the hip and knee LOS between the control and prehabilitation groups (TKA-Con = 2.71 days \pm .61, TKA-Prehab = 2.57 days \pm .76, $p = .587$ and THA-Con = 3.50 days \pm 1.00,

THA- Prehab 2.50 days \pm .84, $p = .124$). However, it is important to reiterate that 17% of the prehabilitation participants postponed their TJA likely due to the benefits of the 12-week exercise program.

Another factor to take into consideration when analyzing the LOS was the discrepancies between the LOS as defined in the current study compared to the *actual LOS*. The LOS for this study was determined when the participants met all discharge criteria (see Appendix D) set out by the orthopedic surgeons. Due to external circumstances such as hospital staffing (availability), weekend coverage, or patient's home care situation, the day the participants met discharge criteria, did not always correspond with their actual discharge date. It will be important in follow-up studies to compare the LOS data as defined in the current study (i.e. meeting discharge criteria) with the actual LOS data in order to compare the theoretical versus the actual cost savings of implementing a prehabilitation program.

The research findings of Coudeyre et al. (2007) and McKay (2011) suggest that the most significant benefit of a prehabilitation program (also known as preoperative rehabilitation) was reduced LOS in the hospital post TJA and the associated cost savings. When looking more closely at the Canada-wide trends, a significant improvement and reduction in LOS of 5.4 days post TJA has already been documented between 1990 to 2008 (Snow et al., 2014). However, this substantial reduction in LOS has come with its own set of problems. The reduced hospital recovery time has led to increased costs for post-acute care. Therefore, although the implementation of a community-based prehabilitation program may not further lessen the LOS, it may

mitigate post-surgery complications and improve patient function and mobility thereby positively impacting post-acute care costs. This specific point will require further investigation in future studies.

Currently, one of the bigger issues in regards to hospital LOS is bed availability. Due to a high volume of patients undergoing overnight procedures and the length of time it takes to discharge these patients, the wait time for TJA is on the rise, at least in the community where this study was conducted. The wait time for TJA at HSN is currently between six to nine months (Health Sciences North, 2015). If a prehabilitation program can reduce LOS, there would be financial savings due to an earlier discharge and more patients could undergo the surgery within a similar timeframe resulting in reduced wait times.

5.4.2 Break-even point to implement a prehabilitation program

A prehabilitation program prior to TJA should be considered given the preliminary findings from the current study, which includes a reduced LOS trend, improved patient functional mobility prior to surgery and potential cost savings owing to some patients postponing their surgery. The cost to administer the pre-TJA exercise program (\$157.80) is under the break-even point of \$331.76. The program can be argued to be cost effective because it has shown promise in bettering pre-operative mobility, but it can also potentially have minimal to no cost to the hospital to implement. Although this is a pilot study, studies by McKay (2011) and Coudeyre et al. (2007) of programs consisting of either exercise or education or a combination of both prior to surgery with small sample sizes have found similar results in regards to the effects of a

prehabilitation program prior to TJA on LOS and associated hospital cost savings. A larger scale study is warranted to validate the preliminary results highlighted in the current pilot study.

In this current study, the land-based and pool-based exercise classes were held at two separate locations. By bringing the two classes to the same location, it would reduce overall program overhead costs. It would also aid in maximizing participation rates, which for this study was approximately 85%. The reduced program cost would be enticing to the health care system in terms of funding and it would reduce stress on patients who attend the classes, as everything would be in one facility. Also, a larger facility would likely receive greater community funding, making the membership fees cheaper and would provide a wider array of exercise options to patients.

5.5 Alignment of the study goals and outcomes with HSN's strategic plan

It is worth noting that this study also touches on some of the directives for HSN's Strategic Plan for 2013-2018. By bringing awareness to the importance and purpose of a prehabilitation program prior to TJA, not only for the patients' well-being and overall health, but in terms of cost savings for the health care system and to the hospital, we are touching on two of HSN's directives. These directives include: "Hospital without walls", and "Adding knowledge to the global community that will change how health care is designed and delivered" (Health Sciences North, 2013, p. 8). Also, as leaders in care transition, the promotion and implementation of a standard community-based prehabilitation program touches on their objective of "Creating and translating our knowledge into best practice to improve the quality, safety and care transition of our

patients within our walls and beyond” (Health Sciences North, 2013, p. 9). Lastly, using this study as a pilot investigation to gather information and to adjust the program using both the participants and caregivers input for future research touches on “Engaging our patients and our providers in the re-design necessary to facilitate seamless care delivery” (Health Sciences North, 2013, p. 9).

5.6 Best practices to implement targeted community-based programs

Community-based programs can be effective in educating and managing health concerns since the programs are easily transferable to different populations and are more affordable in comparison to private programs (Koepsell et al., 1992). Community-based programs usually have two main goals; prevent illnesses and manage illnesses. There has yet to be a standard community-based program developed and implemented for OA prevention, even though OA is one of the main forms of arthritis among Canadians and that some of the risk factors are preventable (i.e. obesity). However, other successful initiatives have been established, for example the community-based cardiac rehabilitation program, which could serve as a model to develop a community-based program targeted towards OA prevention and management. Details are presented in the following paragraphs.

In 1986, Canada implemented the Canadian Heart Health Initiative (CHHI) to combat cardiovascular disease (CVD), which is still the leading cause of death worldwide (Riley et al., 2009). This 15-year research project was composed of five-phases designed to address the CVD epidemic within Canada. The project was comprised of policy and research initiatives, which entailed collaboration between

national, provincial and local groups to administer community-based heart health programs and to also develop the capacity for CVD research and intervention. Phase one focused on policy development and required collaborations between federal and provincial policy makers and program developers. Phase two involved profiling CVD risk factors by administering provincial heart health surveys to all ten provinces to develop a comprehensive data set. Phase three, the demonstration phase, involved the promotion and implementation of community-based heart health projects in 35 areas throughout ten provinces.

The purpose of these projects was to determine best practices at a community level that could be applied to other areas of the country. Phase four was a program evaluation of the demonstration phase. The fifth and final stage of the project was the dissemination phase whereby evidence-based best practices were extended to all communities within Canada taking into account a community's capacity to provide heart health promotion initiatives (Koepsell et al., 1992; Riley et al., 2009). With the correct resources, it may be possible to model this approach to develop a standard community-based program to prevent and manage OA and to assist persons who undergo TJA to circumvent the debilitating effects of OA.

