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Prehabilitation for total knee arthroplasty: A patient-centred approach to maximizing surgical outcomes

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Graduate Program in Kinesiology
A thesis submitted in partial fulfillment of the requirements for the degree in Doctor of Philosophy
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PREHABILITATION FOR TOTAL KNEE ARTHROPLASTY: A PATIENT-CENTRED
APPROACH TO MAXIMIZING SURGICAL OUTCOMES

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Graduate Program in Kinesiology

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of the requirements for the degree of
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THE UNIVERSITY OF WESTERN ONTARIO
School of Graduate and Postdoctoral Studies

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The thesis by

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Date   Chair of the Thesis Examination Board

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Abstract

The purpose of this dissertation was to investigate the role of prehabilitation in post-operative recovery for patients undergoing total knee arthroplasty (TKA) for osteoarthritis. Study one was a meta-analysis that aimed to consolidate the body of knowledge regarding prehabilitation for TKA patients. Study two compared the Lower Limb Tasks Questionnaire (LLTQ) to the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) in terms of agreement and responsiveness. Study three investigated the effect of a six-week pre-surgical strength training program on post-operative outcomes (quadriceps strength, mobility, pain, self-reported function, health-related quality of life, arthritis self efficacy) for TKA patients. Finally, study four provided a preliminary insight into the implementation context of prehabilitation for TKA.

Study one demonstrated that prehabilitation had no effect on post-operative pain or self-reported function, but had a large effect on length of hospital stay (ES = -0.819; 95% CI: -0.985 - -0.653). Pre-operative exercise had no significant effect on quadriceps strength in the early post-operative phase (hospital discharge to 12 weeks after surgery), but did have a small effect on strength beyond 12 weeks (ES = 0.279; 95% CI: 0.018 – 0.540).

Study two found that the LLTQ activities of daily living (ADL) subscale had good agreement with the WOMAC global score [bias = -1.40 (SD = 10.00); 95% limits of agreement = -22.00% to +19.00%.] Conversely, the LLTQ sport/recreation subscale had very poor agreement with WOMAC [bias = -31.00 (SD = 17.00); 95% limits of agreement = -65.00% to +2.40%]. The statistical responsiveness of the WOMAC was superior to that of the LLTQ ADL and sport/recreation subscales (1.17, -0.63, and -0.01, respectively).

Study three showed that pre-surgical strength training had a large effect on quadriceps strength, $F(3,18) = 0.89$, p = 0.47, $\eta^2 = 0.13$, and walking speed, $F(3,18) = 1.47$, p = 0.26, $\eta^2 = 0.20$ before TKA. After TKA, there were no significant differences in any outcome measures between the prehabilitation and control groups. Furthermore, there were no significant correlations between self-reported and objective measures of function.

Finally, study four indicated that TKA patients are likely to participate in prehabilitation, particularly exercise-based programs.

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Foremost, I would like to thank Dr. Harry Prapavessis for his advisorship over the past three years. I am incredibly grateful to have been able to complete my studies with him, and his faith in my abilities was both humbling and empowering. I truly appreciate every opportunity that he has given me along the way, and the experience I have gained as a result will undoubtedly serve me well as I move forward in my career.

Secondly, I must thank Dr. Craig Hall for being another influential figure during my tenure in the EHPL. He was a valuable mentor and constant source of perspective when things were difficult, and I deeply appreciate the kindness with which he helped me get through this process. I would also like to acknowledge the contribution of Dr. Tim Doherty, who provided invaluable insight as I developed my research program. His expertise and advice were crucial to my success.

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Finally, I would like to acknowledge the funding support of the Social Sciences and Humanities Research Council of Canada, and the financial assistance personally provided by Mr. Roy Wilson. Such generosity has made the completion of this dissertation possible.

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Chapter 1

1   Introduction

1.1   An introduction to prehabilitation

In clinical settings, treatment methods for those with progressive conditions, such as osteoarthritis (OA), are arranged along a continuum from conservative to more invasive. Those in the early stages of disease will most often choose conservative options for the management of their symptoms, such as medication or physical therapy (Arden, Arden, & Hunter, 2008). Ultimately, however, the only end-stage treatment available for many patients is surgery. For many, surgery is a frightening prospect, and presents a host of physical and psychological stressors that may affect the success of the procedure (Kagan & Bar-Tal, 2008). In order to maximize positive outcomes after surgery, it is essential to address these stressors as proactively as possible.

The traditional medical paradigm for diseases requiring surgery is defined by diagnosis, followed by a waiting period before the operation, then a post-operative rehabilitation phase. For acute injuries or life-threatening diseases, the waiting period before surgery is often brief, but for non-critical or elective procedures, it can be months in length. During this period, many diseases continue to progress and the patient's health and function deteriorate (Desmeules, Dionne, Belzile, Bourbonnais, & Fremont, 2010). This results in the patient going in for surgery in worse condition than when he was originally diagnosed, consequently requiring greater amounts of post-operative treatment in order to return to a healthy state (Desmeules et al., 2010).

Research has also shown that extended periods of bed rest or similar inactivity lead to rapid loss of function. Declines in physical activity can lead to reductions in the functional reserve of the musculoskeletal and cardiovascular systems, diminishing the body's ability to withstand external stressors (Topp, Ditmyer, King, Doherty, & Hornyak, 2002). As patients awaiting surgery experience the progressive worsening of their condition, it is likely that the amount of time they spend engaging in daily living

activities will decrease due to fatigue, pain, or a loss of motivation. In order to prevent the attendant declines in functional capacity associated with an increasingly sedentary lifestyle, the implementation of pre-surgical exercise programs has been advocated (Ditmyer, Topp, & Pifer, 2002; Topp et al., 2002).

The concept of pre-surgical intervention, or "prehabilitation," has emerged in the literature as a potential means of ameliorating the effects of a prolonged waiting period on surgical outcomes. The basic premise of prehabilitation is to increase the functional capacity of the body in preparation for the stress of surgery (Ditmeyer et al., 2002). It has been speculated that, by improving function, the patient will better withstand the physical and mental stressors of the operation and will therefore require less intervention in the post-operative rehabilitation phase (Topp et al., 2002). Patients undergoing successful prehabilitation are thought to exhibit shorter recovery times, less dependence on caregivers after surgery, and a more rapid return to pre-surgical function than their counterparts receiving standard care (et al.,Ditmeyer et al., 2002; Landry, Jaglal, Wodchis, Cooper, & Cott, 2007; Topp et al., 2002).

Figure 1 depicts the theoretical trajectory of a patient in a prehabilitation condition versus a patient in a standard care condition. While both individuals begin at the same level of function in the pre-operative phase, the prehabilitation patient is able to increase his or her functional capacity before the surgery. Although the degree of decline following the surgery is similar for the two patients, the prehabilitation patient retains a higher level of overall function, and is therefore able to recover to a minimal level of independence much faster. The magnitude of the difference between the prehabilitation patient and the standard care patient is likely a function of the intensity, frequency, and duration of the prehabilitation intervention (Ditmeyer et al., 2002).
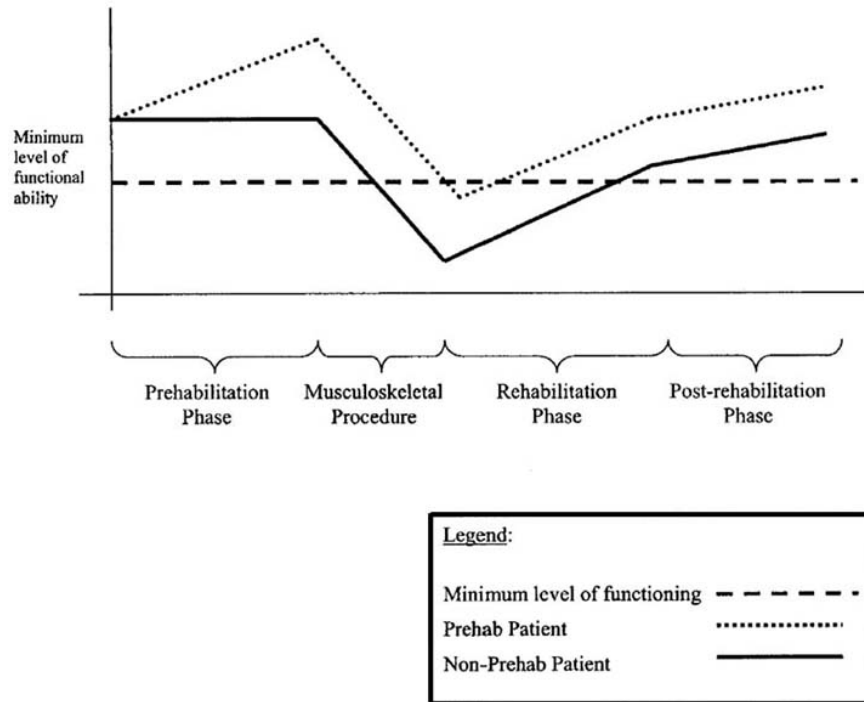
Figure 1. Theoretical potential of prehabilitation (Topp et al., 2002, reprinted with permission).

1.2 Statement of purpose

The present series of studies was conducted to investigate the potential role of prehabilitation in post-operative recovery for patients undergoing total knee arthroplasty as treatment for OA. The primary aim of the research was to develop a simple, easy-to-implement pre-operative exercise intervention that would positively impact post-surgical strength, mobility, pain, and quality of life for patients. The secondary objectives of the program were to consolidate the body of knowledge regarding prehabilitation for lower limb arthroplasty patients by conducting a meta-analysis of existing prehabilitation research, and to examine implementation context as a determinant of intervention uptake in this population.

1.3 Research program structure

Borrowing from the field of sport injury prevention, this research program was structured according to the "Translating Research into Injury Prevention Practice" (TRIPP) framework proposed by Finch (2006) (Figure 2). The model, as originally conceptualized, illustrates six distinct steps to follow when conducting an intervention-based research program. It provides a clear and rational progression from identifying a target public health concern (sport injury), through developing an intervention, to implementing the intervention in a real-world (sport) setting. Although this schematic was developed specifically for athletic injury, it was designed to provide an evidence base for preventive interventions (Finch 2006). As prehabilitation is, at its core, an intervention to prevent functional decline, the tenets of the TRIPP model are easily transferable.
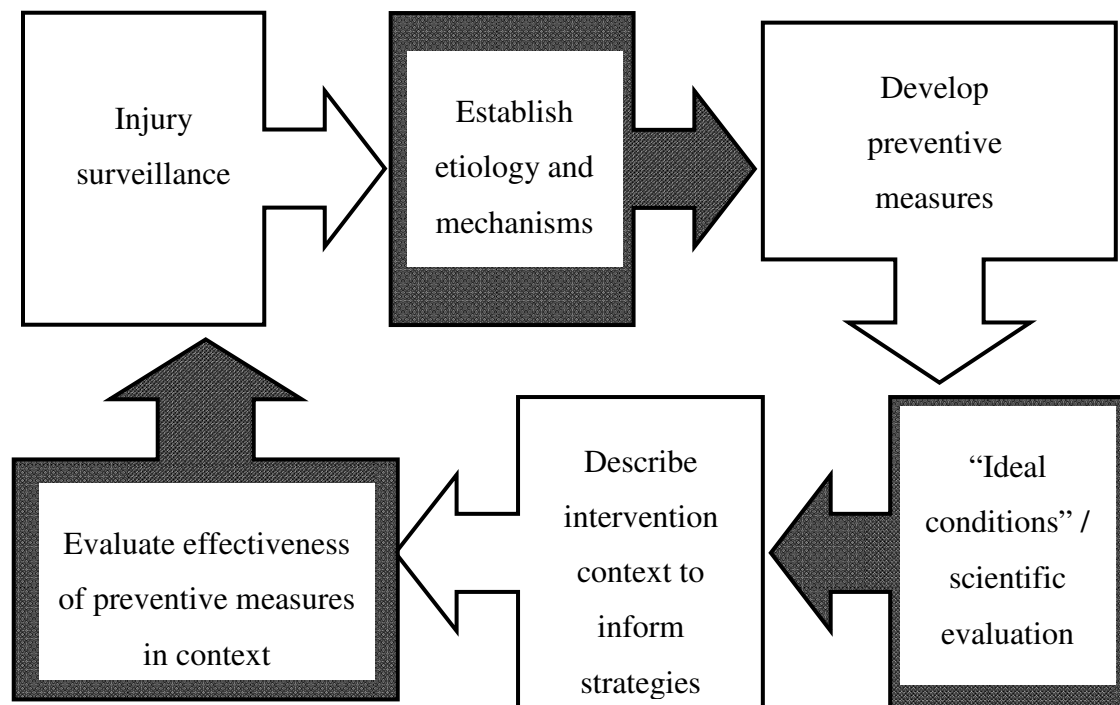
Figure 2. The Translating Research into Injury Prevention Practice (TRIPP) framework (adapted from Finch, 2006).

As Finch (2006) states, the pillars of the TRIPP framework are conceptualized as necessary steps in building an evidence base for successful intervention. Firstly, the extent of the problem at the population level must be determined and described. This step involves surveillance and descriptive investigation in order to measure the public health impact of the problem. It also highlights potential trends in incidence and distribution, both geographically and temporally. The second step then involves identification of the risk factors and mechanisms that contribute to the occurrence of the problem. Risk factors may be distal or proximal to the onset of the problem, and may act independently or in concert with other factors in the causal pathway.

Third, an intervention that is likely to reduce the risk and/or severity of the problem should be developed. This must be guided by the findings from step two, rather than anecdotal evidence or the standards of current practice, and should address risk factors that are modifiable in the target population. Once the intervention has been designed, the fourth step corresponds to an assessment of the efficacy of that intervention under "ideal" conditions, such as in laboratory or clinical settings.

Following the development of an efficacious intervention, the real-world implementation context must be examined in step five. This includes a catalogue of potential motivations or barriers to intervention uptake in the population, as well as an understanding of the impact of biases in the intervention setting that may determine which groups ultimately adopt the program. Finally, the effectiveness of the intervention must be examined in a real-world setting. In other words, the sixth step involves the implementation of a scientifically supported intervention within the context of the at-risk population.

Considering the TRIPP model, one can see how "ideal conditions" laboratory research will influence the interventions that are then tested in "real world" situations, and vice versa. This complementary association between research settings reinforces the notion that meaningful advances in a field will occur with the convergence of evidence from many study types, and when developments from one setting are used to propel investigation in the other (Dunn & Elliott, 2008). This approach is particularly fitting for health research, as there has classically been debate over the superiority of laboratory

versus clinical findings (Dunn & Elliott, 2008). The reconciliation of research types and settings was therefore central to the development of the current program of study, in an effort to advance our understanding of the role of prehabilitation from both laboratory and real-world perspectives.

1.4   Research program outline

As the TRIPP framework illustrates, a complete evidence base in support of an intervention requires an understanding of the etiology of the condition under study, the development of risk factor-targeted interventions, formal testing of these interventions, understanding of the implementation context through assessment of factors affecting uptake and, finally, evaluation of the intervention in the real world. In the interest of forming a cohesive series of four research studies, these tenets formed the basis of this dissertation.

To introduce the population under study, and to highlight our current understanding of the etiology of OA, a review of the literature was conducted. This was undertaken to address the first and second objectives of the TRIPP model, and provided the rationale for the studies that followed.

The first study in the series was a meta-analysis of prehabilitation interventions in orthopedic populations. It was conducted to ascertain the current state of research in this area, and to highlight gaps in our understanding of the types, durations, and intensities of therapy that are most beneficial in the pre-operative period. This analysis not only described the prehabilitation interventions that have been developed, but guided the design of a new intervention, which is presented in the third study.

Before this new intervention could be formally tested, it was imperative to ensure that the most accurate measurement tools were available. To determine the most appropriate instrument to use, an assessment was made of the Lower Limb Tasks Questionnaire, a relatively new diagnostic tool for determining functional status for those with lower body ailments (McNair, Prapavessis, Collier, Bassett, Bryant, & Larmer, 2007). This questionnaire was evaluated on the basis of its convergence with and responsiveness in

comparison to the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which is the current research gold standard (Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988b; Bellamy, 2005).

The third study was a randomized controlled trial that aimed to determine the effectiveness of a new pre-operative strength-training intervention on function, pain, and health-related quality of life for patients undergoing total knee arthroplasty. The role of self-efficacy was also examined as a potential link between exercise and functional status, both pre- and post-operatively. This satisfied the third and fourth steps of the TRIPP framework.

Finally, an uptake study was conducted to ascertain the current demand for prehabilitation programs within the public health care system. Prospective arthroplasty patients were asked about their receptiveness for various types of prehabilitation, and reported on their beliefs regarding the benefits and risks associated with pre-surgical intervention. This provided an initial insight into the implementation context for this type of intervention within the target population, as prescribed in step five of the TRIPP model.

1.5   Summary of dissertation format

This dissertation is written in the imbedded manuscript style, with individual studies being presented as stand-alone articles. Each paper constitutes a chapter in this dissertation, and these are ordered according to the TRIPP model. Literature review and discussion chapters were added as bookends to the articles in order to ensure cohesiveness between the separate papers. As a result of this formatting, there is a small amount of redundancy throughout the dissertation, although this was minimized to the best of my ability.

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Chapter 2

2   The physiology of osteoarthritis

Osteoarthritis (OA) is a common condition, and its chronic symptoms of pain and joint stiffness are a leading cause of disability in those aged 65 years and older (Garstang & Stitik, 2006). With such a large public health impact, OA has been the focus of a vast amount of research; however, a definitive model of OA pathogenesis is elusive, and gold standard treatments consequently more so. Yet, regardless of treatment course, there is no cure for OA and the goal of any intervention is to reduce functional impairment resulting from the condition. Adjuncts, such as prehabilitation, may be one way of improving patient outcomes by maximizing existing treatment effectiveness, and may therefore be an attractive option from both patient and public health care perspectives.

In this chapter, the impact of knee OA, in terms of both prevalence and cost, will be highlighted. Additionally, models of OA pathogenesis will be outlined, and current treatments will be discussed on the basis of their ability to successfully reduce the level of disability associated with knee OA symptoms. Finally, a rationale will be provided for examining knee OA in the context of the current program of study, with attention to the potential for prehabilitation to augment standard treatment courses.

2.1   Definition and diagnosis

Osteoarthritis (OA) is commonly defined as a degenerative joint disorder, and is characterized by loss of articular cartilage alongside abnormal bone growth (Arden, Arden, & Hunter, 2008; Berger & Doherty, 2007; Felson, 2006; Punzi, Oliviero, & Ramonda, 2010). Although OA is typically operationalized as a singular condition, it has been defined as "the clinical and pathologic outcome of a range of disorders that result in structural and functional failure of the synovial joints" (Nuki, 1999, pg. 1). It can also be classified as either primary or secondary, based on the presumed etiological pathway of disease. Primary, or idiopathic, OA usually develops with no known cause (Dekker, Boot, van der Woude, & Bijlsma, 1992; Mandl, 2007), while secondary OA occurs as a

result of an identifiable, underlying systemic disease, congenital condition, or physical trauma (Dekker et al., 1992; Schumacher, 1984). OA can affect one or many joints simultaneously, and is most prevalent in weight-bearing joints (predominantly knees and hips) (Dekker et al., 1992; World Health Organization, 1997).

The hallmark symptoms of OA are pain and joint stiffness. For those suffering from knee OA in particular, pain with activity is the predominant clinical complaint (Arden et al., 2008; Creamer, Lethbridge-Cejku, & Hochberg, 2009; Dekker et al., 1992; Hunter & Felson, 2006; Lachance, Sowers, Jamadar, Jannausch, Hochberg, & Crutchfield, 2001; Ordeberg, 2009). As OA severity increases, the associated pain often interrupts sleep, and may be enough to prevent individuals from engaging in their normal activities of daily living (Arden et al., 2008). Stiffness upon waking and after extended periods of immobility is also common, and the patient will typically report worsening symptoms over a period of time (Kettlekamp & Colyer, 1984). Other signs, including tenderness on palpation, crepitus, varus or valgus alignment, joint effusion, reduced range of motion, and joint instability may also be present to varying degrees (Felson, 2006; Moskowitz, 1984).

Although the signs and symptoms of OA may be easily recognizable, arriving at a diagnosis is not as straightforward. Clinicians usually rely on radiographic evidence to corroborate patients' symptoms before confirming that they do have OA. Typical radiographic findings show narrowing or loss of joint space as a result of hyaline cartilage loss, along with subchondral bone remodeling and the formation of cysts (Berger & Doherty, 2007). There is, however, an inconsistent relationship between radiographic evidence of joint degradation and clinical symptoms (Lachance et al., 2001). For example, the Framingham Study found a 33% prevalence of radiographic knee OA among those aged 63-93, but only about 9% of these cases were symptomatic (Felson, Naimark, Anderson, Kazis, Castelli, & Meenan, 1987). Conversely, patients may report severe symptoms with very minimal or no radiographic findings (Lachance et al., 2001; Mandl, 2007). It has been observed that structural changes are often only visible later in OA progression, so individuals may be symptomatic long before clinicians have

radiographic support for their diagnosis (Punzi, et al. 2010). As radiographic evidence has a particularly poor association with pain severity (Felson, 2006), and pain is the primary symptom leading patients to present in clinic, knee OA may be under-diagnosed by a wide margin.

2.2 Epidemiology of osteoarthritis

Although estimates of OA prevalence vary depending on whether studies operationalize it radiographically or symptomatically, it is undeniably one of the most common musculoskeletal disorders worldwide, affecting approximately 40% of adults aged 70 and older (Punzi et al., 2010). Of those suffering from OA, an estimated 80% will exhibit limitations in movement, and upwards of 25% will experience severe impairment in carrying out activities of daily living (Punzi et al., 2010). The World Health Organization (WHO) has recognized OA as the 4th leading cause of global impairment as measured by total years lived with a disability (YLD), accounting for 3% of worldwide total YLDs (World Health Organization, 1997).

As one of the most prevalent conditions worldwide, the burden of OA is high in terms of not only proportion of the population affected, but also associated health care costs. In the United States, at least 27 million people are currently afflicted with OA, with costs to society in medical care and lost wages expected to top $100 billion USD annually by 2020 (Punzi et al., 2010). In Canada, approximately 3 million people have OA, with an estimated annual cost to society between $4.4 billion and $5.9 billion CDN per year (Public Health Agency of Canada, 2003). To put this in perspective, the annual costs of heart disease, cancer, and diabetes in Canada are estimated at $18.5 billion CDN, $14.2 billion CDN, and $1.6 billion CDN respectively (Public Health Agency of Canada, 2007). As much as 75% of the cost associated with OA is attributable to long-term disability, with smaller proportions of the total going toward physician visits, prescription drugs, and hospitalizations (Public Health Agency of Canada, 2003).

As the number of prevalent cases of OA is projected to increase with our upward-shifting population demographics, the cost of OA will also increase. The World Health

Organization projects that by 2020, the global over-65 population will increase by 82% (World Health Organization, 1997), meaning that more than 690 million people worldwide will be in the high-risk age group for developing OA. As life expectancy increases, the number of years that people are symptomatic will also rise, thereby increasing the long-term cost of care and treatment.

2.3   Pathophysiology and treatment

In order to reduce the impact of OA, it is essential to develop treatments that act on not only the risk factors for OA onset, but also the symptoms that constitute the major source of associated disability. To this end, a large body of research has been focused on the underlying causes of OA, with particular attention paid to the molecular and cellular basis of cartilage loss. While this type of research has not yielded a clear picture of OA pathogenesis, it has identified a number of factors that contribute to functional impairment, and treatment modalities have been developed to mitigate their effects.

2.3.1 Risk factors and OA onset

One risk factor that has consistently garnered attention is age. Although OA was originally thought to be the result of "wear and tear," research has shown that it is not an inevitable process of aging (Arden et al., 2008). The fact that not everyone develops OA as they get older underscores the conception of its onset as a disease process, and although the prevalence of OA increases in parallel with age, accumulated exposure to a combination of risk factors is likely the reason for this relationship (Arden et al., 2008; Dekker et al., 1992; Manek, Hart, Spector, & MacGregor, 2003). Several risk factors that may act in concert to promote OA have been identified, including obesity (et al.,Cooper, Snow, McAlindon, Kellingray, Stuart, Coggon et al., 2000; Manek, Hart, Spector, & MacGregor, 2003;), gender (female) (Felson, 2006; Garstang & Stitik, 2006), joint laxity (Garstang & Stitik, 2006), and previous injury (Cooper et al., 2000; Felson, 2006; Garstang & Stitik, 2006). Although there is contradicting evidence, high bone density appears to be a risk factor (Bruno, Sauer, Rosenberg, Block, & Sumner, 1999; Dequeker, Aerssens, & Luyten, 2003; Garstang & Stitik, 2006; Madsen, Brot, Petersen, & Sorensen,

1997; Sandini, Arokoski, Jurvelin, & Kroger, 2005; Stewart & Black, 2000), as do proprioceptive deficiencies (Felson, 2006; van der Esch, Steultjens, Harlaar, Knol, Lems, & Dekker, 2007) and occupations that result in repetitive joint stress (Hunter & Felson, 2006). There is also evidence that OA has a degree of heritability, suggesting some people may be genetically predisposed to developing the condition (Felson, 2006; Garstang & Stitik, 2006; Manek, et al., 2003; Punzi et al., 2010; Spector, Cicuttini, Baker, Loughlin, & Hart, 1996 et al.,).

Two large cross-sectional studies have also found a relationship between quadriceps weakness and knee OA. Slemenda and colleagues demonstrated that, after controlling for age, gender, and body weight, a decrease in quadriceps strength was related to both radiographic and symptomatic OA (odds ratio [OR] = 0.8; 95% confidence interval [CI]: 0.71-0.90 and OR = 0.71; 95% CI: 0.51-0.87, respectively) (Slemenda, Brandt, Heilman, Mazzuca, Braunstein, Katz et al., 1997). Similarly, the Beijing Osteoarthritis Study found that, for women, muscle weakness was associated with radiographic tibiofemoral (OR = 0.7; 95% CI: 0.4-0.9), patellofemoral (OR = 0.6; 95% CI: 0.4-0.9) and mixed OA (OR = 0.4; 95% CI: 0.3-0.6) (Baker, Xu, Zhang, Nevitt, Niu, Aliabadi et al., 2004), but for men the association was only present for mixed OA (OR = 0.5; 95% CI: 0.3-0.8) (Baker et al., 2004). Although causality cannot be assessed using cross-sectional data, and it cannot be stated with certainty whether quadriceps weakness is a risk factor for OA or a symptom, emerging evidence suggests that muscle dysfunction may precede OA onset (Becker, Berth, Nehring, & Awiszus, 2004; Berger & Doherty, 2007; Hurley, 1999; Slemenda, Heilman, Brandt, Katz, Mazzuca, Braunstein et al., 1998).

Quadriceps weakness in OA may be attributed to muscle atrophy. As women exhibit a greater relationship between weakness and OA, however, it is likely separate from age-related sarcopenia, which typically affects men more readily than women (Berger & Doherty, 2007). Disuse atrophy secondary to joint pain is the widely accepted alternative explanation, supported by the fact that those with OA exhibit progressively decreasing activity levels. However, this does not account for muscle weakness in those with asymptomatic radiographic OA. A second proposed mechanism of quadriceps weakness

that is gaining popularity in response to this is voluntary activation failure. It is hypothesized that joint degeneration may result in abnormal afferent information being sent to the alpha-motorneurons, thereby inhibiting muscle contraction (Lewek, Rudolph, & Snyder-Mackler, 2004; Slemenda et al., 1997). Several studies have demonstrated failure of volitional activation in samples of knee OA patients (Hassan, Mockett, & Doherty, 2001; Hurley & Scott, 1998; Hurley, Scott, Rees, & Newham, 1997; Lewek et al., 2004), although to date there is inconsistent evidence regarding the magnitude of this effect and its temporal association to OA onset.

Despite general consensus in the literature about the existence of OA risk factors, their relative contributions to the progression of OA are unknown. This is largely because there is no definitive model of OA pathogenesis. While some researchers have identified a biomechanical basis for onset, citing joint malalignment and increased mechanical loading (Arokosky, Jurvelin, Vaatainen, & Helminen, 2000; Astephen Wilson, Deluzio, Dunbar, Caldwell, & Hubley-Kozey, 2011; Garstang & Stitik, 2006), others have focused on subchondral bone ischemia resulting in the interruption of nutrient flow to the adjacent cartilage, or even the failure of subchondral bone as a shock absorber (Findlay, 2007; Punzi et al., 2010). Yet others point to a cellular cause, reporting that a deficit in cartilage metabolism arising from upregulation of inflammatory cytokines and other bone-derived products may contribute to cartilage deterioration (Martel-Pelletier & Pelletier, 1997; Punzi et al., 2010). Recognizing that there is evidence to support the occurrence of all of these processes, it reinforces the idea that OA is in fact the common endpoint of a number of distinct disorders, and the etiological pathway may not be the same in all cases.

2.3.2 Non-surgical treatment

Because the underlying cause of OA may differ from patient to patient, it is difficult to develop treatments that act on the mechanisms of OA onset. As Berger and Doherty note, therapy targeting the processes of structural change has been largely unsuccessful to date; however, as joint degradation itself does not predict the amount of functional impairment experienced by the patient (2007), addressing risk factors and treating symptoms are far

more effective methods of improving patient well-being. Although not all risk factors are modifiable (ex. gender, genetic predisposition, previous injury), those constituting the major sources of disability for those with knee OA, namely pain, reduced quadriceps strength, and obesity are amenable to intervention (Berger & Doherty, 2007; Creamer et al., 2000; McAlindon, Cooper, Kirwan, & Dieppe, 1993). Pain correlates highly with disability for those living with knee OA (Creamer et al., 2000; McAlindon et al., 1993), and as it is the primary symptom leading patients to seek treatment, its management is paramount. Additionally, loss of lower-extremity muscle strength is a strong predictor of reduced functional performance and stability while carrying out daily living activities (Berger & Doherty, 2007; Hall, Mockett, & Doherty, 2005), and it has been reported that muscle weakness is a better predictor of pain and disability than radiographic OA (McAlindon et al., 1993; O'Reilly, Jones, Muir, & Doherty, 1998). As OA progresses, muscle strength decreases, thereby causing many individuals to avoid activity that exacerbates their symptoms (Steultjens, Dekker, & Bijlsma, 2002). This in turn may promote disuse atrophy and, consequently, increased pain and disability (Baker & McAlindon, 2000). This vicious circle translates to ever-increasing inactivity and progressive loss of functional independence, and is associated with decreasing health-related quality of life in this population (Hinman, Heywood, & Day, 2007; Maurer, Stern, Kinossian, Cook, & Schumacher, 1999).

To prevent disability arising from OA symptoms, a number of therapeutic options are available to patients. Clinicians have advocated a treatment hierarchy starting with non-pharmacological management, then drugs, followed by surgery only when necessary (Hunter & Felson, 2006). Those with mild to moderate symptoms may experience adequate relief from physical therapy, braces and orthotics, assistive devices, or simple weight loss (Brandt, 1998; Dougados, 2007; Felson, 2006; Hunter & Felson, 2006; Jordan, Arden, Doherty, Bannwarth, Bijlsma, Dieppe et al., 2003). As symptom severity increases, oral or topical analgesics may be used, or patients may opt for intra-articular corticosteroid injections (Dougados, 2007; Felson, 2006). Yet, while these treatments reliably reduce pain and may help to mitigate the impact of abnormal joint loading, they

do not sufficiently address limits in physical functioning brought about by the strength or neuromuscular deficits associated with OA.