In order to evaluate the effectiveness of a health intervention program, the use of a randomized control trial is widely accepted and considered to be the gold standard. A sustainable program will evolve based on the "Optimal Treatment theory" (Shediach-Rizkallah & Bone, 1998), which helps to create a model of intervention program. The base of the model is the inputs (i.e. prehabilitation community-based program for knee

and hip TJAs) and the top of the model is the outputs (i.e. optimal outcomes post TJA). The model also details the specific steps that connect the inputs to the outputs (Shediac-Rizkallah & Bone, 1998). Some key elements of successful programs include but are not limited to: engaging communities to participate, implementing the program in a variety of community settings and tailoring intervention strategies according to the environment and to individual needs (Elliott et al., 2003). Program implementation can occur in a variety of community settings including schools, workplaces, health care settings and places of worship. Intervention strategies could also include screening programs; self help programs and contests or competitions (Elliott et al., 2003). An example of interventions related to CVD prevention/management within the environment would be marking restaurant menus and labeling heart healthy foods at the grocery store. Since the prehabilitation program in the current investigation was a pilot study, the focus for implementation was within clinics where the patients underwent medical consultations for severe OA and possible candidacy for TJA. However in the future, promotion and advertisement of the program could be expanded more broadly via other venues.

Determining the efficacy and long-term sustainability of community-based programs is of great importance. With the success of several large CVD prevention programs, there is more interest in investing and developing programs targeting other populations and diseases such as OA (Shediac-Rizkallah & Bone, 1998). For future community-based programs to be sustainable, they should be evidence-based relying on outcome measures of longitudinal and cross sectional studies. The future programs should consider the validity of self-reported health characteristics as it is sometimes

difficult to blind participants to being a part of the treatment or control group and they need to take into account or control for the effect of the community environment (Shediac-Rizkallah & Bone, 1998). An example of a community environment effect would be weather; certain interventions depend on weather-dependent activities. All of these aspects should be considered when designing a community-based prehabilitation program prior to TJA.

Based on the success and failures of other community based programs, there are key strategic areas that should be given high consideration to ensure the successful implementation of a prehabilitation program prior to and post TJA. There should be a high level of commitment to continue the program for a defined period of time to demonstrate its potential to achieve the desired outcomes (i.e. improve mobility and reduce joint pain prior to surgery, reduce length of stay post-surgery and improve recovery). There should be sustained funding of the program as support and trust of the community can be broken with the abrupt or unjustified ending of past programs (Mathus-Vliegen, 2012). Finally there should be careful long-term planning regarding alignment of resource allocation with specific and measurable strategic outcomes. The National Cancer Institute for instance funded phase one of a cancer prevention program in Baltimore, Maryland for an initial period of five years (Mathus-Vliegen, 2012). In the fifth year, initiatives were implemented to continue the program, however, due to cut backs, a lack of staff and limited availability of resources, the program was unable to successfully transition past phase one likely because proper planning did not occur in a timely fashion. A number of factors must therefore be considered to create a sustainable prehabilitation program.

5.7 Limitations

One of the biggest limitations of the study was *low patient recruitment*. Although a sizeable number of patients were recruited for a pilot study, in order to validate the results, a greater number of participants will be required. Some of the reasons for low recruitment numbers included: patients not wanting to postpone their surgery date to participate in an exercise program; lack of travel accommodations to get to weekly exercise classes; availability during summer months. Another factor that may have accounted for a low patient recruitment was that the participants had to have a BMI of 30 kg/m^2 or greater. Although approximately 82% of TJA patients in Canada fit this category, it is probable that individuals in this group may have apprehensions around an exercise program (De Guia et al., 2006). Having participants with a BMI greater than 30 kg/m^2 also meant that our sample was not representative of all TJA patients.

As the study was a pilot project, when creating the prehabilitation group and control group, it was decided to combine exercise and education into one group as previous research found that the combination of the two yielded the most beneficial results. Determining the *effectiveness of the education program and exercise program* on their own was therefore not possible because we did not have four groups in the study design (i.e. control, exercise, education and combined exercise and education). Another limitation was that the data collection focused on *mobility and pain measures*, and therefore lacked in being able to take a holistic view of wellbeing by measuring mental wellness.

In regards to the exercise program, the program was developed around OA patients who fall into the categories of: older adults; obesity; diminished mobility; and increased pain. Although progressions were put into place for both the land and pool-based exercises, the program was standard for all participants in order to evaluate both the prehabilitation and control group equally. Therefore specific accommodations were not available for participants with better mobility prior to starting the program. In other words, the *program was not individualized*.

For this study, once the participants committed to the prehabilitation program, the time commitment and a hindered mobility led to an average of two missed classes per participant. Campbell (2001) looked at *patient non-compliance* regarding physiotherapy and found that initially compliance is high due to loyalty to the physiotherapist, however with time, compliance is guided by the patients perceptions of pain severity, accommodating exercises into their daily lives and previous experiences regarding OA and other comorbidities.

Lastly, due to timeframe restraints and the logistics of the study, mobility measure data was not collected *after* the 12-week period post surgery, which limits the data available on the *long-term effects* of the program post TJA. An example of why this information is important is highlighted by the research of McKay (2011), where a prehabilitation program showed no effect on quadriceps strength between the time of hospital discharge to 12-weeks post-op, but a small effect was noted after the 12-week period post-surgery.

5.6 Future Research

Further research is necessary to validate the results in this study on a larger scale. This includes looking at a larger sample size, including participants with a BMI below 30 kg/m² to make the data representative of the entire TJA population and introducing groups that measure the effect of education and exercise alone in comparison to a control group. In addition, data related to psychological and mental wellbeing at baseline and subsequent to the implementation of a prehabilitation program prior to TJA would be valuable and provide a more holistic view of the impact of the program. The VAS showed some limitations in measuring perceived pain so the data pertaining to mental wellness could be complimentary. Performance measures could also be recorded at six months and one year following TJA to observe any differences between the control and prehabilitation group. Dividing the participants into groups according to their baseline mobility measures and tailoring the prehabilitation program to optimize exercise progression as opposed to having one standard program for all TJA candidates should also be explored in future studies.

Future research could also look at the correlation between a reduction in BMI due to participation in an exercise program and their mobility measures and pain level. It would also be of value to look at the effect of a prehabilitation program on exercise adherence rates following TJA to see if the participants in the exercise group are most likely to continue exercising several weeks or months after surgery. This would show whether the prehabilitation program provided the proper tools and guidance leading participants to remain engaged in physical activity. As seen in this study, some participants in the prehabilitation program delayed TJA. It may be envisaged that

components of the prehabilitation program could serve a dual purpose as a prehabilitation program for TJA candidates and as a community-based OA management/prevention program for at risk individuals.