To offset the effects of increasing muscle weakness and resultant loss of function, exercise is considered to be an integral component of OA treatment (Bennell & Hinman, 2005; Brandt, 1998; Petrella, 2000). Along with the positive health outcomes associated with regular physical activity, those with OA may particularly benefit from joint-specific strengthening and improved flexibility. Many clinical guidelines therefore advocate exercise, but it has been recognized that few of these rely on evidence-based findings to support their recommendations (Berger & Doherty, 2007; Roddy, Zhang, Doherty, Arden, Barlow, Birrell et al., 2005). Nonetheless, several expert panels have attempted to synthesize current evidence to formulate practical therapeutic manuals for clinicians. After reviewing the literature, the Philadelphia Panel (2001) recommends the use of strengthening, stretching, and functional exercises as interventions for reducing pain, although they cite limited and inconsistent evidence to support the use of exercise for improving functional status. This is congruent with the guidelines of the American College of Rheumatology (2000), which recommends the use of strength exercises and aerobic activity for OA symptom management.

Evidence supporting the benefits of aerobic exercise has been reasonably persuasive. A meta-analysis conducted in 2004 identified 12 randomized controlled trials investigating the effects of aerobic-based exercise interventions on OA symptoms (Brossaeu, Pelland, Wells, MacLeay, Lamothe, Michaud et al., 2004). The results indicate that walking programs, jogging in water, yoga, and Tai Chi can have significant impact on pain, joint tenderness, and functional status for OA patients (Brosseau et al., 2004). Walking programs demonstrated particular efficacy for reducing pain and disability, with reductions in self-reported pain ranging from 29% - 47% and self-reported disability during daily living activities (such as bathing, dressing, and transferring from bed to a chair) decreasing approximately 15% - 20% (Brosseau et al., 2004). There has been some research conducted to investigate the differences in land-based versus aquatic exercise, with the thought that exercising in water may not exacerbate OA symptoms in

weight-bearing joints. It has been shown, however, that both exercise settings result in similar symptom reductions and land-based programs do not result in greater discomfort or higher dropout rates (Minor, Hewett, Webel, Anderson, & Kay, 1989; Zhang, Nuki, Moskowitz, Abramson, Altman, Arden et al., 2010). Aquatic exercise has only been examined in short-term studies as well, so the utility of this exercise modality is somewhat understudied as a stand-alone intervention for long-term symptom management (Bartels, Lund, Hagen, Dagfinrud, Christensen, & Danneskiold-Samsoe, 2007).

Strength training has also been consistently supported in the literature, with a recent systematic review identifying 18 studies that investigated the effects of lower limb strengthening on knee OA symptoms (Lange, Vanwanseele, & Fiatarone Singh, 2008). In this review, positive associations were found between increased muscle strength and decreased pain, improved overall function, and reduced self-reported disability. Of the studies included, 56% showed significant improvements in pain for resistance training groups versus controls (Lange et al., 2008). Importantly, none of the studies reported an increase in pain with resistance training, suggesting that this type of intervention can safely increase muscle strength without exacerbating OA symptoms. Physical disability also significantly improved in 79% of the studies in which it was measured, although effect sizes across studies ranged from -3.58 to 2.15 (Lange et al., 2008).

Other researchers have found that both high-resistance (60-80% of 1 repetition maximum [RM]) and low-resistance (10-50% of 1 RM) programs are beneficial, but the effects of high-resistance training appear to be larger (Jan, Lin, Liau, Lin, & Lin, 2008). It is also believed that isokinetic or isotonic exercises are of greater benefit than simple range-of-motion or isometric exercises, as they develop functional strength in muscles used to perform daily living activities (Felson, 2006). Although improved quadriceps strength is key to increasing functional ability for those with knee OA, it may be contraindicated in some cases. Sharma and colleagues investigated the role of quadriceps strength in tibiofemoral OA. They found that, although increased strength may protect against OA progression in normally aligned knees, it might actually increase the risk of progression

for those with malaligned or lax joints (Sharma, Dunlop, Cahue, Song, & Hayes, 2003). It is therefore important to tailor strengthening interventions to the patient in order to ensure that the treatment itself does not contribute to worsening symptoms.

While strengthening exercise appears to be superior for short-term outcomes related to impairment (such as pain), aerobic activity seems more suited to improving long-term function (Bennell & Hinman, 2005). Knowing that exercise is most effective when it is patient-centred and accounts for factors like age, comorbidities, and personal preference (Roddy et al., 2005), it is important to consider individual goals and abilities when prescribing an exercise regime. For those who have no contraindications for exercise, though, a combination of strength training and aerobic activity, together with other treatment modalities such as pharmacotherapy, is likely to confer the greatest protection against disability. Regardless of training type, there is a presumed dose-response relationship between exercise and patient benefit, but additional research is necessary to determine the optimal type, volume, and intensity of training for this population.

2.3.3 Arthroplasty

Although symptom management through pharmacotherapy, assistive devices, and exercise may allow those with mild or moderate OA to maintain a sufficient level of physical functioning, individuals with severe OA may not experience adequate relief from conservative treatments. When all other therapeutic options are exhausted, total joint arthroplasty is often the only available course of action for those with end-stage symptoms (Deyle, Allison, Matekel, Ryder, Stang, Gohdes, et al, 2005; Fortin, Clarke, Joseph, Liang, Tanzer, Ferland, 1999; Larsen, Hvass, Hansen, Thomsen, & Soballe, 2008). Arthroplasty is an irreversible procedure during which damaged bone and cartilage are removed and prosthetic implants, made of metal alloys, high-density plastic, and ceramic components, are affixed in their place (Arden et al., 2008). In cases where the patient has fragile bones, the artificial pieces are cemented to remaining bone surfaces to increase the strength of the new joint. The cement can weaken over time however, and require revision surgery to repair (Arden et al., 2008). For those with stronger bones, surgeons use prosthetics with spaces that allow bone to grow into them and secure the

joint naturally (Arden et al., 2008). Uncemented joints tend to last longer, although all replacements are vulnerable to wearing out, and the average lifespan of the prosthetic is approximately 15 years (Arden et al., 2008).

The number of total knee arthroplasties (TKAs) performed each year is on the rise, with over 441,000 reported in the United States in 2004 alone (Riddle, Jiranek, & McGlynn, 2008). This popularity is due, in part, to the success rate of the procedure: clinicians report satisfactory outcomes in up to 95% of patients (Hunter & Felson, 2006). Yet, while the operation is effective in terms of pain reduction, improving range of motion, and correcting joint alignment, there are a number of factors that may affect the patient's ability to achieve full function afterward. Regaining strength and mobility is key to attaining maximal benefit from the operation (Ditmeyer, Topp, & Pifer, 2002), and it has been found that those who have surgery earlier in the progression of OA generally have a better prognosis for doing so than those with more severe symptoms (Fortin et al., 1999). Additionally, the faster patients are able to become independently mobile and begin to perform daily living activities, the lower their risk of complications after surgery (such as failure to achieve full range of motion or prolonged swelling) (Arden et al., 2008). Patients are therefore encouraged to attend physical therapy sessions, return to normal activity as soon as possible, and to engage in a physically active lifestyle following the rehabilitation period to maintain their functional ability long-term (et al.,Ditmeyer, et al, 2002; Rooks, Huang, Bierbaum, Bolus, Rubano, Connolly et al., 2006).

2.4   Prehabilitation and osteoarthritis

With OA prevalence expected to continue increasing, and no clear understanding of how to prevent its onset, it is essential to maximize the efficacy of existing treatments in order to manage the public health burden of the condition. As a large proportion of those who are affected ultimately require total joint arthroplasty, adjunct therapies that help to ensure positive surgical outcomes warrant investigation. Because it has been speculated that patients who are better able to withstand the physical and mental stressors of the operation will experience greater benefit, researchers have begun to examine the potential

role of prehabilitation in OA management (Topp, Ditmeyer, King, Doherty, & Hornyak, 2002).

Although a number of prehabilitation modalities have been investigated (see chapter 4), exercise interventions are particularly attractive due to the physiological plausibility of their effect. Quadriceps strength is one of the largest contributing factors to function for those with knee OA, and pre-operative function has been shown to be the greatest overall predictor of post-operative function for those undergoing TKA (Fortin et al., 1999). By increasing quadriceps strength before surgery, patients may not only be more likely to regain full function after the procedure, but may thereby be able to engage in a greater number of daily living activities long-term. Cardiovascular fitness, healthy body weight, and optimal immune function are also crucial to recovery, as they allow patients to safely undergo anaesthetic and fight off infection. Exercise can help patients to achieve these health prerequisites as well, further supporting its role in pre-surgical treatment.

As the relationship between pre-surgical function and post-surgical outcomes is so strong for those undergoing TKA, it was determined that this population would be ideal for examining exercise as a prehabilitative intervention. Additionally, considering that this paradigm affords the potential to benefit a large number of people, it also provides a unique opportunity to conduct laboratory-based research with immediate real-world applications. The current program of study was therefore designed to investigate the effect of exercise prehabilitation on post-operative outcomes for TKA patients, with particular emphasis on determining the mechanism of action through which the intervention may impart its benefits.

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Chapter 3

3   The psychological symptoms of osteoarthritis

While the physiological symptoms of osteoarthritis (OA) have been the subject of a vast amount of research, less attention has been paid to the psychological effects of the condition. It is known that patients suffering from chronic pain often exhibit a host of negative psychological consequences, including depression and anxiety, and when coupled with the inability to perform daily living activities, those with OA are likely to experience severe decreases in self-efficacy as well (Arden, Arden, & Hunter, 2008). Because these symptoms directly contribute to worsening health-related quality of life, and directly impact treatment success, it is important to address them when developing new interventions for this population.

In this chapter, the psychological symptoms of OA will be discussed, with emphasis on their role in promoting disability. The theoretical basis of self-efficacy will also be examined in detail, highlighting its relationship to physical function and treatment adherence. Finally, the inclusion of psychological variables in the present program of study will be outlined, with particular attention to their contribution to long-term outcomes following total joint arthroplasty.

3.1   The psychological symptoms

3.1.1 From diagnosis to surgery

Early in the progression of OA, patients tend to experience a range of negative thoughts and emotions. Denial, anger, and worry are predominant reactions after receiving a positive diagnosis, as patients are often unwilling to believe that their symptoms are the result of OA, and are initially frightened at the prospect of living with a chronic condition (Arden et al., 2008). For many, the primary source of these psychological reactions is concern about being unable to continue performing basic daily tasks and losing independence as OA symptoms worsen (Arden et al., 2008). Mounting frustration at the inability to engage in regular activities, coupled with guilt associated with asking for help

with simple chores, can lead to feelings of helplessness or worthlessness (Arden et al., 2008).

If these reactions are left unchecked, they can develop into serious depression or anxiety (Arden et al., 2008). In a sample of 1,021 patients with osteoarthritis, Rosemann and colleagues found that nearly 20% of participants exhibited at least moderately severe depression, which is much higher than the point prevalence of depression in the general population (Lin, 2008; Ormel, VonKorff, Ustun, Pini, Korten, & Oldehinkel, 1994; Rosemann, Backenstrass, Joest, Rosemann, Szesenyi, & Laux, 2007). Similarly, in a smaller investigation, Axford and colleagues reported that 40.7% (95% Confidence Interval [CI]: 27.6-55.0%) of those with lower limb osteoarthritis suffered from clinically significant depression, anxiety, or both (Axford, Butt, Heron, Hammond, Morgan, Alavi et al., 2010). There is also evidence that the strongest predictor for depression severity is perceived pain, followed by limited social support, disability, and body mass index (Rosemann et al., 2007), suggesting that the impact of psychological symptoms may increase as OA progresses. It is therefore important to consider how depression and anxiety may influence treatment outcomes, particularly for those with end-stage physical symptoms.

In terms of their effect on function, depression and anxiety have been observed to influence disability for those with OA (Dekker, Boot, van der Woude, & Bijlsma, 1991). Depression is associated with increased pain sensitivity and less effective coping, as well as disengagement from the activities of daily living (Zautra & Smith, 2001). Moreover, there appears to be a bi-directional relationship between depression and both pain and physical limitation, whereby depression may be both a consequence of living with chronic OA symptoms and a contributing factor to increasing disability (Graney, 2000). Anxiety exhibits a similar pattern, with more anxious OA patients reporting poorer physical function and less frequent performance of daily living activities (Scopaz, Piva, Wisniewski, & Fitzgerald, 2009). Anxiety has a demonstrated association with poorer performance on objective measures of function as well (Scopaz et al., 2009). As an explanation for this relationship with diminished physical ability, it is believed that

anxiety may contribute to maladaptive coping responses that promote activity avoidance, hypervigilance, and consequently, increased disability (Scopaz et al., 2009).

Passive coping styles characterized by worrying, resting, and catastrophizing have been positively related to disability in studies of patients with various chronic disorders, including OA (Covic, Adamson, & Hough, 2000: Mercado, Carroll, Cassidy, & Cote, 2005). Anxiety and other negative emotional reactions to pain are hypothesized to increase the individual's tendency to avoid pain-causing activities; however, avoidance of activity enhances muscle weakness, ultimately leading to greater pain and disability (Dekker et al., 1991; Steultjens, Dekker, & Bijlsma, 2002). In a longitudinal investigation of the effect of coping style on disability for knee OA patients, Steultjens and colleagues found that a passive coping style of resting predicted higher levels of disability up to 36 weeks later (Steultjens et al., 2002). This result is supported by evidence that muscle strength mediates the relationship between avoidance and disability, suggesting that the longer one avoids activity, the greater the resulting disability will be (Steultjens et al., 2002). Furthermore, catastrophizing has been implicated in reduced physical functioning, as those who tend to focus on pain and magnify its potential consequences report greater levels of pain and disability (McKnight, Afram, Kashdan, Kasle, & Zautra, 2010: Watkins, Shifren, Park, & Morrell, 1999). This relationship appears to be partially mediated by self-efficacy, however, suggesting that positive assessments of one's own ability to manage pain and other chronic symptoms may translate to more adaptive coping responses (McKinght et al., 2010).

Dispositional optimism has also been linked to adaptive coping strategies (Carver, Scheier, & Segerstrom, 2010). A review examining the relationship between optimism and coping in a wide range of populations found that it was positively associated with approach coping strategies (r = .17) and negatively associated with avoidance coping strategies (r = -.21) (Solberg Nes & Segerstrom, 2006). A number of health-related benefits may also be derived from optimism, including greater resistance to depression (Long & Sangster, 1993), better adjustment to medical stressors (Friedman, Nelson, Baer, Lane, Smith, & Dworkin, 1992: Tennen, Affleck, Urrows, Higgins, & Mendola, 1992),

and greater overall life satisfaction (Ferreira & Sherman, 2007). Additionally, there is some evidence that optimism partially mediates the relationship between pain and life satisfaction (Ferreira & Sherman, 2007). In terms of its effect on physical function, a recent meta-analysis found that optimism is a significant predictor of positive physical health outcomes across disease populations: for subjective measures, the mean effect size (ES) was 0.20 (K = 42; N = 5,255; 95% CI: 0.17-0.23), while for objective measures it was 0.08 (K = 24; N = 8,493; 95% CI: 0.06-0.10) (Rasmussen, Scheier, & Greenhouse, 2009). When examined specifically in the context of OA, however, the results have been somewhat less definitive than for other populations. Although it has been shown to significantly predict successful psychosocial adjustment, for those with OA, physical symptoms appear to be a more salient predictor for coping strategy (Long & Sangster, 1993). Other researchers have found that, for those with knee OA, optimism is not robustly related to physical function (Brenes, Rapp, Rejeski, & Miller, 2002), again indicating that perhaps OA symptom severity outweighs the effect of optimism. As optimism has not been examined exclusively in a sample of end-stage OA patients, however, this hypothesis has yet to be verified.

3.1.2 Arthroplasty and recovery

Once patients have made the decision to have surgery, the emphasis of their thoughts and emotions shifts from the burden of living with OA to the potential for symptom alleviation and a return to functional independence. In a recently conducted grounded theory study, patients described experiences of "struggling," "enduring," and "seeking comfort" while awaiting surgery (Marcinkowski, Wong, & Dignam, 2005). They were deeply affected by living with constant pain in the months leading up to their operation, and described having been burdened by the ever-increasing challenges presented by routine chores and activities. These patients frequently cited the promise of relief afforded by a total knee arthroplasty (TKA) as a key motivator to continue persevering through the waiting period, and most looked forward with anticipation to having the operation done (Marcinkowski et al., 2005).

Perhaps because they are so desperate for relief, patients' pre-operative expectations tend to be overly optimistic. One study found that, after asking TKA patients to compare their expectations against the reality of their recovery two years postoperatively, time for full recovery was underestimated (expected 4.7 ± 2.8 months; actual time 6.1 ± 3.7 months, p = 0.005), and the likelihood of being pain free was overestimated (85% expected it, 43% were), as was ability to participate in usual activities without limits (52% expected it, 20% were) (Mannion, Kampfen, Munzinger, & Kramers-de Quervain, 2009). Yet, despite the discrepancy between their expectations and actual outcomes, the authors found that patients' satisfaction was skewed to the positive: 46.4% of respondents rated their global outcome as "excellent," 42.0% as "good," 9.8% as "fair," and only 1.8% as "poor" (Mannion et al., 2009). This incongruence between satisfaction rating and outcome discrepancy speaks to the amount of symptom relief the surgery itself provides. Even when positive surgical outcomes do not occur as rapidly or to the extent that patients anticipate, they are still satisfied with the result, lending support to the idea that psychological well-being following surgery is closely tied to symptom relief for this population.

Conversely, a number of psychological factors can affect postsurgical outcomes for arthroplasty patients. For example, pre-operative mental wellbeing is positively correlated with self-reported postoperative function and pain scores (Walton & Newman, 2008). Pre-operative anxiety has also been shown to negatively affect postoperative function (Faller, Kirschner, & Konig, 2003), and it increases the risk of postoperative complications (Kagan, & Bar-Tal, 2007) while hampering short-term recovery (Brull, McCartney, & Chan, 2002). Postoperative pain and length of hospital stay are also partially predicted by psychological processes, primarily catastrophizing (Sullivan, Tanzer, Stanish, Fallaha, Keefe, Simmonds et al., 2009; Witvrouw, Pattyn, Almqvist, Crombez, Accoe, Cambier et al., 2009) and negative mood (Roth, Tripp, Harrison, Sullivan, & Carson, 2007). Because psychological factors in the pre-operative phase appear to predict physical outcomes postoperatively, and these in turn influence psychological recovery after surgery, it is incumbent upon researchers and clinicians to

examine both physical and psychological variables together when working with OA patients who are undergoing a total joint arthroplasty.

Following arthroplasty, one of the most pressing concerns for patients is to maintain their independence and, to this end, they may behave cautiously to avoid setbacks in their recovery (Marcinkowski et al., 2005). Many report adapting their behaviour to allow for slower, more deliberate actions in the belief that they need to protect their new joint (Marcinkowski et al., 2005). Despite this attention to recovery, however, rehabilitation may be inhibited by a lack of confidence in the new joint, and patients may not achieve functional milestones as a result (Marcinkowski et al., 2005). It is therefore crucial to enhance patients' efficacy beliefs in both the prosthetic, and their own ability to function with it, in order to maximize postsurgical outcomes.

3.2   Self-efficacy theory

Self-efficacy theory is, at its core, concerned with judgments of personal capability (Bandura, 1977). The basic tenets of the theory state that a person's belief in his effectiveness in a given situation will direct behaviour, will determine how much effort he or she expends, and how long he or she will persist when confronted by obstacles (Bandura, 1977). According to the theory, individuals will avoid situations that they believe exceed their skills, but will actively engage in behaviours when they perceive their abilities to be equal to, or greater than, what is required to ensure a desired outcome. They are more apt to invest effort into attaining a goal when they favourably perceive their ability to do so, and perseverance following a setback will reinforce self-efficacious beliefs, thereby promoting sustained behaviour (Bandura, 1977). Proponents of the theory generally consider self-efficacy to be domain-specific, but a partial transfer of increased efficacy expectations between similar situations has been supported (Bandura, 1977; Bandura, Jeffery & Gajdos, 1975).

Self-efficacy beliefs are derived from four major sources of information: mastery experiences, vicarious experiences, verbal persuasion, and physiological or affective states (Bandura, 1977). Mastery experiences are the most influential source of

information, as they provide authentic evidence of one's abilities to perform a behaviour, and as such they produce stronger and more generalized efficacy beliefs (Bandura, 1997). Vicarious experiences, based on referential comparisons with similar others, are slightly less influential, but may be particularly salient when the model conveys effective coping strategies to individuals who have struggled with successful performance (Bandura, 1997). For example, a coping model is likely to foster motivation in the observer by demonstrating efficacy beliefs in his or her ability to persevere in the face of barriers. This may be especially useful when working with chronic disease populations by whom a variety of challenges must be overcome in order to receive maximal benefit from treatment. Similarly, verbal persuasion from a significant other can also serve to bolster self-efficacy in difficult situations, although this type of information can be limited in its ability to influence long-term changes to efficacy beliefs. As Bandura points out, promoting unrealistic beliefs may invite failures that simply serve to discredit the persuader and further undermine one's trust in his own capabilities (Bandura, 1997). Finally, physiological or affective states can inform efficacy beliefs by influencing one's cognitive appraisal of the source, intensity, and context of somatic input, thereby allowing the individual to derive subjective feedback about his ability to perform a given behaviour (Bandura, 1997). This process is typically discussed in terms of its detrimental effects, such as when the individual interprets stress, fatigue, or failing stamina as indicative of dysfunction or physical inefficiency (Bandura, 1997). This source of efficacy information is particularly relevant in domains that hinge on physical accomplishment, and may therefore be particularly salient to those with physical disabilities, as this populations tends to ascribe poor performance to physical limitations irrespective of actual skill level or natural fluctuations in physical state (Bandura, 1997).

Although self-efficacy theory has been studied extensively in many settings (including clinical psychology, sport performance, and education), one of its rapidly growing applications is to aide individuals in exercising direct control over modifiable determinants of health. As Bandura (1997) notes, patients' personal beliefs about their ability to regulate their actions play a crucial role in whether or not they consider pursuing health-promoting behaviours, and whether they continue to engage in them

long-term. Those with chronic conditions, such as OA, often exhibit poor adherence to treatment because of a general disbelief in their abilities to do what they are prescribed (Taal, Rasker, Seydel, & Wiegman, 1993). The effect of diminished self-efficacy on adherence is even thought to be greater than the effects of pain and disability (Schiaffino & Revenson, 1992: Schiaffino, Revenson, & Gibofsky, 1991), suggesting that a large proportion of treatment outcome variance may be attributed to patients' subjective evaluations of their condition more so than their actual physiological state.

Conversely, because they have greater perceptions of personal control over their condition, patients with higher levels of self-efficacy are more likely to adopt and maintain positive health behaviours (Marks, Allegrante, & Lorig, 2005). These patients are therefore more apt to adhere to treatment protocols and, due to the dose-response nature of many therapeutic courses, are likely to experience better health outcomes than their low-efficacy counterparts. Indeed, studies have demonstrated that those with greater self-efficacy for controlling disease-related symptoms often experience a corresponding reduction in severe symptoms, fewer hospitalizations, and better health-related quality of life (Marks et al., 2005). This highlights not only a potential avenue for non-pharmacological intervention, but also a method of encouraging proactive patient involvement in disease management, and speaks to the necessity of promoting self-efficacy in tandem with clinical treatments.

3.3   Self-efficacy and osteoarthritis

Considering the clear potential for self-efficacy to influence health outcomes for those with chronic conditions, it has been examined with respect to its effect on arthritis self-management. Consistent with the postulates of Schiaffino and associates (1991, 1992) early researchers suggested that functional limitations associated with arthritis may be governed more by perceived self-efficacy than by the patient's actual degree of physical impairment (Baron, Dutil, Berkson, Lander, & Becker, 1987). O'Leary and colleagues tested this hypothesis by comparing pain, disability, and joint function in a group who received arthritis self-management training compared to a group who did not (O'Leary, Shoor, Lorig, & Holman, 1988). The program significantly increased patients' perceived

self-efficacy to reduce pain and engage in potentially painful activities, and those in the treatment group experienced less joint inflammation and less disability overall. Importantly, there was a significant negative association between perceived coping efficacy and pain, impairment, depression, and general stress (O'Leary et al., 1988). Following a similar efficacy-boosting protocol, other researchers extended these findings by showing increased self-efficacy, reduced pain, and slower biological progression of arthritis up to four years later (Holman & Lorig, 1992).

More recently it has been shown that, for those with arthritis, a greater sense of efficacy to exert control over how their symptoms affect their lives predicts functional disability, regardless of pain level or disease duration (Schiaffino & Revenson, 1992; Schiaffino, Revenson, & Gibofsky, 1991). In fact, self-efficacy has been reported to account for between 7-21% of variance in function for OA patients (Gaines, Talbot, & Metter, 2002; Rejeski, Craven, Ettinger, McFarlane, & Shumaker, 1996). Yet, while stronger self-efficacy beliefs have been associated with better self-reported function for women living with osteoarthritis, one study found that this relationship does not appear to hold for men (Gaines et al., 2002). This is in contrast with evidence that suggests high-functioning older men tie efficacy to performance, but women do not (Seeman, Unger, McAvay, & Mendes de Leon, 1999). The reversal of this trend in the presence of OA may indicate that efficacy beliefs are more salient for women as function deteriorates, although small sample size may have prevented the detection of a relationship between efficacy and function for men in this study (Gaines et al., 2002). Nevertheless, this may contribute to our understanding of how self-efficacy and gender interact to either inhibit or promote participation in activities of daily living when faced with the functional impairment associated with osteoarthritis.

Self-efficacy not only affects daily living activities, but compliance with treatment as well. For example, it has been stated that, after controlling for degree of physical disability, those with greater belief in their competence to exert control over how their condition affects them tend to lead more active lives (Lorig & Holman, 1993; Shoor & Holman, 1984). Yet, though exercise therapy is commonly prescribed as OA treatment,

adherence tends to be quite low. Estimates from clinical trials gauge adherence to exercise interventions for OA to be from 50% - 95% (Lin, Davey, & Cochrane, 2004; Marks & Allegrante, 2005), but actual adherence in non-research settings may be far lower (Thomas, Muir, Doherty, Jones, O'Reilly, & Bassey, 2002). Several authors have therefore recognized the importance of fostering self-efficacy for engaging in physical activity in OA populations (Belza, Topolski, Kinne, Patrick, & Ramsey, 2002; Gyurcskik, Estabrooks, & Frahm-Templar, 2003; Hughes, Seymour, Campbell, Polla, Huber, & Sharma, 2004; McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003; Oliver & Cronan, 2002; Damush, Perkins, Mikesky, Roberts, & O'Dea, 2005), primarily because increased self-efficacy is a strong predictor of exercise initiation and adherence (Lee, Arthur, & Avis, 2008; McAuley 1993; McAuley 1994). It may also be a key component in exercise motivation specifically for older adults diagnosed with OA (Damush et al., 2005). Furthermore, there is evidence that self-efficacy mediates the effect of exercise on performance outcomes for those with knee OA, reinforcing the notion that efficacy beliefs can directly impact physical functioning in this population (Rejeski, Ettinger, Martin, & Morgan, 1998).

3.4   Psychological symptoms and prehabilitation

Although there are a number of psychological factors that affect people living with OA, understanding those that influence treatment outcomes is of vital importance. In order to maximize the effectiveness of current therapeutic modalities, it is necessary to target the psychological variables that are likely to promote positive outcomes while minimizing the risk of negative ones. The current research program therefore aimed to investigate the contribution of dispositional optimism and self-efficacy to post-surgical outcomes for patients undergoing TKA.

Acknowledging that optimism confers many benefits to those living with OA, it may provide additional protection against negative outcomes for those preparing for and recovering from surgery. Optimism has been studied in a number of surgical settings, and has consistently been found to equate to less distress before the operation (Carver 1993; Fitzgerald 1993; Scheier 1989), less long-term postoperative pain (Rosenberger, Kerns,

Jokl, & Ickovics, 2009), and better quality of life afterward (Allison, Guichard, & Gilain, 2000: Fitzgerald 1993). For patients undergoing TKA specifically, optimism may have a protective effect against pain and functional limitation. In a retrospective cohort study of 702 patients, Singh and colleagues found that pessimists reported significantly more pain two years following a TKA (Odds ratio [OR] = 2.21; 95% CI: 1.12-4.35), as well as less improvement in knee function (OR = 0.53; 95% CI: 0.30-0.96) than non-pessimists (Singh, O'Byrne, Colligan, & Lewallen, 2010). Optimism was thus included in the current program of research as a likely contributor to TKA success and a potential moderator of a prehabilitation program's effect on postsurgical outcomes. It could not, however, be included as a target of the prehabilitation intervention, as it is by definition dispositional, and therefore unable to be manipulated.

Akin to optimism, pre-operative self-efficacy has been shown to consistently impact postsurgical function and pain (Dohnke, Knauper, & Muller-Fahrnow, 2005; Engel, Hamilton, Potter, & Zautra, 2004; van den Akker-Scheek, Stevens, Groothoff, Bulstra, & Zijlstra, 2007). One study found that pre-operative self-efficacy and expectancies explained, on average, 10% of the outcome variance in self-reported pain, function, and health-related quality of life for TKA patients (Engel et al., 2004). Similar findings have been reported for objective measures of function, with van den Akker-Scheek and associates reporting that pre-operative self-efficacy significantly predicted walking speed six months after knee or hip arthroplasty ($R^2 = 0.47$) (van den Akker-Scheek et al., 2007). These results clearly highlight the role of pre-surgical self-efficacy in ensuring positive outcomes after arthroplasty, and as such, it was a target of investigation in the present research.

Perhaps not surprisingly, postoperative self-efficacy has been shown to influence surgical outcomes to an even greater extent than pre-operative self-efficacy (Kurlowicz, 1998; Moon & Backer, 2000; Orbell, Johnston, Rowley, Davey, & Espley, 2001; van den Akker-Scheek et al., 2007). Moon and Backer (2000) examined the effect of immediate postoperative self-efficacy on ambulation frequency and exercise performance the following day, and found that it accounted for 8-33% of the variance. This is echoed in

the findings of van den Akker-Scheek, et al. (2007) who found that postoperative self-efficacy was a significant predictor of long-term physical and mental functioning (R^2 = 0.30 and R^2 = 0.53, respectively). Because postoperative efficacy beliefs exert such a strong influence over surgical outcomes, they too were included as a focus of the current series of studies.

While researchers have looked at the role of psychological variables in arthroplasty outcomes, they have not explicitly included them in prehabilitation studies in this population. Considering that prehabilitation is predicated on the notion of preparation for both the physical and mental stressors of surgery (Topp, Ditmeyer, King, Doherty, & Hornyak, 2002), there is a paucity of information regarding the ability of such an intervention to successfully influence pre-operative psychological factors. Because prehabilitation conceptually extends to psychological constructs, provided that they are modifiable and targeted by the program, the present research included self-efficacy in an initial attempt to combine physiological and psychological factors in a prehabilitation intervention.