Chapter 6

6 Conclusion

In conclusion, this pilot study has demonstrated that the implementation of a 12-week community-based exercise and education program prior to TJA modestly improved the mobility of participants from the prehabilitation group in comparison to the control group who received standard pre-TJA care. Although no significant difference in LOS between the control and the prehabilitation group were found, an average difference of 0.29 days less for the prehabilitation group was noted. An unexpected finding was that 17% of the prehabilitation participants postponed their surgeries because their symptoms related to OA had improved. Twelve-weeks post surgery, similar improvements (i.e. pain and mobility) were seen for both the control and prehabilitation group, which suggests that the TJA was equally effective for both groups. To determine any long-term differences between the groups, measures should be taken six months post TJA. Ultimately, more participants are required to increase the power of the study. Collectively, the preliminary data suggests that a community-based prehabilitation program may benefit patients prior to TJA and would not be a cost burden to implement when considering that some participants from the prehabilitation program postponed their surgery and given that the LOS is trending downward for the prehabilitation group.

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Appendices

Appendix A: Recruitment Form

Northern Prehabilitation Arthroplasty Recruitment Script

Hi. My name is _____ and I am the Research Coordinator for the Northern Prehabilitation Arthroplasty Program. I will be explaining the purpose of the study, outlining the tasks that you will be required to perform if you choose to participate and answer any questions that you may have.

Once this is completed, you may read over the consent form and ask any additional questions that have previously not been answered. At this point, you may choose to either become a participant and sign the consent form or decline without having your current treatment plan affected or changed.

A. The purpose of this study is to assess how a 12 week pre-surgery exercise program can impact length of stay for patients in hospital after their joint replacement surgery.

There will be 2 groups assigned to the study:

1. **Control group:** If you are assigned to this group, you will receive standard exercise recommendations and will attend regular scheduled doctors' appointments prior to surgery. Initial testing at Kinnect to Wellness will take place as well as at 6 weeks and 3 months. Your surgery will then be booked and you will again be tested at 6 weeks and 3 months after surgery.

2. **Experimental group:** If you are assigned to this group, you will participate in a 12 week exercise program, with classes taking place 3 times per week: 2 pool classes at the YMCA and 1 gym class at Kinnect to Wellness. Initial testing at Kinnect to Wellness will take place as well at 6 weeks and 3 months. Your surgery will then be booked and you will again be tested at 6 weeks and 3 months after surgery.

Please take the time now to read over the details of the consent form and I welcome any additional questions that you may have.

November 2013, NPA-

Appendix B: Measures

Appendix B1: Lower Extremity Functional Scale (LEFS)

Name: _____ Date: _____

Instructions

We are interested in knowing whether you are having any difficulty at all with the activities listed below because of your lower limb problem for which you are currently seeking attention. Please provide an answer for each activity.

Today, *do you or would you* have any difficulty at all with:

Activities	Extreme/ Unable	Quite a bit	Moderate	Little	None
1. Any of your usual work, housework or school activities.	0	1	2	3	4
2. Your usual hobbies, recreational or sporting activities.	0	1	2	3	4
3. Getting into or out of the bath.	0	1	2	3	4
4. Walking between rooms.	0	1	2	3	4
5. Putting on your shoes or socks.	0	1	2	3	4
6. Squatting.	0	1	2	3	4
7. Lifting an object, like a bag of groceries from the floor.	0	1	2	3	4
8. Performing light activities around your home.	0	1	2	3	4
9. Performing heavy activities around your home.	0	1	2	3	4
10. Getting into or out of a car.	0	1	2	3	4
11. Walking 2 blocks.	0	1	2	3	4
12. Walking a mile.	0	1	2	3	4
13. Going up or down 10 stairs (about 1 flight of stairs).	0	1	2	3	4
14. Standing for 1 hour.	0	1	2	3	4
15. Sitting for 1 hour.	0	1	2	3	4
16. Running on even ground.	0	1	2	3	4
17. Running on uneven ground.	0	1	2	3	4
18. Making sharp turns while running fast.	0	1	2	3	4
19. Hopping.	0	1	2	3	4
20. Rolling over in bed.	0	1	2	3	4
COLUMN TOTALS:					
Total Score: (total possible = 80)					
Total Score (above)/80 x 100 = Score Percentage					

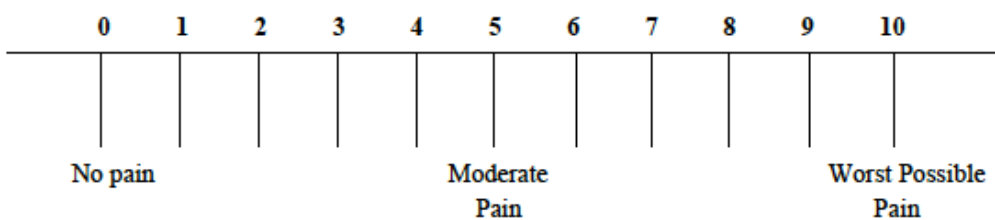
Patient Signature: _____

Appendix B2: Visual Analogue Scale (VAS)

Name: _____ Date: _____

Instructions

How severe is your pain today? Place a vertical mark on the line below to indicate how bad you feel your pain is today.



Reference



Appendix B3: Timed Up and Go (TUG)

Name: _____ Date: _____

Instructions

Participants wear their regular footwear and can use a walking aid if needed. Begin by having participant sit back in a standard arm chair and identify a line 3 meters or 10 feet away on the floor.

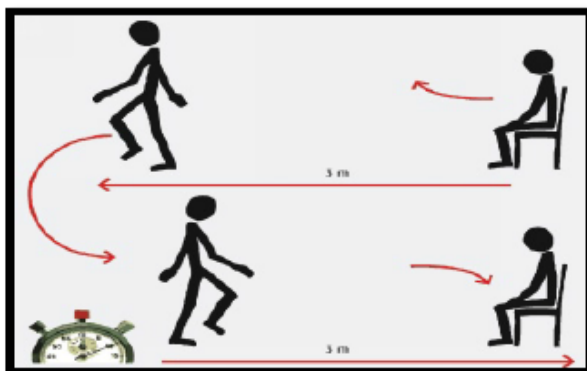
On the word 'GO', begin timing. Stop timing after the participant has sat back down and record time to nearest 1/100 of a second. **REPEAT** procedure and record time.