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3.5 References

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Chapter 4

4 The effect of prehabilitation on post-operative outcomes for total hip and knee arthroplasty patients: A meta-analysis

4.1 Background

Osteoarthritis (OA) is one of the most prevalent musculoskeletal conditions worldwide, and a leading cause of disability for those aged 65 years and older (Garstang & Stitik, 2006). Although a number of conservative treatments are available to manage symptoms for those in the early stages of OA progression, joint replacement surgery is often the endpoint for those with severe pain and loss of function. The number of total hip (THA) and knee (TKA) arthroplasties performed each year is on the rise. Kurtz and colleagues estimate that, between 1990 and 2002, the number of primary THAs performed in the United States increased from 119,000 to 193,000, while TKAs increased from 129,000 to 381,000 (Kurtz, Mowat, Ong, Chan, Lau, & Halpern, 2005). This reflects a global trend that is expected to continue with our upward-shifting population demographics, bringing with it a large upswing in treatment costs and resource utilization.

Wait times for a THA or TKA can be months in length. During this time, OA continues to progress, symptoms worsen and, consequently, health and function deteriorate (Desmeules, Dionne, Belzile, Bourbonnais, & Fremont, 2010). This results in patients going into the operating room in even worse condition than when they originally opted for surgery, thus requiring greater amounts of post-operative treatment in order to return to a healthy state (Desmeules et al., 2010). In the interest of maximizing the benefits conferred to the patient from a total joint arthroplasty, while simultaneously reducing the need for intensive postoperative therapy, there is increasing demand for adjuncts that serve to improve THA and TKA outcomes (Landry, Jaglal, Wodchis, Cooper, & Cott, 2007).

The concept of prehabilitation has therefore emerged in the literature in recent years as a topic of considerable interest. Loosely defined as a proactive approach to enhancing the body's ability to endure stress, its theoretical underpinnings rest on the assumption that increasing functional capacity in preparation for an anticipated stressor should help to minimize the impact of that stressor on health-related outcomes (Ditmeyer, Topp, & Pifer, 2002). In the context of total joint arthroplasty, the surgery itself is viewed as a stressor, and the goal of prehabilitation is to prepare the patient to better withstand that stress in order to maximize post-operative outcomes. For example, this may be accomplished by reducing patient anxiety to facilitate earlier hospital discharge, or by increasing quadriceps strength to promote faster mobility recovery. Overall, those undergoing successful prehabilitation are thought to exhibit shorter recovery times, less dependence on caregivers after surgery, and a more rapid return to pre-surgical function than their counterparts receiving standard care (Ditmeyer et al., 2002; Landry et al., 2007; Topp, Ditmeyer, King, Doherty, & Hornyak, 2002 et al., et al.,).

Considering the length of the typical waiting period for THA and TKA patients, and the potential benefits of prehabilitation, clinicians and researchers have targeted the pre-operative period as an ideal time for intervention. A number of approaches to prehabilitation in this population have therefore been investigated. Pre-operative education, physical therapy, and exercise have all received research attention, although the types and doses of these interventions have varied greatly. This has contributed to the somewhat contradictory evidence in the literature. To illustrate, one recent review of 11 studies (total 1,044 patients) found that pre-operative education reduced patient anxiety in three studies, but had no significant effect in two others (Johansson, Nuutila, Virtsnen, Katajisto, & Salantera, 2005). Similar discrepancies were reported for pain and length of hospital stay (Johansson et al., 2005). In a review of 5 studies (total 146 patients) investigating pre-operative physiotherapy, Ackerman and Bennell (2004) found that significant differences in outcomes between prehabilitation and control groups were consistently reported for THA patients, but not TKA patients. A third review of 3 studies (total 130 patients) stated that, due to methodological inconsistencies and underpowered studies, there was inconclusive evidence to support the use of pre-operative exercise

interventions in this population (Barbay, 2009). Because each of these reviews focused on only one intervention type, and studies that examined combined programs (ie: education and exercise) were not included, the overall effect of prehabilitation is unclear.

Furthermore, inconsistent selection of outcomes, measurement tools and follow-up periods in the reviewed articles make it difficult to directly compare results across studies. A meta-analytic approach is therefore warranted, as it would permit aggregate effect sizes to be calculated from a variety of measures, enabling more global conclusions about the effect of prehabilitation on outcomes that are evaluated in multiple ways. Moreover, in order to fully understand the effect of prehabilitation on post-operative recovery, it is necessary to examine how these effects change over time following surgery. Delineating effects early in the recovery phase from those occurring weeks or months later may provide additional insight into the efficacy of prehabilitation for THA and TKA patients.

The purpose of this meta-analysis was therefore twofold. The primary objective was to consolidate existing evidence regarding the efficacy of prehabilitation for those undergoing a lower limb arthroplasty to determine the overall effect on post-operative pain, function and clinical outcomes (ie: length of hospital stay). The secondary objective was to determine if this effect is consistent across intervention types and post-operative time points, or if one intervention in particular may provide greater benefit to the patient at specific times during recovery.

4.2 Methods

4.2.1 Study Selection

A computerized literature search was conducted in order to identify eligible studies for inclusion in the meta-analysis. Four electronic databases [MEDLINE (1966-April 1, 2011), PubMed (1966-current), PsycINFO (1887-current), and SPORTDiscus (1830-current)] were searched using the keywords *prehabilitation, rehabilitation, pre-surgical, pre-operative, intervention, therapy, treatment, exercise, arthroplasty, joint replacement, hip, knee,* and *osteoarthritis*. Studies were eligible if they (1) examined pre-surgical

interventions for total knee or hip arthroplasty (THA or TKA); (2) explicitly stated inclusion/exclusion criteria; (3) included data from at least one pre-operative and one post-operative measurement; (4) provided adequate information from which to calculate effect sizes; and (5) were reported in English.

The database searches yielded 519 studies, 12 of which were retained for analysis (see Figure 3). A subsequent manual search of the reference lists from retained articles was then performed to identify additional eligible studies. Six articles were obtained from this secondary search.

Potentially relevant studies identified in database search:

N = 519

Studies excluded:

Based on title / abstract screen – 505

Insufficient data to calculate effect sizes – 2

Unique and relevant studies retained:

N = 12

Additional studies identified from reference lists of retained studies:

N = 13

Studies excluded:

No preoperative data - 1

No postoperative data - 1

Insufficient data to calculate effect sizes - 4

Not in English – 1

Total number of studies contributing to analysis:

N = 18

Figure 3. Study selection process.

4.2.2 Data extraction

Data were extracted and coded independently by two investigators (the lead author and another graduate student) using a standardized form. Discrepancies were resolved through review of the original article and discussion until consensus was reached.

From each study, information was extracted regarding authorship, publication year, sample size, sample demographics [age, sex, body mass index (BMI), comorbidities], surgery type, intervention details (type, duration, frequency), nature of the control condition (if applicable), pre-surgical outcomes (pain, function, intervention adherence), post-surgical outcomes (pain, function, length of hospital stay, discharge location, health-related quality of life), measures used, and all corresponding estimates of effect (ex. means and standard deviations, correlations and p-values).

4.2.3 Analysis strategy

The methodological quality of the included studies was assessed using the PEDro scale, a commonly employed rubric for evaluating clinical research (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003). It is a 10-item scale based on the presence (1) or absence (0) of key methodological details (such as blinding and randomization), and a summated score out of 10 is obtained. The PEDro scale has been found valid and reliable for study quality assessment in systematic reviews and meta-analyses (de Morton, 2009; Maher, et al., 2003).

All data synthesis for the meta-analysis was performed with Comprehensive Meta-Analysis Version 2 software (Biostat, 2005). Effect sizes (ES) using Hedge's g and corresponding 95% confidence intervals (CI) were calculated from data presented in the included articles, using a random-effects model approach. A random effects model was deemed most appropriate for use in this analysis because it allows for the generalization of findings beyond the included sample studies in the event that all relevant studies were not located (Burke, Carron, Eys, Ntoumanis, & Estabrooks, 2006; Field, 2001; Hedges &

Vevea, 1998). Furthermore, a random effects model accounts for heterogeneity in ES variance in the sample. A formal test of homogeneity was conducted by calculating the Q statistic, which was significant ($Q = 145.37$, $p < 0.001$). This indicated a heterogeneous distribution of effect sizes, reinforcing the choice of a random effects model (Hedges & Olkin, 1985). Furthermore, before each ES calculation to examine the effect of prehabilitation on the outcome variables of interest, the Q statistic was again computed to determine if the effect size variance was zero. In every case, the Q value was statistically significant ($p < 0.01$).

Studies including multiple endpoints (ie: more than one measure of a single outcome) were deemed to violate the assumption of independent data points (Gleser & Olkin, 1994). For example, some studies assessed self-reported function using both the Western Ontario & McMaster Universities Osteoarthritis Index (WOMAC) and the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) (Beaupre, Lier, Davies, & Johnston, 2004; Mitchell, Walker, Walters, Morgan, Binns, & Mathers, 2005; Rooks, Huang, Bierbaum, Bolus, Rubano, Connolly et al., 2006; Walls, McHugh, O'Gorman, Moyna, & O'Byrne, 2010). In such cases, results from these various measures were pooled to compute an average effect size for that outcome category in order to prevent a single study from exerting inordinate influence on the results relative to studies with single endpoints (Burke et al., 2006).

Because of the wide variability in measurement time periods between studies (from three days to two years), data from the first post-operative assessment in each study were pooled to form a single time-point, as were data from subsequent assessments ("post-op time 1" and "post-op time 2," respectively). Post-op time 1 covered the period from immediately after surgery to 12 weeks post-operatively, while post-op time 2 encompassed all measurements past 12 weeks. This permitted a comparison between the immediate and delayed effects of prehabilitation.

Throughout the results, effect size values of .20, .50, and .80 are referred to as small, medium, and large, respectively, as per Cohen's (1969, 1992) recommendation.

4.3 Results

The characteristics of the 18 studies included in this meta-analysis are presented in Table 1. The sample covered a number of different study designs, including quasi-experimental interventions, case studies, and effectiveness trials; however, RCTs comprised the bulk of the studies (n = 11; 61.1%). In terms of the prehabilitation approaches used, nine of the interventions centred on strength training (50.0%), five focused on pre-operative education (27.8%), and four were based on traditional physiotherapy (22.2%). One of the physiotherapy studies included a cardiovascular exercise group as well. There were also a wide variety of intervention durations, ranging from one day to eight weeks. Only six studies (33.3%) reported participant adherence to the prehabilitation intervention, but in all cases it was stated to be greater than 85% of the prescribed sessions. Study quality, based on PEDro scores, ranged from two to eight, with 11 studies (61.1%) falling at or below the scale mid-point of five.

Demographic information about the study participants is summarized in Table 2. Altogether, there were 10 studies that included TKA patients only (55.6%), five included THA patients only (27.8%), and three included both (16.6%). Participants across studies were of similar age and BMI, but only eight articles reported the number of patients with comorbidities. The number of participants in each study ranged from one to 247, yielding a total sample size of 1,529 for this meta-analysis.

4.3.1 Overall effect of prehabilitation

When examining the general effect of prehabilitation, independent of the nature of the intervention, there were no significant effects compared to baseline for all outcome variables combined in the first follow-up time period (ES = -0.016; 95% CI: -0.489 - 0.457), or second time period (ES = -0.106; 95% CI: -0.541 – 0.330). Compared to post-intervention (pre-operative) values, there was no significant effect of prehabilitation during the first follow-up period (ES = -0.062; 95% CI: -0.523 – 0.399), but there was a small effect during the second follow-up period (ES = 0.209; 95% CI: 0.001 – 0.419).

There was no significant effect of study quality on ES estimates, so further analyses were not stratified by PEDro score.

When separately examining exercise interventions (including strength training, physiotherapy, and cardiovascular activity) there was no significant effect on all outcomes combined at any time point except when comparing post-intervention (pre-operative) values to outcomes in the second follow-up time period (Table 3). Education-based interventions only collected follow-up data in the first follow-up period, and there was no significant overall effect of the intervention on the combined outcomes.

Table 1. Characterisitics of included studies (NS = no significant differences between groups, + favours prehabilitation group, - favours control group) (ROM = range of motion; LOS = length of stay; STAI = State-Trait Anxiety Inventory; HSSKR = Hospital for Special Surgery Knee Ratings Score; AIMS = Arthritis Impact Measurement Scale).

Authors and publication year	Study design	Intervention type	Intervention dose & duration	Control condition	Outcomes	Follow-up time points	PEDro score
Beaupre, et al. (2004)	RCT	Resistance training and education	Length ? 3 times/wk 4 weeks	Standard care	WOMAC (NS) SF-36 (NS) Quadriceps/hamstring strength (NS) ROM (NS) LOS (NS)	12 weeks 24 weeks 1 year	8
Brown, et al. (2010)	Case study	Resistance / step training and flexibility	45 min 3 times/wk 4 weeks	Standard care	WOMAC (pain) (+) Isokinetic knee flexion/extension (+) 30 sec sit-to-stand (+) 6 minute walk (NS) Stair ascent/descent (NS)	4 weeks 12 weeks	2
Butler, et al. (1996)	RCT	Education	1 mail out 4-6 weeks	Standard care	STAI (State) (+) # in-hospital physiotherapy sessions (+) LOS (NS)	Hospital discharge	8

Crowe & Henderson (2003)	RCT	Multimodal (tailored to needs)	Various dose / duration	Standard care	Day to reach discharge criteria (+) Location of discharge (NS) LOS (+)	Hospital discharge	6
D'Lima, et al. (1996)	RCT	Physical therapy OR cardiovascular exercise	45 min 3 times/wk 6 weeks	Standard care	HSSKR (NS) AIMS (NS) Quality of Well Being (NS)	1 week 3 weeks 12 weeks 24 weeks 48 weeks	4
Daltroy, et al. (1998)	RCT	Education	Length ? 1 session 1 day	Standard care	STAI (State) (+) Mini-Mental State Exam (+) Pain medication (+) LOS (+)	4 days	5
Gammon & Mulholland (1996)	Quasi-experimental	Education	45 min 2 sessions 1 day	Standard care	Linear Analogue Coping Scale (+) Intramuscular analgesia (+) Day of mobilization (+) Postoperative complications (NS) LOS (+)	Hospital discharge	3
Gocen, et al. (2004)	RCT	Physiotherapy and education	Length ? 3 times/day Daily 8 weeks	Education	Harris Hip Score (NS) Pain VAS (NS) Day started transfer activities, climbing stairs (+)	Hospital discharge 12 weeks 2 years	6

Jaggers, et al. (2007)	Case-control	Resistance / step training and flexibility	45 min 3 times/wk 4 weeks	Standard care	WOM5AC (+) 30sec sit-to-stand (+) 6 minute walk (+) Movement detection threshold (+) Angle reproduction (+)	12 weeks	3
Larsen, et al. (2008)	Effectiveness trial	Multimodal (exercise, nutrition, education)	? dose Various duration	Standard care	Readmission (NS) Mortality (NS) LOS (+)	Hospital discharge	5
Lin, et al. (1997)	Quasi-experimental	Education	Length ? 2 sessions 3 – 28 days	Standard care	STAI (State) (NS) TKA knowledge questionnaire (+) Postoperative exercise frequency (+) Knee flexion ROM (+) LOS (-)	6 days	4
Mitchell, et al. (2004)	RCT	Home-based physiotherapy	Various dose Up to 8 weeks	Standard care	WOMAC (NS) SF-36 (NS) Resource cost (-)	12 weeks	7
Rodgers, et al. (1998)	Quasi-experimental	Physical therapy	Length ? 3 times/wk 6 weeks	Standard care	HSSKR (NS) Isokinetic knee flexion/extension (NS) 10m walk (NS) Thigh circumference (+)	6 weeks 12 weeks	3

Rooks, et al. (2006)	RCT	Water and land-based strengthening exercise	30-60min 3 times/wk 6 weeks	Education	WOMAC (+) SF-36 (+) 1RM leg press (+) Functional reach test (NS) Timed up and go (NS) Distance walked on postoperative day 3 (NS)	3 days 8 weeks 26 weeks	6
Topp, et al. (2009)	RCT	Resistance / step training and flexibility	3 times/wk	Standard care	30 sec sit-to-stand (+) Stair ascent/descent (NS) Isokinetic knee extension (NS) 6 minute walk (NS)	4 weeks 12 weeks	5
Walls, et al. (2010)	Randomized Pilot study	Neuromuscular electrical stimulation	20 min 5 days/wk	Standard care	WOMAC (NS) SF-36 (NS) Quadriceps MVIC (+) Quadriceps area (NS) Chair-rise test (+) 25m walk (+) Stair ascent (+)	6 weeks 12 weeks	6
Wang, et al. (2002)	RCT	Resistance training	60 min 4 times/wk	Standard care	Walk cadence (+) Stride length (+) Gait velocity (+) 6 minute walk (+)	3 weeks 12 weeks 24 weeks	5
Wong & Wong (1985)	RCT	Education	1 session 1 day	Standard care	Patient satisfaction (+) Exercise performance (+) Postoperative complications (NS)	4 days	5

Table 2. Study participant demographics.