Instructions to the Participant

- When I say 'GO', I want you to:
1. Stand up from the chair
 2. Walk to the line on the floor at your normal pace
 3. Turn
 4. Walk back to the chair at your normal pace
 5. Sit down again
 6. **REPEAT** a second time.

Time: _____ seconds

Time: _____ seconds



Appendix B4: Self-Paced Walk Test (SPWT)

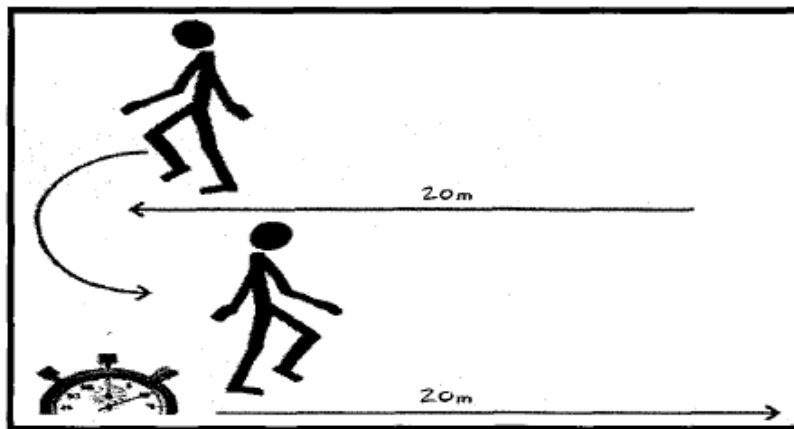
Name: _____ Date: _____

Instructions

Participant is to walk 2 lengths of a 20 meter indoor course. Instruct participant to walk as quickly as they can without overexerting themselves for 20 meters. Once they have reached the 20 meters, they are to turn around and walk 20 meters to return to the original start position. Regular gait aid permitted.

Time measured to the nearest 1/100 of a second. Turn-around time is not measured.

Time: _____ seconds



Appendix B5: Stair Test (ST)

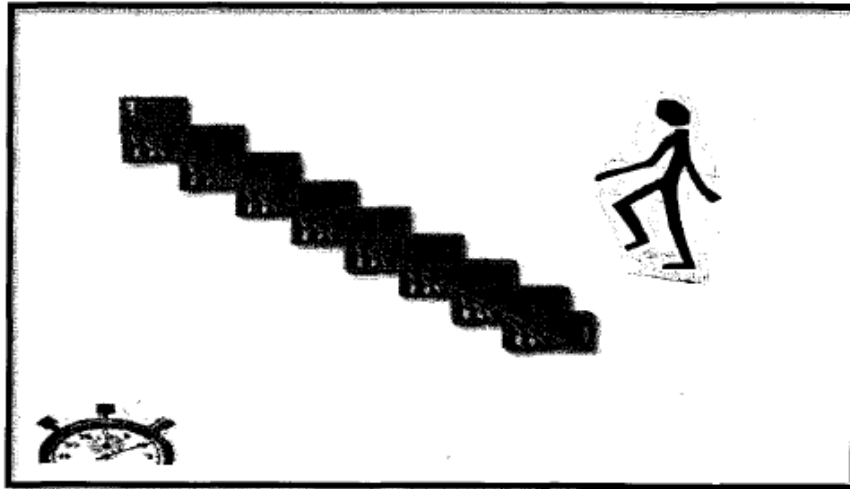
Name: _____ Date: _____

Instructions

Participant is to ascend and descend 9 stairs in usual manner with handrail, at a safe and comfortable pace. Usual gait aid permitted.

Time is measured to the nearest 1/100 of a second.

Time: _____ seconds



Appendix C: Prehab Program
Appendix C1: Land-Based Prehab Program

LAND-BASED PREHABILITATION EXERCISE PROGRAM GUIDELINE

PROGRAM LENGTH: Twelve Weeks

NUMBER OF CLASSES: Once a Week

Level 1: Weeks one to three

Length: Approximately twenty to thirty minutes, additional 30 minutes of education

Focus: Low impact, range of motion, isometric exercises and total body flexibility

SECTION	FOCUS	EXERCISES	REPS	DURATION
Warm Up	Seated Position	Knee flexion and extension Hip rotation (internal and external) Arm circles (big and small) Arm hugs (cross arms and reach for upper back) Press feet into floor (engage core) Heel raises (calf, engage core) Lateral bending with arm above head Sit to stand (with assistance if necessary)	5 x	5 minutes
Circuit	Standing dynamic interval exercises	Marching Arm circles (forwards and backwards) Bum kicks	10 x	5-10 minutes
	Sitting strength interval exercises	Place feet on inside of chair base and push outwards (isometric quad) Place feet on outside of chair legs and push inwards (isometric hamstrings) Yoga block knee squeeze Place hands on the outside of both knees and push outwards (isometric adductor)	5 x	
Stretching	Seated Position	Place heel of one foot in front of you and lean forward (hamstring) Sit on the edge of the chair and lean forward letting arms fall to the floor (lower back) Rotate upper body to one side while using arms to grab the back of the chair	Hold each for 15 seconds	10 minutes
	Standing	While holding back of chair, stretch one leg back keeping that leg straight (calf) While holding back of chair, use other arm to lift same side leg up towards the buttocks (quadriceps, may use a strap) Lift one arm straight up in front of you and bring it across your body to the opposite side, holding it with opposite arm Standing shoulder width apart, lift one arm up to the ceiling and bend from the hip to one side With legs wider than shoulder width apart, lean forward at the hips using chair for support (adductor)		

Progression: Increase number of repetitions for the circuit (week 2: 12x; 8x, week 3: 15x; 10x)

Level 2: Weeks Four to Six

Length: Approximately forty to fifty minutes

Focus: Addition of resistance bands (yellow- light, red- medium)
Addition of cardio portion (treadmill, stationary bike, arm ergometer)

SECTION	FOCUS	EXERCISES	REPS	DURATION
Warm Up	Seated Position	Knee flexion and extension Arm circles (big and small) Heel raises (calf, engage core) Marching	10 x	5 minutes
	Standing	¼ squat Marching Bum kicks (hip extension/knee flexion) Side stepping (out and back)	10 x	
Stations (divide group into 2 or 3 smaller groups)	3 stations/ attend each once	<u>Station 1: Aerobic exercises</u> Treadmill; stationary bike, arm ergometer	5-10 mins	30 minutes
	Standing (as tolerated)	<u>Station 2: Upper extremity theraband exercises</u> Lateral shoulder raises (up to 90 degrees, step on one end of the band and hold other in hand) Frontal shoulder raises (up to 90 degrees, step on one end of the band and hold other in hand)) Upright row (hold one end of band in each hand, bring hands to chest, squeeze traps)	8-10 x 3 sets	
	Sitting (can stand)	<u>Station 3: Lower extremity theraband exercises</u> Tie band above knees, then bring one leg out to the side and back in (hip abduction and adduction) Bring band down to ankles and step on the band with one foot, leaving the band around the opposite ankle. Lift the foot with the band around it straight up and bring it back down (knee extension and flexion)	8-10 x 3 sets	
Balance	Choose one (increase time each week)	One leg stand (use chair for support if necessary) Hip bend (bend at hip and reach forward, then to the side, forward again and then the other side)	15-30 seconds 3 x	3-5 minutes
Stretching	Seated Position	Place heel of one foot in front of you and lean forward (hamstring) Sit on the edge of the chair and lean forward letting arms fall to the floor (lower back) Rotate upper body to one side while using arms to grab the back of the chair	Hold each for 15 seconds	5-10 minutes
	Standing	While holding back of chair, stretch one leg back keeping that leg straight (calf) While holding back of chair, use other arm to lift same side leg up towards the buttocks (quadriceps, may use a strap) Lift one arm straight up in front of you and bring it across your body to the opposite side, holding it with opposite arm Standing shoulder width apart, lift one arm up to the ceiling and bend from the hip to one side With legs wider than shoulder width apart, lean forward at the hips using chair for support (adductor)		

Level 3: Weeks Seven to Twelve				
Length: Approximately sixty minutes				
Focus: Resistance bands (green-medium heavy and blue- heavy) Addition of weight bearing dynamic exercises				
SECTION	FOCUS	EXERCISES	REPS	DURATION
Warm Up	Seated Position	Knee flexion and extension Arm circles (big and small) Heel raises (calf, engage core)	10 x	5 minutes
	Standing	¼ squat Marching Bum kicks (hip extension/knee flexion) Side leg lift (hip abduction/adduction)	10 x	
Stations (divide group into 2 or 3 smaller groups)	3 stations/ attend each once	<u>Station 1: Aerobic exercises</u> Treadmill; stationary bike, arm ergometer	7-12 mins	30-35 minutes
	Standing (as tolerated)	<u>Station 2: Upper extremity theraband exercises</u> Lateral shoulder raises (up to 90 degrees, step on one end of the band and hold other in hand)) Frontal shoulder raises (up to 90 degrees, step on one end of the band and hold other in hand)) Upright row (hold one end of band in each hand, bring hands to chest, squeeze traps) While stepping on one end of band, hold the other end in hand and bring it up towards the same shoulder, bending at elbow (bicep curl) Hold one end of the band on chest and with the other arm pull it straight down and bring it back up bending at the elbow (triceps)	8-10 x 3 sets	
	Sitting (can stand)	<u>Station 3: Lower extremity theraband exercises</u> Tie band above knees, then bring one leg out to the side and back in (hip abduction and adduction) With band still around knees, bring one leg up towards chest and bring back down Bring band down to ankles and step on the band with one foot, leaving the band around the opposite ankle. Lift the foot with the band around it straight up and bring it back down (knee extension and flexion)	8-10 x 3 sets	
Circuit	Whole group completes as a cycle (repeat cycle twice)	Wall push-ups Step ups (on small stepper) Side step outs	8-10 x 5-10 x 5x/leg	10 minutes
Gait	Perform as a group in a circle	Tandem walk (one foot in front of the other) Walking on tip toes Walking on heels Long strides	15 seconds each	
Balance	Perform both exercises standing (increase number of times each move is performed each week)	Hip bend (bend at hip and reach forward, then to the side, forward again and then the other side) Toe touches (while standing on one leg, tap opposite foot forwards, backwards and to each side in random order)	2-5 x 2-5 x	3-5 minutes
Stretching	Seated Position	Place heel of one foot in front of you and lean forward (hamstring) Sit on the edge of the chair and lean forward letting arms fall to the floor (lower back) Rotate upper body to one side while using arms to grab the back of the chair	Hold each for 15 seconds	
	Standing	While holding back of chair, stretch one leg back keeping that leg straight (calf) While holding back of chair, use other arm to lift same side leg up towards the buttocks (quadriceps, may use a strap) Lift one arm straight up in front of you and bring it across your body to the opposite side, holding it with opposite arm Standing shoulder width apart, lift one arm up to the ceiling and bend from the hip to one side With legs wider than shoulder width apart, lean forward at the hips using chair for support (adductor)		

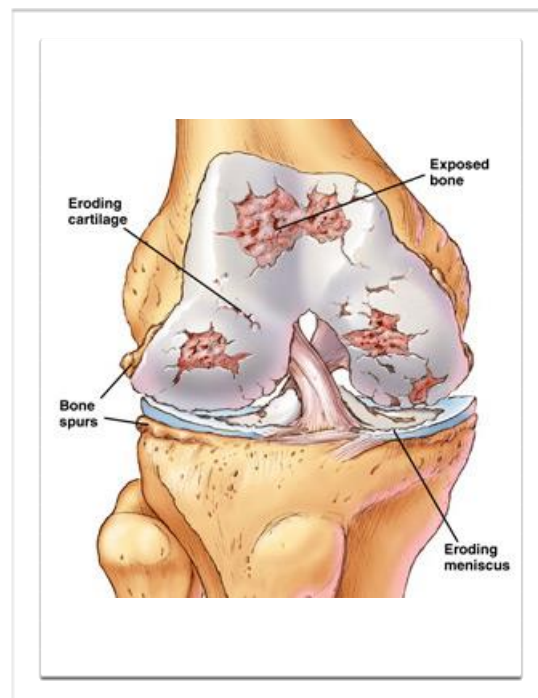
Appendix C2: Education Portion

MOVE%TO%IMPROVE%BY%WEEK%ONE%

Welcome to an Education Component of your care!