Authors and publication year	Sample type	N	Gender	Age [Mean (SD) or n (range)]	BMI [Mean (SD)]	Comorbidities [Proportion with or median # (range)]
Beaupre, et al. (2004)	Knee arthroplasty	131	Both	Control: 67 (6) Experimental: 67 (7)	Control: 31 (5) Experimental: 32 (6)	Control: 45% Experimental: 30%
Brown, et al. (2010)	Knee arthroplasty	1	Female	69	34.0	0
Butler, et al. (1996)	Hip arthroplasty	80	Both	Control: 61.83 (12.86) Experimental: 63.86 (13.08)	-	-
Crowe & Henderson (2003)	Hip or knee arthroplasty	133	Both	Control: 70.7 (10.7) Experimental: 66.9 (11.9)	Control: 29.6 (5.9) Experimental: 29.3 (5.9)	Control: 81.8% Experimental: 87.7%
D'Lima, et al. (1996)	Knee arthroplasty	30	Both	Control: 69.5 (6.5) Experimental 1: 68.5 (4.6) Experimental 2: 71.6 (6.6)	-	-
Daltroy, et al. (1998)	Hip or knee arthroplasty	222	Both	64 (12)	-	-

Gammon & Mulholland (1996)	Hip arthroplasty	82	Both	Control: n=5 (<55) n = 30 (56-75) n = 6 (>76) Experimental: n=5 (<55) n = 29 (56-75) n = 5 (>76)	-	Control: 37% Experimental: 40%
Gocen, et al. (2004)	Hip arthroplasty	59	Both	Control: 55.50 (14.44) Experimental: 46.93 (11.48)	Control: 27.69 (3.70) Experimental: 24.94 (3.70)	0
Jaggers, et al. (2007)	Knee arthroplasty	2	Female	Control: 62 Experimental: 57	Control: 23 Experimental: 33	-
Larsen, et al. (2008)	Hip or knee arthroplasty	247	Both	Control: 65(11.0) Experimental: 65 (11.0)	-	-
Lin, et al. (1997)	Knee arthroplasty	60	Both	Control: n = 11 (45-64) n = 18 (65-84) n = 1 (>85) Experimental: n = 4 (45-64) n = 26 (65-84)	-	-
Mitchell, et al. (2004)	Knee arthroplasty	160	Both	Control: 70.6 (8.2) Experimental: 70.0 (7.2)	-	-

Study	Procedure	N	Sex	Age	BMI	Comorbidities
Rodgers, et al. (1998)	Knee arthroplasty	20	Both	Control: 65 (50-83) Experimental: 70 (63-78)	-	-
Rooks, et al. (2006)	Knee arthroplasty	45	Both	Control: 69 (8) Experimental: 65 (8)	Control: 33.9 (6.5) Experimental: 35.7 (9.2)	Control: 1 (range 0-6) Experimental: 2 (range 0-8)
Rooks, et al. (2006)	Hip arthroplasty	63	Both	Control: 59 (7) Experimental: 65 (11)	Control: 30.3 (9.1) Experimental: 28.4 (5.3)	Control: 1 (range 0-6) Experimental: 1 (range 0-7)
Topp, et al. (2009)	Knee arthroplasty	54	Both	Control: 63.5 (6.68) Experimental: 64.1 (7.05)	Control: 32.00 (6.09) Experimental: 32.16 (5.87)	-
Walls, et al. (2010)	Knee arthroplasty	14	Both	Control: 63.2 (11.4) Experimental: 64.4 (8.0)	Control: 32.8 (6.3) Experimental: 30.7 (3.0)	-
Wang, et al. (2002)	Hip arthroplasty	28	Both	Control: 65.7 (8.4) Experimental: 68.3 (8.2)	-	-
Wong & Wong (1985)	Hip arthroplasty	98	Both	Control: 67.6 (50-89) Experimental: 65.7 (50-89)	-	-

Follow-up period	N effect sizes	Exercise ES (g)	Exercise 95% CI	N effect sizes	Education ES (g)	Education 95% CI
All outcomes combined						
Baseline to post-op 1	11	-0.050	-0.719 – 0.620	5	0.066	-0.270 – 0.343
Baseline to post-op 2	9	-0.106	-0.541 – 0.330	-	N/A	N/A
Pre-op to post-op 1	11	-0.034	-0.099 – 0.583	5	-0.096	-0.345 – 0.152
Pre-op to post-op 2	9	0.209	0.001 – 0.419*	-	N/A	N/A

Table 3. Effect sizes and 95% confidence intervals (95% CI) by intervention type.
* denotes statistical significance based on 95% CI

4.3.2 First post-operative assessment

The timing of the first measurement after surgery occurred anywhere from three days to twelve weeks (see Table 1). A total of 13 different outcome categories were identified in the included studies during this time frame, but only six were assessed in multiple studies and were therefore included in this analysis. Also, due to the heterogeneity of outcomes assessed during this follow-up period, comparisons could not be made between intervention types.

ES estimates are presented in Table 4. No significant effects were found for pain, self-reported function, or objective measures of mobility and strength when compared to baseline or pre-operative values. Prehabilitation patients did, however, have significantly shorter hospital stays than those patients receiving standard care (ES = -0.819; 95% CI: -0.985 - -0.653). There also appeared to be a small effect on post-operative strength, and although this was not statistically significant (ES = 0.256; 95% CI: -0.004 – 0.516) it may be clinically meaningful.

4.3.3 Additional follow-up assessments

Follow-up periods between studies were greatly variable, with assessments occurring only at hospital discharge in some cases, and up to one or two years post-operatively in

others (see Table 1). During this time period, there were again no significant effects of prehabilitation on pain, self-reported function, or objective measures of mobility (Table 4). There was a small, significant effect on quadriceps strength compared to baseline for those receiving prehabilitation (ES = 0.279; 95% CI: 0.018 - 0.540), but there was no strength benefit relative to post-intervention values.

Four additional outcome categories were assessed only in single studies during this second follow-up period and were therefore not included in the analysis. Again, due to the heterogeneity of outcomes assessed during this period, comparisons could not be made between intervention types.

Follow-up period	N effect sizes	Mean effect size (g)	Standard error (SE)	95% CI
Pain				
Baseline to post-op 1	6	0.140	0.128	-0.111 – 0.391
Baseline to post-op 2	6	0.035	0.105	-0.172 – 0.241
Pre-op to post-op 1	6	0.173	0.129	-0.080 – 0.426
Pre-op to post-op 2	6	0.131	0.130	-0.124 – 0.385
Self-reported function				
Baseline to post-op 1	4	0.069	0.140	-0.205 – 0.342
Baseline to post-op 2	5	0.078	0.112	-0.141 – 0.297
Pre-op to post-op 1	5	0.044	0.534	-0.198 – 0.286
Pre-op to post-op 2	5	0.082	0.125	-0.162 – 0.327
Objective measures of mobility				
Baseline to post-op 1	4	0.262	0.145	-0.023 – 0.546
Baseline to post-op 2	3	0.332	0.174	-0.018 – 0.662
Pre-op to post-op 1	3	0.279	0.191	-0.095 – 0.652
Pre-op to post-op 2	3	0.348	0.057	-0.122 – 0.817
Quadriceps strength				
Baseline to post-op 1	4	0.256	0.133	-0.004 – 0.516
Baseline to post-op 2	4	0.279	0.133	0.018 – 0.540*
Pre-op to post-op 1	4	0.221	0.133	-0.040 – 0.482
Pre-op to post-op 2	4	0.103	0.133	-0.157 – 0.362
Length of hospital stay				
Post-op	5	-0.819	0.085	-0.985 - -0.653*
Days to reach functional milestones in hospital				
Post-op	2	-0.253	0.149	-0.544 - 0.039

Table 4. Effect sizes and 95% CI for specific outcomes.
* denotes statistical significance based on 95%

4.4 Discussion

The primary objective of this meta-analysis was to determine the overall effect of prehabilitation on post-operative pain, function, and clinical outcomes. While most individual studies indicate that prehabilitation is beneficial, the present analysis suggests that it has no broad impact across these outcomes when all available data are taken into consideration. It should be noted, however, that prehabilitation may have positive effects on outcomes that were not included in this analysis (such as post-operative complication rate, or psychological well-being). Additionally, due to the wide variety of measurement tools used in the included studies, and their inconsistent selection of dependent variables,

the overall impact of prehabilitation may have been somewhat diluted. Considering the somewhat poor methodological quality (or perhaps simply inadequate reporting) of the studies included, it is also likely that research design issues have prevented more accurate ES estimates.

It must also be considered that a number of the interventions examined in the literature are multimodal. They typically have a main focus (such as exercise), but also include additional treatment modalities. By incorporating more than one type of prehabilitation (ie: strengthening exercise and dietary counseling), it is difficult to determine whether one component of the intervention might have an effect on its own, but is being masked by other, ineffective components. Moreover, in cases where there is a significant effect, it cannot be stated with certainty what part of the intervention is causing it. A general inability to tease apart effects attributable to various intervention components is a limitation of the present research literature, and may be contributing to the results of this meta-analysis.

Regardless, the non-significant effect of prehabilitation on pain and self-reported function is somewhat consistent with the literature. Several review articles examining the effects of various types of prehabilitation have reported equivocal findings, largely because the majority of published studies have been inconclusive (et al.,Ackerman & Bennell, 2004; Barbay, 2009; Johansson et al., 2005). This contradictory evidence base has been attributed to inconsistent measurement and reporting, but the present meta-analysis has shown that, accounting for these differences, there still appears to be little evidence to support or contraindicate the use of prehabilitation for THA and TKA patients. Yet, as there are some significant effects attributable to prehabilitation (ie: quadriceps strength, length of hospital stay), it cannot be said that the theory behind prehabilitation is refuted. It is more likely that the interventions under investigation have simply been insufficient to elicit additional post-operative benefits.

In terms of those ES that were significant, prehabilitation patients appear to have an increase in quadriceps strength relative to baseline during the second follow-up period. Quadriceps strength is one of the greatest predictors of function in this population (Fortin,

Clarke, Joseph, Liang, Tanzer, Ferland et al., 1999), but the corresponding relationship between prehabilitation and increased post-operative mobility at follow-up time two is not statistically significant. The confidence interval narrowly contains the null value, however, and the ES for mobility (0.332; 95% CI: -0.018 – 0.662) represents a net gain of approximately 12% over the control condition and may therefore be clinically meaningful (McNamara, 1994). Despite these similar increases in post-operative strength and mobility during the second follow-up period, prehabilitation curiously does not have an effect on self-reported function. This incongruence may point to a disconnect between the objective evaluation of function and the patient's perception of his or her own abilities. This relationship may ultimately influence long-term recovery after arthroplasty and should therefore be considered in future research.

Prehabilitation patients also appear to have a significantly shorter hospital stay after surgery than do their standard care counterparts, independent of the number of days it takes to achieve functional milestones. This may be important from an administrative standpoint. Reducing the cost of in-patient care is key to offsetting the rising burden of OA in our aging population, and it may be economically feasible to implement a minimal-cost pre-surgical intervention as a means of accomplishing this. The minimum intervention dose necessary to achieve this reduction remains to be determined, however, as does the cost-benefit ratio of such an intervention.

One of the secondary objectives of this meta-analysis was to examine the effect of prehabilitation across intervention types. Because of the wide disparity in outcome categories between studies, however, only overall estimates of intervention effect were possible. Although neither exercise nor education had any significant effect on post-operative outcomes during the first follow-up, exercise did have a small effect during the second follow-up (ES = 0.209; 95% CI: 0.001-0.419), which is equivalent to a net gain of about 8% over patients receiving standard care. This effect appears to be derived completely from the influence of prehabilitation on quadriceps strength at this time point.

As none of the education interventions assessed patients beyond 12 weeks post-operatively, no comparison with exercise can be made in this regard. Yet, it may be

worthwhile to consider that, while exercise interventions are designed to protect against the physical stressors of the surgery, perhaps education-based interventions are protective against psychological stress. This could account for the lack of evidence to support education prehabilitation, as psychological variables were not accounted for in the studies included in this meta-analysis. This may therefore be a promising avenue for future investigation.

The other secondary objective was to determine whether the effect of prehabilitation changed as patients progressed through the post-operative recovery phase. The significant impact of exercise later in rehabilitation when compared to pre-operative measures provides some insight into the potential mechanism of action of this type of intervention. According to the theory of prehabilitation, preparation for an anticipated stressor should dampen the effect of that stressor on function. For THA and TKA patients, the physiological stress of arthroplasty reduces quadriceps strength initially, with a recovery occurring gradually in the following months (Arden, Arden, & Hunter, 2008; Ditmeyer, Topp, & Pifer, 2002). Considering the small effect of prehabilitation on strength recovery, it appears as though prehabilitation acts by speeding strength recovery after that initial reduction caused by the surgery. Additional focus on intervention types that promote this strength benefit is recommended, as it is likely to contribute to increased mobility and health-related quality of life in the long-term for these patients.

4.4.1 Limitations

This meta-analysis was subject to the classic limitations associated with data aggregation. Firstly, it is possible that not all relevant studies were identified in the literature search. Moreover, studies in this area continue to be published, and as this analysis captured only those that were available as of April 1, 2011, it is necessarily out of date. A random effects model was specifically selected to help offset this limitation, but generalizing the findings should be approached with caution.

A second limitation is one that afflicts all meta-analyses: the accusation of comparing "apples to oranges" (Thomas & French, 1986). The heterogeneity of the studies included

in terms of intervention type and dose, the outcome variables assessed, and so on, represents a fundamental challenge inherent to this type of analysis.

Another limitation specific to this particular meta-analysis is that few of the included studies provided demographic information about the participants, preventing adjustment for potential moderators such as age, gender, BMI, or various comorbidities. The total number of included participants was also relatively small, resulting in a great deal of variability in the data and, consequently, large confidence intervals. Both of these issues may contribute to the lack of significant evidence for or against prehabilitation in this analysis.

Statistical power was also a concern. ES were calculated using data from very few contributing studies in most cases, reflecting the heterogeneity of outcomes in the literature. This affected the precision of the ES estimates, and led to broad confidence intervals that likely underestimated the number of statistically significant results.

Finally, because the focus of this investigation was to determine the effect of prehabilitation on post-operative outcomes for lower limb arthroplasty patients only, the findings cannot generalize to other surgical populations. The broader influence of pre-operative intervention is therefore still unknown.

4.4.2 Future Directions

There is a need to systematically investigate the component parts of previously developed multimodal interventions to determine which of these parts is responsible for post-operative benefits, and what the minimum necessary dose is. It is also crucial for future research to standardize follow-up time points to enable comparisons between studies. Furthermore, the consistent use of outcome measures would not only allow for the pooling of data for broader analysis, but would provide clinicians who are using the same measures with a rubric by which to evaluate their own patients' progress.

It is also recommended that future studies include psychological outcomes to determine whether prehabilitation might act on them directly, or if they might moderate the effect of prehabilitation on various physiological measures.