OSTEOARTHRITIS is a degenerative joint PROCESS which involves:

- Loss of normal cartilage
- Bone on bone contact
- Abnormal bone growth – bony spurs, osteophytes
- Loss of normally functioning joint fluid
- Production of abnormal joint fluid that causes joint swelling and stiffness



TEAM approach to management :

- T**each
- E**quipment
- A**lternatives
- M**edications

TEACH:

EXERCISE

- Studies prove that patients who exercise regularly improve significantly
- Exercise helps strengthen cartilage, bone, ligaments and muscles
- Flexibility
 - Range of Motion/Stretching
 - Helps with stiffness
 - Best if done daily
- Strengthening
 - Strong muscles give joints support and stability
 - Done several times a week
- Balance / Proprioception
 - Improved balance decreases stress and irritation of joint
 - Stand on one leg – work up to 2 minutes each leg per day
 - Be sure to be near a solid structure to avoid falls!
 - Be sure to touch down and restart rather than wobble!
- Endurance / Conditioning
 - Helps muscle strengthening, balance, weight loss, energy level
 - Walking/Pole-Walking/Swimming/Aquasize/Biking.....

HEAT THERAPY

- May decrease pain, stiffness, spasm
- Useful before exercising
- Heat packs/Water bottles/Heating blankets/Shower/Hot-tub or Bath
- 20 minutes on/ 20 minutes off

COLD THERAPY

- Useful after exercise
- Ice Packs/Frozen Veggies/Cold Bath
- 15 minutes every several hours

ACTIVITY CHANGES

- Modifications to decrease pain and protect the joint
- Pace yourself – take breaks regularly
- Avoid irritating situations – Squat/Kneel/Stairs with heavy loads, etc
- Aids – seat lifts, walking poles, grabbing tools, high shelves, etc

MOVE TO IMPROVE - WEEK TWO

WEIGHT LOSS

- Every **1 pound** of weight loss is equal to **4 pounds** for your joint!
- As little as **10 pounds** will make a **huge difference!**
- **Combination** of **weight loss** and **exercise** is most effective!!
- Set **Realistic goals** – first goal is to avoid gaining weight
- **Choose a Goal to work towards:**
 - Decreasing Waist Circumference
 - Decreasing your weight on the scale
 - Decrease your BMI
 - Get back into your favourite pair of pants!
- **Portion Control:**
 - Proper ratios – see portion plate photo
 - Use small plates
 - Don't eat it till it is on the plate!
- **Tips:**
 - Water before and during meals
 - Eat veggies and fruits first
 - Eat slow – forks down or count chews
 - Eat at regular times
 - Stop eating when you start to feel full
 - Buy snacks as single servings
 - Don't eat in front of the TV
- **Eating Out:**
 - Drink water and eat some veggies or fruits before you go
 - Order half-portions or take half home for lunch the next day
 - Have an appetizer as your dinner
 - Avoid large sugary drinks – remember the pop-sugar picture!!

EQUIPMENT%

- **Walking aids!** –!poles/canes!!
- **Sleeves!for!knees!**
 - warmth!and!compression!decrease!pain!
 - help!with!proprioception!(balance)!
- **Unloader!knee!braces!**
 - Useful!for!problems!on!one!side!of!the!joint!
- **Patellofemoral!braces!**
 - For!pain!behind!the!knee!cap!

!

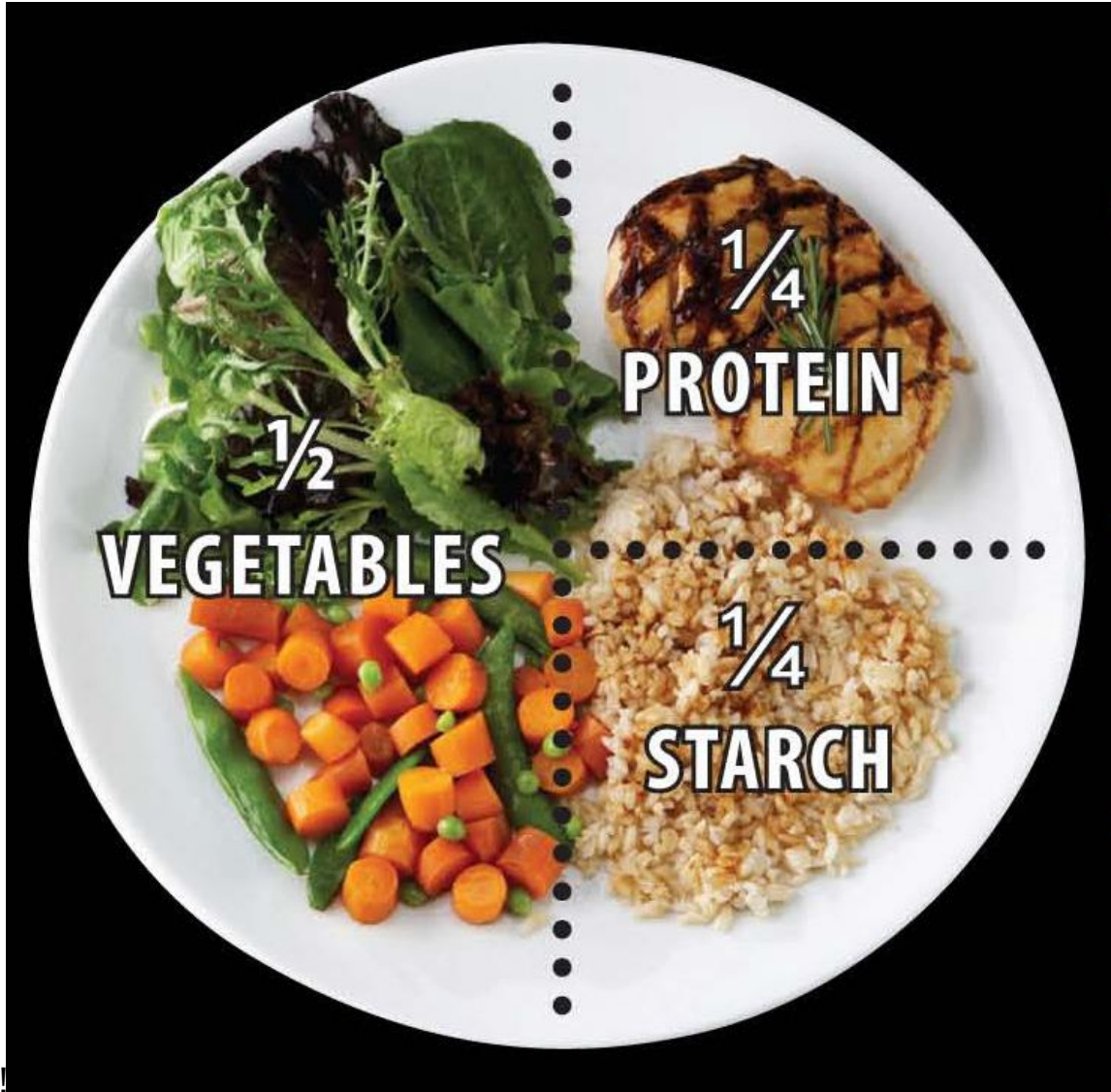
ALTERNATIVES%

- **Capsaicin!cream!**
 - Made!from!hot!pepper!plants!!
 - Tricks!the!body!to!feel!heat!pain!rather!than!the!arthritis!pain!
- **A5Q5!and!similar!products!help!decrease!pain!by!triggering!other!sensations!that!the!body!feels!rather!than!the!arthritis!pain!**

!

MEDICATIONS%

- **Acetaminophen!!=!Tylenol!**
 - Best!choice!for!nonQnflammatory!arthritis!
 - Safer!than!antiQnflammatories!
 - Maximum!dose!is!4!grams!in!24!hours!
- **AntiQnflammatories!**
 - Advil/Ibuprophen/Motrin/Naprosyn/Mobicox/Celebrex!
 - Help!with!pain!at!the!time!of!use!
 - Must!take!regularly!to!help!with!inflammation!
 - New!ones!are!equally!effective!but!have!fewer!side!effects!
- **Topical!AntiQnflammatories!**
 - !Pennsaid/Diclofenac/Voltaren!
 - Studies!show!they!may!help!with!knee!osteoarthritis!symptoms!
 - No!systemic/whole!body!side!effects!
- **Narcotics!**
 - Codeine/Morphine/Tramadol!
 - Useful!in!patients!who!can!not!tolerate!other!medications!
 - Useful!as!an!addition!to!other!medications!during!flareQps! !
 - Side!effects!less!notable!if!the!dose!if!increased!slowly!



Body Mass Index (BMI) Chart for Adults

Obese (>30)
 Overweight (25-30)
 Normal (18.5-25)
 Underweight (<18.5)

WEIGHT	HEIGHT in feet/inches and centimeters																					
	4'8" 142cm	4'9" 147	4'10" 150	4'11" 152	5'0" 155	5'1" 157	5'2" 160	5'3" 163	5'4" 165	5'5" 168	5'6" 170	5'7" 173	5'8" 175	5'9" 178	5'10" 180	5'11" 183	6'0" 185	6'1" 188	6'2" 191	6'3" 193	6'4" 196	
260 (117.9)	58	56	54	53	51	49	48	46	45	43	42	41	40	38	37	36	35	34	33	32	32	31
255 (115.7)	57	55	53	51	50	48	47	45	44	42	41	40	39	38	37	36	35	34	33	32	31	30
250 (113.4)	56	54	52	50	49	47	46	44	43	42	40	39	38	37	36	35	34	33	32	31	30	30
245 (111.1)	55	53	51	49	48	46	45	43	42	41	40	38	37	36	35	34	33	32	31	31	30	29
240 (108.9)	54	52	50	48	47	45	44	43	41	40	39	38	36	35	34	33	33	32	31	30	29	28
235 (106.6)	53	51	49	47	46	44	43	42	40	39	38	37	36	35	34	33	32	31	30	29	29	28
230 (104.3)	52	50	48	46	45	43	42	41	39	38	37	36	35	34	33	32	31	30	30	29	28	27
225 (102.1)	50	49	47	45	44	43	41	40	39	37	36	35	34	33	32	31	31	30	29	28	27	27
220 (99.8)	49	48	46	44	43	42	40	39	38	37	36	34	33	32	32	31	30	29	28	27	27	26
215 (97.5)	48	47	45	43	42	41	39	38	37	36	35	34	33	32	31	30	29	28	28	27	26	25
210 (95.3)	47	45	44	42	41	40	38	37	36	35	34	33	32	31	30	29	28	28	27	26	26	25
205 (93.0)	46	44	43	41	40	39	37	36	35	34	33	32	31	30	29	29	28	27	26	26	25	24
200 (90.7)	45	43	42	40	39	38	37	35	34	33	32	31	30	30	29	28	27	26	26	25	24	24
195 (88.5)	44	42	41	39	38	37	36	35	33	32	31	31	30	29	28	27	26	26	25	24	24	23
190 (86.2)	43	41	40	38	37	36	35	34	33	32	31	30	29	28	27	26	26	25	24	24	23	23
185 (83.9)	41	40	39	37	36	35	34	33	32	31	30	29	28	27	27	26	25	24	24	23	23	22
180 (81.6)	40	39	38	36	35	34	33	32	31	30	29	28	27	27	26	25	24	24	23	22	22	21
175 (79.4)	39	38	37	35	34	33	32	31	30	29	28	27	27	26	25	24	24	23	22	22	21	21
170 (77.1)	38	37	36	34	33	32	31	30	29	28	27	27	26	25	24	24	23	22	22	21	21	20
165 (74.8)	37	36	34	33	32	31	30	29	28	27	27	26	25	24	24	23	22	22	21	21	20	20
160 (72.6)	36	35	33	32	31	30	29	28	27	27	26	25	24	24	23	22	22	21	21	20	19	19
155 (70.3)	35	34	32	31	30	29	28	27	27	26	25	24	24	23	22	22	21	20	20	19	19	18
150 (68.0)	34	32	31	30	29	28	27	27	26	25	24	23	23	22	22	21	20	20	19	19	18	18
145 (65.8)	33	31	30	29	28	27	27	26	25	24	23	23	22	21	21	20	20	19	19	18	18	17
140 (63.5)	31	30	29	28	27	26	26	25	24	23	23	22	21	21	20	20	19	18	18	17	17	17
135 (61.2)	30	29	28	27	26	26	25	24	23	22	22	21	21	20	19	19	18	18	17	17	16	16
130 (59.0)	29	28	27	26	25	25	24	23	22	22	21	20	20	19	19	18	18	17	17	16	16	15
125 (56.7)	28	27	26	25	24	24	23	22	21	21	20	20	19	18	18	17	17	16	16	15	15	15
120 (54.4)	27	26	25	24	23	23	22	21	21	20	19	19	18	18	17	17	16	16	15	15	15	14
115 (52.2)	26	25	24	23	22	22	21	20	20	19	19	18	17	17	16	16	15	15	14	14	14	14
110 (49.9)	25	24	23	22	21	21	20	19	19	18	18	17	17	16	16	15	15	15	14	14	13	13
105 (47.6)	24	23	22	21	21	20	19	19	18	17	17	16	16	16	15	15	14	14	13	13	13	12
100 (45.4)	22	22	21	20	20	19	18	18	17	17	16	16	15	15	14	14	14	13	13	12	12	12
95 (43.1)	21	21	20	19	19	18	17	17	16	16	15	15	14	14	14	13	13	13	12	12	12	11
90 (40.8)	20	19	19	18	18	17	16	16	15	15	15	14	14	13	13	13	12	12	11	11	11	11
85 (38.6)	19	18	18	17	17	16	16	15	15	14	14	13	13	13	12	12	12	11	11	11	10	10
80 (36.3)	18	17	17	16	16	15	15	14	14	13	13	13	12	12	11	11	11	10	10	10	9	9