4.4.3 Conclusions

This meta-analysis suggests that there is limited evidence for the efficacy of prehabilitation for improving post-operative pain and functional outcomes for THA and TKA patients. Yet, prehabilitation patients do have significantly shorter hospital stays after surgery, which may be promising for reducing related health care costs. Additional research is required to determine the optimum type and dose of prehabilitation for achieving this benefit.

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Chapter 5

5 A comparison of the Lower-Limb Tasks Questionnaire (LLTQ) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for the functional assessment of those with symptomatic knee osteoarthritis

5.1 Background

Osteoarthritis (OA) is one of the most prevalent musculoskeletal conditions amongst those aged 65 and older, and is one of the leading causes of disability in this demographic worldwide (Garstang & Stitik, 2006). It is a degenerative condition characterized by pain, stiffness, and progressive loss of function associated with hyaline cartilage loss and abnormal bone growth (Berger & Doherty, 2007; Felson, 2006; Hunter & Felson, 2006; Punzi, Oliviero, & Ramonda, 2010). As there is no method of reversing these structural changes in the joint, treatment is primarily targeted at alleviating symptoms and preserving the patient's quality of life. There is, however, an inconsistent relationship between clinical symptoms and radiographic evidence of joint degradation (Lachance, Sowers, Jamadar, Jannausch, Hochberg, & Crutchfield, 2001). Patients who report pain or loss of function severe enough to inhibit daily living activities may have minimal or no associated radiographic findings (Lachance et al., 2000; Mandl, 2007). In such cases, clinicians must rely heavily on self-report measures of symptom severity when determining the appropriate treatment course.

A wide variety of outcome measures is available for the assessment of pain and function in this population (Riddle, Stratford, & Bowman, 2008; Sun, Sturmer, Gunther, & Brenner, 1997). In an effort to determine how many of these measures are used in practice, Haigh and colleagues conducted a survey of 418 European rehabilitation facilities (Haigh, Tennant, Biering-Sorensen, Grimby, Marincek, Phillips et al., 2001). They found that over 60 different outcome measures were being used to assess patients with hip and knee OA, with no more than five centres using any one instrument. This echoes the findings of similar studies in Canada, Australia, and the UK, indicating that

the use of standard, validated measures for OA assessment is not widespread (Bellamy, Kaloni, Pope, Coulter, & Campbell, 1998; Bellamy, Wilson, & Bellamy, 2009; May, 2003).

Additionally, these authors found that common outcomes from the research literature were not among those routinely employed in clinical settings. For example, one of the most ubiquitous self-report instruments for assessing OA symptom severity in the research literature is the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988a,b). It is the most commonly endorsed questionnaire for use with OA patients, and has been found to be valid and reliable for clinical use (Beaton & Schemitsch, 2003; Brazier, Harper, Munro, Walters, & Snaith, 1999; Riddle et al., 2008). Yet, the WOMAC was only used to assess 675 of more than 23,000 hip replacement patients during the survey period (Haigh et al., 2001).

Consequently, there has been a call for the implementation of standardized measures for assessing OA symptoms (Riddle et al., 2008). Yet, many practitioners are not specialists, and maintaining an inventory of questionnaires to assess a variety of conditions is cumbersome. Not only does it require storage space, clinicians must also be familiar with the administration of each measure and be trained to interpret the scores (Greenhalgh, Long, & Flynn, 2005). Furthermore, the use of multiple instruments does not allow the pooling of data, preventing broader analyses of outcomes across clinical populations (Deyo, 1988; McNair, Prapavessis, Collier, Bassett, Bryant, & Larmer, 2007). Considering these hurdles to clinician uptake, it has been suggested that the development of a single instrument to assess outcomes for a number of clinical populations would encourage routine instrument use in everyday practice (McNair et al., 2007; Forbes, 2010).

The World Health Organization (WHO) has promoted the use of function as a primary outcome measure in clinical settings (WHO, 2001). It has therefore been suggested that the development of a universal instrument should primarily focus on patients' abilities to carry out everyday tasks (McNair et al., 2007). It is important to recognize, however, that

functional assessments should differentiate between activities of daily living (ADLs) and sport or recreation activities in order to reflect the population under study. For example, questions regarding sport activities are not likely appropriate for an older group with OA, and including them in an overall function measure would only confound the results. Thus, when evaluating a new measure for use in a given population, it is essential to compare it to currently endorsed instruments to ensure that it is valid for that patient group.

The Lower-Limb Tasks Questionnaire (LLTQ) is a relatively new, function-based, self-report questionnaire that was specifically developed to address issues of clinician uptake. It was formulated based on the recommendations of the WHO, with emphasis on the delineation between ADLs and sport or recreation activities (McNair et al., 2007). Furthermore, it was specifically created to be easy to administer and score, and takes participants under 10 minutes to complete. The LLTQ has been shown to be appropriate for use with several patient groups, including those with sprains, strains, overuse injuries, and low back pain (Forbes, 2010; McNair et al., 2007). While the original validation study did include OA patients, a direct comparison of the LLTQ's performance to a standard OA evaluation tool has not yet been undertaken.

The purpose of this study was therefore to examine the LLTQ in terms of its convergent validity with the WOMAC function subscale (WOMAC-PF) and the WOMAC total score. Additionally, the LLTQ's responsiveness compared to that of the WOMAC was assessed over a six-week period for OA patients undergoing a total knee arthroplasty (TKA).

It was hypothesized that the LLTQ ADL subscale would demonstrate strong convergence with the WOMAC-PF, but the LLTQ sport/recreation subscale would not. It was also anticipated that the LLTQ ADL subscale would agree with the WOMAC total score to a greater extent than the sport/recreation subscale. Furthermore, the LLTQ was expected to be equally responsive to changes in functional status as the WOMAC.

5.2 Methods

5.2.1 Participants

Participants were recruited through community-based seniors' centres and arthritis clinics in London, Ontario, Canada. To be eligible, volunteers had to be 18 years or older, able to read and write in English, and have been experiencing symptomatic knee OA for a minimum of six weeks at the time of questionnaire completion. Participants were also required to provide informed consent, as per the Office of Research Ethics at the University of Western Ontario.

5.2.2 Measures

The WOMAC is a 24-item self-administered questionnaire, divided into subscales for pain (5 items), joint stiffness (2 items), and physical function (17 items) (Bellamy et al., 1988a,b). It is rated on a 5-point Likert scale (0-4), with lower scores indicating lower symptom or disability levels. The instrument is scored by summating each subscale to a maximum score of 20, 8, or 68, respectively, or by computing a global score (the sum of all three subscale scores). Cronbach's alphas for the subscales have reportedly ranged from 0.86-0.97, and test-retest reliability of the global score ranges from 0.77-0.83 (McConnell, Kolopack, & Davis, 2001; Soderman & Malchau, 2000).

The LLTQ is a 20-item self-administered questionnaire, with 10 items forming the ADL subscale, and 10 forming the sport/recreation subscale. It is scored on a 5-point Likert scale, with lower scores indicating that the respondent has more difficulty performing the given task. The subscales are summated separately, each to a maximum score of 40, to indicate overall impairment in the two functional domains. The LLTQ also has an importance scale, allowing patients to indicate the relative importance of each of the tasks in their daily lives. It is also understood that, for some populations, completing the sport/recreation subscale may not be appropriate, and the ADL subscale is sufficient for determining functional disability on its own for these groups. The LLTQ has demonstrated strong internal consistency and concurrent validity, and is highly reliable [intraclass correlation coefficients (ICCs) of 0.96 and 0.98 for the ADL and sport/recreation subscales respectively]. Cronbach's alpha values have been reported to

be 0.91 for the ADL subscale and 0.95 for the sport/recreation subscale, and both domains demonstrate moderate correlations to actual task performance (r = 0.62, r = 0.72) (McNair et al., 2007).

5.2.3 Procedure

Participation in the study entailed a one-time completion of the WOMAC and LLTQ, which took approximately 20 minutes. Following this initial questionnaire administration, a sub-sample of participants underwent a total knee arthroplasty then completed both questionnaires again to allow for an assessment of the LLTQ's responsiveness to surgical treatment.

5.2.4 Analysis

Convergence of both LLTQ domains with both the WOMAC-PF subscale and total score was assessed using a Bland and Altman plot of agreement, with associated 95% confidence limits (Bland & Altman, 1999). This approach uses the variability in individual participant scores, plotting the difference between measurements by the two methods against their mean, to show bias between the two instruments. Confidence limits are then calculated based on the standard deviation of the mean difference. In the present study, scores on both instruments were standardized to a percentage of the possible total score, and then the LLTQ values were transformed (100 minus percentage score) so that high scores on both instruments indicated greater impairment.

Statistical responsiveness was calculated as the mean change between initial and six-week questionnaire scores, divided by the standard deviation of the initial scores (Hevey & McGee, 1998; Kazis, Anderson, & Meenan, 1989). Standardized response mean (SRM) was calculated as the mean score change between the initial and six-week testing, divided by the standard deviation of the change score (Forbes, 2010; Liang, Fossel, & Larson, 1990). The statistical responsiveness and SRM analyses yielded effect sizes that were interpreted using Cohen's classifications of small (0.2), medium (0.5), and large (> 0.8) (Cohen, 1969).

5.3   Results

A total of 78 participants were recruited for this study. The overall sample was 56.4% female, and had a mean age of 64.5 (SD = 16.5). From this sample, 20 individuals underwent total knee arthroplasty, and were therefore included in the responsiveness analysis. This sub-sample was comprised of 65.0% women, and had a mean age of 62.4 (SD = 6.9). Unadjusted mean scores on the WOMAC and LLTQ for the overall sample, as well as the sub-sample, are presented in Table 5.

	Overall sample (n=78) Mean (SD)	Sub-sample (n=20) Mean (SD)
Baseline WOMAC-PF	25.2 (13.4)	31.1 (11.0)
Baseline WOMAC total	35.9 (18.8)	44.9 (14.7)
Baseline LLTQ-A	25.4 (7.9)	21.7 (5.6)
Baseline LLTQ-B	13.9 (9.0)	7.6 (4.7)
6 week WOMAC-PF	-	31.1 (11.0)
6 week WOMAC total	-	44.9 (14.7)
6 week LLTQ-A	-	21.8 (6.9)
6 week LLTQ-B	-	6.4 (5.3)

Table 5. Unadjusted WOMAC and LLTQ mean scores.

The agreement between the WOMAC-PF and the subscales of the LLTQ are presented in Figure 4. The bias associated with the LLTQ ADL scale was 1.00% (SD = 10.00%), and the 95% limits of agreement were -19.00% to +22.00%. For the LLTQ sport/recreation subscale, the bias was -32.00% (SD = 17.00%) and the 95% limits of agreement were -65.00% to +1.30%.

a)

b)

Figure 4. Bland and Altman plots of (a) WOMAC function vs. LLTQ ADL scores; and (b) WOMAC function vs. LLTQ sport/recreation scores.

The agreement between the WOMAC total score and the subscales of the LLTQ are presented in Figure 5. The bias associated with the LLTQ ADL scale was -1.40 (SD = 10.00), and the 95% limits of agreement were -22.00% to +19.00%. For the LLTQ sport/recreation subscale, the bias was -31.00 (SD = 17.00) and the 95% limits of agreement were -65.00% to +2.40%.
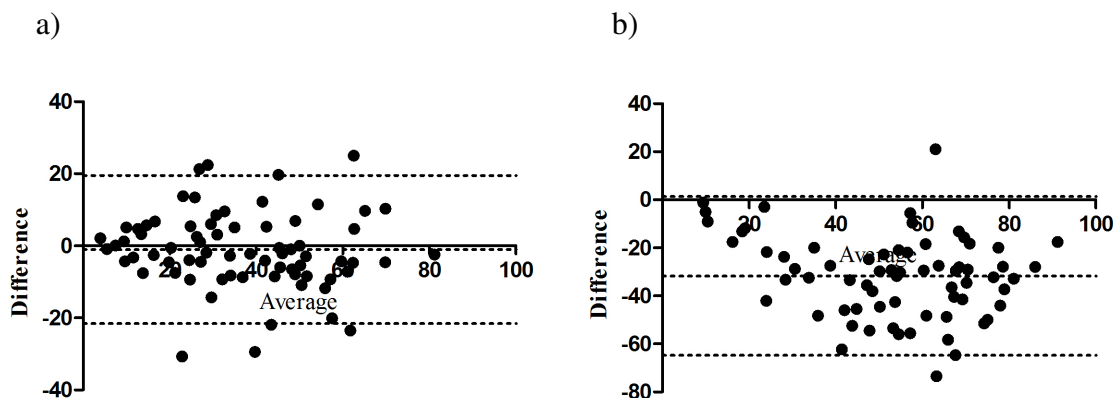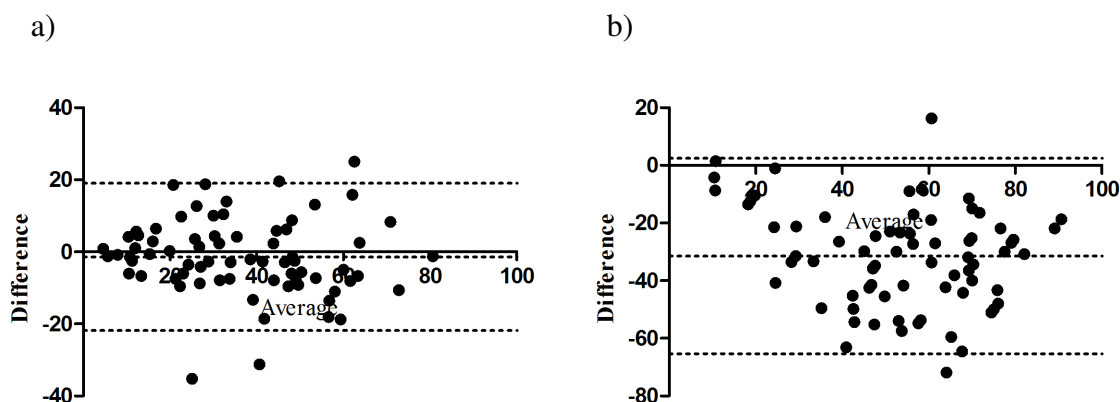
a)

b)

Figure 5. Bland and Altman plots of (a) WOMAC total vs. LLTQ ADL scores; and (b) WOMAC total vs. LLTQ sport/recreation scores.

The statistical responsiveness of the WOMAC-PF, LLTQ ADL subscale, and LLTQ sport/recreation subscale were 1.17, -0.63, and -0.01, respectively. The SRM for these scales were 0.90, -0.61, and -0.02.

5.3.1 Discussion

The ADL subscale of the LLTQ demonstrated good agreement with the WOMAC-PF, supporting the hypothesis that the two scales would exhibit convergent validity. The small amount of bias indicates that scores on the LLTQ tend to be marginally lower than scores on the WOMAC, but this difference is negligible. The 95% limits of agreement, however, suggest that there is still quite a bit of variability in the differences between the two measures. The limits of agreement translate to a raw score difference of -12.92 to +14.96 on the WOMAC-PF. Considering that the minimal clinically important difference (MCID) for this subscale has been reported to be ± 10.00 (Escobar, Quintana, Bilbao, Arostequi, Lafuente, &Vidaurreta, 2007), this range of score differences is large enough to potentially affect treatment decisions. It must be acknowledged, though, that MCID is highly context-dependent and some clinicians may find the LLTQ ADL scale adequate for use in their practice (de Vet, Terwee, Ostelo, Beckerman, Knol, & Bouter, 2006; Revicki, Cella, Hays, Sloan, Lenderking, & Aaronson, 2006).