Note: BMI values rounded to the nearest whole number. BMI categories based on CDC (Centers for Disease Control and Prevention) criteria.
www.vertex42.com BMI = Weight[kg] / (Height[m] x Height[m]) = 703 x Weight[lb] / (Height[in] x Height[in]) © 2009 Vertex42 LLC !

MOVE TO IMPROVE - WEEK THREE

STAYING MOTIVATED – DON'T GIVE UP!!

“People who exercise regularly despite their arthritis will typically have less pain and better function than those who are inactive”

IT HURTS!

- Exercising may be hard at first, but it will decrease pain in the long run!
- Improving Flexibility and Strength:
 - Takes strain off the joints
 - Decreases pain
 - Improves function

I'M HAVING SURGERY ANYWAYS!

- Exercising before surgery helps:
 - Patients have less discomfort during recovery
 - Better mobility after surgery – moving in bed, getting to the toilet
 - Decreased risk of falls
 - Patients need less rehab after surgery and recover quicker

STAYING ON TRACK

- Recording activities, eating habits, etc can keep you focused
- Keeping records also helps you see improvements

PERSONAL GOAL EXAMPLES FOR YOUR WEEKLY MONITORING SHEET:

- Fill in the monitoring sheet all week
- Stretch at least 4 days of the week
- No eating in front of the TV
- Walk 10 minutes each day
- Etc, etc, etc - be creative and pick something that motivates you!

Appendix C3: Pool-Based Prehab Program



Prehab Program Hydrotherapy

Mondays, Thursdays 3:15-4pm

Length: 45 minutes Music: Relaxing

Location: Therapy pool; Participants are in a line with instructor or in a circle with instructor

All exercises are between 12-15 reps

Warm-up 10minutes:

Gentle range of motion; Arms are gently "swirling" through the water; Shoulder rolls, Rotation, Shrugs; Side bends; Holding knee; Calf stretch; Leg crossed over thigh into sitting position; Arms across chest; Triceps stretch; Working into a back stretch cueing arms in front as if you are diving into the water reversing into a chest stretch; Moving into working the core muscles with pelvic tilts; Working into hip rotations in both directions; Ankle rotations reversing direction.

Cardio 15 minutes:

Walking from the side of the pool to the wall and back; Lifting opposite knee with opposite arm; Lifting one knee, extending the leg and returning foot to ground; Kicking one leg up behind back, alternating legs; Side stepping with big steps; Walking on tip toes; Walking on heels; Lunges facing forward; Lunges facing backwards. In a circle performing plyometrics; Squat jumps; Tuck jumps; Jumping jacks; Cross country skiing and jogging on the spot.

Muscular Development 10 minutes:

Arms straight out to the front reaching and pushing the water out to the sides and back to the midline; Arms out to the sides pulling the water down; Bicep curls in water; Triceps extension in water; One hand on top of the other making circles in the water, reverse direction and put other hand on top; Chest fly in water; Holding the wall for balance, leg stays straight, kicking forward, kicking to the side and kicking back; Finishing with calf raises.

Cool down, Stretch and ROM 10 minutes:

Against wall begin with hamstring/ back stretch, hold for 30secs; Quadriceps stretch; Reaching arms up and bending to each side, then moving into chest and back stretches; Opening & closing fingers (making a fist) good for arthritis in the knuckle joints; Finishing with neck stretches and relaxation.

Progressions:

Level 1 (weeks 1-3): No weights, use of speed and water resistance.

Level 2 (weeks 4-6): Increase in reps and introduction of water dumbbells.

Level 3 (weeks 7-12): Further increase in reps, increase movement speed, use of water bottles.

Building healthy communities

Plein de vies

	1	2	3	4	5	6	7
To be completed by PHYSIOTHERAPISTS							
Able to perform home exercise and knowing how to progress them							
ROM >70 degrees (not relevant for hips)							
Day Met ALL Discharge Criteria							
Day ACTUALLY Discharged							
Reason for delay							
Complications (ie PE, DVT, infection etc)							

Patient ID Code: _____ NPA-_____

Appendix E: Ethics



APPROVAL FOR CONDUCTING RESEARCH INVOLVING HUMAN SUBJECTS

Research Ethics Board – Laurentian University

This letter confirms that the research project identified below has successfully passed the ethics review by the Laurentian University Research Ethics Board (REB). Your ethics approval date, other milestone dates, and any special conditions for your project are indicated below.

TYPE OF APPROVAL	New	Modifications to project	Time extension X
Name of Principal Investigator and school/department		Kevan Saidi and Jasmine Pham, Masters in Human Kinetics, supervisors, Celine Boudreau-Lariviere and Olivier Serresse	
Title of Project		Northern Rehabilitation Arthroplasty Program: Impact of Exercise and Rehabilitation programs on Length of Stay, Post-Total-Joint Arthroplasty	
REB file number		2013-11-12	
Date of original approval of project		Jan 02, 2014	
Date of approval of project modifications or extension (if applicable)		July 02, 2015 June 22, 2016	
Final/Interim report due on: (You may request an extension)		June 22, 2017	
Conditions placed on project		Final Extension	

During the course of your research, no deviations from, or changes to, the protocol, recruitment or consent forms may be initiated without prior written approval from the REB. If you wish to modify your research project, please refer to the Research Ethics website to complete the appropriate REB form.

All projects must submit a report to REB at least once per year. If involvement with human participants continues for longer than one year (e.g. you have not completed the objectives of the study and have not yet terminated contact with the participants, except for feedback of final results to participants), you must request an extension using the appropriate LU REB form. In all cases, please ensure that your research complies with Tri-Council Policy Statement (TCPS). Also please quote your REB file number on all future correspondence with the REB office.

Congratulations and best wishes in conducting your research.

Rosanna Langer, PHD, Chair, *Laurentian University Research Ethics Board*