The sport/recreation subscale of the LLTQ has very poor agreement with the WOMAC-PF. The large bias and wide 95% limits of agreement suggest that this domain of the LLTQ is not valid for assessing function in a knee OA population, as compared to the WOMAC. Because the WOMAC-PF measures ADLs, not sport or recreation behaviours, this incongruence was anticipated. Most individuals seeking treatment for OA are older, and do not typically engage in sport activities due to the severity of their symptoms. As such, the LLTQ sport/recreation subscale is not particularly useful in this population. It is therefore recommended that, should the LLTQ be administered for OA assessment, it needs to be restricted to the ADL subscale only.

The associations found between the LLTQ domains and the WOMAC total score were nearly identical to those between the LLTQ and WOMAC-PF. This result is not surprising, as 17 of the WOMAC's 24 items are intended to measure function. Because the subscales are not weighted, the total score is thus heavily influenced by the WOMAC-PF. The 95% limits of agreement associated with this comparison again favour the WOMAC, which provides further evidence against the utility of the LLTQ for the clinical management of knee OA.

The similarity between the WOMAC-PF and WOMAC total also illustrates the difficulty in differentiating between pain and function in this population. There are emerging concerns regarding the structure of the WOMAC subscales, as high correlations between function and pain scores suggest that they are not measuring distinct constructs as intended (Gandhi, Tsvetkov, Davey, Syed, & Mahomed, 2009; Maly, Costigan, & Olney, 2006; McConnell et al., 2001; Terwee, van der Slikke, van Lummel, Benink, Meijers, & de Vet, 2006; Wright, Hegedus, Baxter, & Abbott, 2011 et al.,). Although this has prompted discussion about discarding the WOMAC in favour of an instrument that does not suffer from the same problem, this convergence may reflect the nature of OA itself. Pain is one of the largest sources of disability for those with OA (Berger & Doherty, 2007; Creamer, Lethbridge-Cejku, & Hochberg, 2000; McAlindon, Cooper, Kirwan, & Dieppe, 1993), and patients likely evaluate their functional abilities based on how limited they are by pain. From this perspective, any self-report instrument used in this population will be unable to tease apart pain and function, and based upon the agreement between the WOMAC total and LLTQ ADL scale, neither instrument is superior in this regard.

The LLTQ was expected to be equally responsive to changes in functional status as the WOMAC. Based on the very large effect size associated with the statistical responsiveness of the WOMAC-PF (1.17) and the substantially smaller values corresponding to the LLTQ ADL and sport/recreation subscales (-0.63, and 0.01 respectively), this hypothesis was not supported. This is reinforced by the SRM values, which indicate that the WOMAC is far superior to the LLTQ. It must be considered that, because responsiveness and SRM are calculated using the standard deviation of participant scores, the amount of variability in the responses will impact these values. To illustrate, as the LLTQ ADL has only 10 items to the WOMAC's 24 items, the LLTQ is likely subject to greater variability in the responses, and therefore lower responsiveness, despite strong agreement between the two measures.

Also of note is that the effect sizes attributed to the WOMAC were similar to those previously reported (Angst, Aeschlimann, Steiner, & Stucki, 2001), but the small effect sizes associated with both domains of the LLTQ are inconsistent with previous research that has demonstrated values ranging from 1.3 - 2.0 (et al.,Forbes, 2010; McNair et al.,

2007). Although this could be a function of low sample size in the present study, it also may reflect the fact that responsiveness is not an inherent characteristic of a measure, but a product of the sample and context (Beaton, Bombardier, Katz, & Wright, 2001; Revicki, Hays, Cella, & Sloan, 2008). For patients undergoing a total knee arthroplasty, therefore, the WOMAC provides a more accurate estimate of functional change, but the LLTQ may be equally responsive to the WOMAC for other treatments.

5.3.2 Limitations

This study is limited by a relatively low sample size, particularly for the responsiveness analysis. It is possible that the variability seen in score differences between the WOMAC and LLTQ in the present sample does not represent the population value, and a larger sample would more accurately estimate the bias or limits of agreement for these instruments.

The generalizability of the responsiveness results is also limited because only one treatment type (arthroplasty) was assessed. It is unclear whether both questionnaires are equally responsive to other, more conservative forms of intervention.

5.3.3 Future directions

Additional research is recommended to address the sample size limitations of the present study. Furthermore, examining both the WOMAC and LLTQ in terms of clinically important differences and responsiveness to other treatments is necessary. It would also be useful to get clinician perspectives on the use of standardized instruments in practice to determine the relative ease of administration and interpretation of both questionnaires, with the purpose of identifying features that may be improved upon to encourage use in clinical settings.

5.3.4 Conclusions

To accurately catalogue symptoms and evaluate treatment progress, it is essential for clinicians to adopt the regular use of valid and reliable instruments (Fischer, Stewart, Bolch, Lorig, Laurent, & Holman, 1999). Based on the results of the present study, the WOMAC appears to be a more valid and responsive measure than the LLTQ for

evaluating function for knee OA patients, particularly those undergoing a total knee arthroplasty. Standardizing OA assessment using the WOMAC would therefore be ideal, although this questionnaire is disease-specific and would require non-specialized practitioners to include multiple inventories in their repertoire.

As the need for many instruments in a clinical setting has been acknowledged as a barrier to practitioner uptake, using the ADL subscale of the LLTQ may present a reasonable alternative. It demonstrated adequate psychometrics in this sample, and for clinicians who are not currently using a patient-reported outcome measure, or would like to streamline their questionnaire inventory in a non-specialized clinic, the LLTQ ADL is a better option than no instrument at all. Because it is not as responsive as the WOMAC, however, it is suggested that it be administered in conjunction with objective measures of function to better inform treatment decisions. For rheumatologists and sport medicine specialists, however, the WOMAC is the better choice for patient assessment, based on its superior responsiveness.

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Chapter 6

6 The effect of a six-week prehabilitation intervention on post-operative outcomes for total knee arthroplasty patients

6.1 Background

Osteoarthritis (OA) is one of the most common musculoskeletal disorders worldwide, and its prevalence is rising in response to our upward-shifting population demographics (Garstang & Stitik, 2006). Reflecting this trend, the number of total knee arthroplasties (TKAs) performed each year is also increasing, with over 441,000 reported in the United States in 2004 alone (Riddle, Jiranek, & McGlynn, 2008). While the surgery is generally effective in terms of pain reduction and correcting joint alignment, there are a number of factors that may affect the patient's ability to achieve full function afterward. Regaining strength and mobility is key to attaining maximal benefit from the procedure (Ditmeyer et al., 2002), but it has been found that those with severe functional impairment prior to surgery are less likely to achieve these benefits than those with milder symptoms (Fortin, Clarke, Joseph, Liang. Tanzer, Ferland et al., 1999).

Due to high demand, there is often an extended waiting list for TKAs. While awaiting surgery, patients must continue to manage OA symptoms even as their condition progressively worsens. Increasing periods of bed rest or similar inactivity during this period can lead to rapid loss of function (Desmeules, Dionne, Belzile, Bourbonnais, & Fremont, 2010). Declines in physical activity can lead to reductions in the functional reserve of the musculoskeletal and cardiovascular systems, diminishing the body's ability to withstand external stressors (Topp, Ditmyer, King, Doherty, & Hornyak, 2002). It has been speculated that, by improving function in the pre-surgical period, the patient will better handle the physical and mental stressors of the surgery itself and consequently require less post-operative rehabilitation (Topp et al., 2002). Researchers have therefore begun to examine the potential role of prehabilitation as a means of ameliorating the effects of a prolonged waiting period on surgical outcomes (Topp et al., 2002).

Although a number of prehabilitation modalities have been investigated (for reviews, see: Ackerman & Bennell, 2004; Barbay, 2009; Johansson, Nuutila, Virtsnen, Katajisto, & Salantera, 2005), exercise interventions are particularly attractive because of the physiological plausibility of their effect. Quadriceps strength is one of the largest contributing factors to function for those with knee OA, and pre-operative function has been shown to be the greatest overall predictor of post-operative function for those undergoing TKA (Fortin et al., 1999). Increasing quadriceps strength before surgery should therefore confer some post-operative benefit to the patient. Yet, evidence to support strength training as a prehabilitation modality is inconclusive. While some studies have reported improved post-operative strength (Brown, Swank, Quesada, Nyland, Malkani, & Topp, 2010; Topp, Swqank, Quesada, Nyland, & Malkani, 2009; Walls, McHugh, O'Gorman, Moyna, & O'Byrne, 2010), mobility (Jaggers, Simpson, Frost, Quesada, Topp, Swank et al., 2007), and self-reported function (Jaggers et al., 2007) for patients engaging in various types of strengthening interventions, other studies have found no effect (et al.,D'Lima, Colwell, Morris, Hardwick, & Kozin, 1996; Mitchell, Walker, Walters, Morgan, Binns, & Mathers, 2005; Rogers, Garvin, Walker, Morford, Urban, & Bedard, 1998; Rooks, Huang, Bierbaum, Bolus, Rubano, Connolly et al., 2006;). Although the intervention length was similar in most cases (4-6 weeks), differences in program content or outcome measurements could account for these equivocal findings.

A meta-analysis, recently conducted to clarify the role of prehabilitation in TKA, found that the benefits of prehabilitation emerge as time passes after arthroplasty (see chapter 4). It appears that, overall, prehabilitation has a small but measurable effect on post-operative quadriceps strength. The same study did not find a corresponding increase in post-operative mobility, but it was stated that the analysis might have been underpowered to detect such an effect. Furthermore, prehabilitation did not have an effect on self-reported function, indicating that, despite measurable improvements in strength, patients did not perceive a change in their functional status. This would suggest that there is

incongruence between the objective and subjective benefits of prehabilitation that warrants further investigation.

One weakness of previous prehabilitation studies that may have contributed to this very limited supportive evidence is in the design of the interventions themselves. A number of programs have been multi-modal in nature, combining different types of exercise (ie: resistance and flexibility training) or exercise along with other interventions (ie: education, nutritional counseling) (et al., Beaupre, Lier, Davies, & Johnston, 2004; Crowe & Henderson, 2003;Larsen, Hvass, Hansen, Thomsen, & Soballe, 2008; Rooks, Huang, Bierbaum, Bolus, Rubano, Connolly et al., 2006; Topp, Swank, Quesada, Nyland, & Malkani, 2009). These combinations may have diluted the impact of one particularly effective component of the intervention, or the individual components may not have been prescribed at the dose necessary to convey benefit. Multi-modal interventions also make it difficult to determine which part of the program is responsible for any benefits the patients did experience. As quadriceps strength exhibits the greatest change in response to prehabilitation, it is likely that the mechanism of action for previous interventions is through their strength training components. Examination of resistance training as a stand-alone intervention is required to verify this hypothesis.

Another limitation of previous research is that the potential role of moderating factors in the prehabilitation-postoperative outcome relationship has not been addressed. One such factor that bears consideration is dispositional optimism. Optimism has been studied in a number of surgical settings, and has consistently been found to equate to less long-term postoperative pain (Rosenberger, Kerns, Jokl, & Ickovics, 2009), and better quality of life after surgery (Allison, Guichard, & Gilain, 2000; Fitzgerald 1993). For patients undergoing TKA specifically, optimism may have a protective effect against pain and functional limitation. In a retrospective cohort study of 702 patients, Singh and colleagues found that pessimists reported significantly more pain two years following a TKA (Odds ratio [OR] = 2.21; 95% CI: 1.12-4.35), as well as less improvement in knee function (OR = 0.53; 95% CI: 0.30-0.96) than non-pessimists (Singh, O'Byrne, Colligan, & Lewallen, 2010). The effect of optimism earlier in TKA recovery has not been examined, however, rendering the true nature of its influence unclear. Moreover, it is

possible that optimism may moderate the relationship between prehabilitation and postoperative outcome, but this has not yet been investigated.

Arthritis self-efficacy is another psychological variable that bears consideration for TKA patients. It has been shown that preoperative self-efficacy and expectancies explained, on average, 10% of the outcome variance in self-reported pain, function, and health-related quality of life for TKA patients (Engel, Hamilton, Potter, & Zaustra, 2004). Similar findings have been reported for objective measures of function, with van den Akker-Scheek and associates reporting that preoperative self-efficacy significantly predicted walking speed six months after knee or hip arthroplasty ($R^2 = 0.47$) (van den Akker-Scheek, Stevens, Groothoff, Bulstra, & Zijlstra, 2007). Postoperative self-efficacy has been shown to influence surgical outcomes to an even greater extent than preoperative self-efficacy (Kurlowicz, 1998; Moon & Backer, 2000; Orbell, Johnston, Rowley, Davey, & Espley, 2001; van den Akker-Scheek et al., 2007). Moon and Backer (2000) examined the effect of immediate postoperative self-efficacy on ambulation frequency and exercise performance the day following joint replacement, and found that it accounted for 8-33% of the variance. This is echoed in the findings of van den Akker-Scheek, et al. (2007) who found that postoperative self-efficacy was a significant predictor of long-term physical and mental functioning ($R^2 = 0.30$ and $R^2 = 0.53$, respectively). Self-efficacy may therefore help to clarify some of the discrepancies in previous prehabilitation research, although to date it has not been examined in that context.

The purpose of this study was to examine the effect of a six-week, pre-surgical strength training program on the primary outcome of post-operative quadriceps strength, as well as the secondary outcomes of mobility, pain, self-reported function, health-related quality of life, and arthritis self-efficacy for patients undergoing TKA. Additionally, dispositional optimism was investigated as a potential moderator in the prehabilitation-function relationship. The correlation between self-reported and objectively measured function, as well as the relationship between arthritis self-efficacy and functional outcomes were also explored.

It was hypothesized that all patients would have lower quadriceps strength immediately after surgery when compared to their presurgical values, but those in the prehabilitation group would have greater relative strength after surgery than those in the control group. Prehabilitation patients were also expected to exhibit better mobility, less pain, and greater self-efficacy than their control group counterparts. Finally, it was anticipated that self-reported function would reflect changes in objectively measured function, and that self-efficacy would be related to functional outcomes.

6.2   Methods

6.2.1 Participants

Participants were recruited, using a convenience sampling strategy, from a single joint replacement clinic at St. Joseph's Hospital (London, Ontario, Canada) from April - December 2010. All participants had a primary diagnosis of osteoarthritis and were scheduled for unilateral total knee arthroplasty (TKA) at least six weeks after their date of recruitment.

Potentially eligible patients were first informed of the study by the surgeon during their initial surgical consultation. Patients who wished to participate were then screened for eligibility by an on-site research assistant. Patients were included if they (1) had a primary diagnosis of knee OA; (2) were ambulatory with or without a walking aide; and (3) exhibited unilateral or bilateral OA symptoms. Patients were excluded if they (1) had scheduled additional, unrelated surgery within three months of their TKA; (2) had undergone surgery in the three months prior to recruitment; (3) had contraindications for exercise; or (4) were undergoing a revision surgery. Eligible patients then provided written informed consent, as per the Health Research Ethics Board, University of Western Ontario.   The conduct of the trial followed the principles outlined in the Declaration of Helsinki (World Medical Association, 2008) and the World Health Organization 2002 Good Clinical Research Practice. The conduct and reporting of the trial followed CONSORT principles (Schulz, Altman, & Moher, 2010).

6.3 Procedures

6.3.1 Baseline Testing

Participant flow through the study is illustrated in Figure 6. Baseline testing occurred at the Exercise & Health Psychology Laboratory, University of Western Ontario (London, Ontario, Canada) six weeks (+/- 3 days) prior to the participant's scheduled arthroplasty. All participants were asked to complete a questionnaire package consisting of: (1) demographic questionnaire; (2) Western Ontario and McMaster Universities Osteoarthrits Index (WOMAC) (Appendix B); (3) Arthritis Self-Efficacy Scale (ASE) (Appendix C); and (4) Medical Outcomes Study Short Form 36 (SF-36) (Appendix D). After completing the questionnaires, participants performed a timed 50-ft flat surface walking test, a timed single-flight stair ascent and descent, and an isometric quadriceps extension assessment (using a HUR 3530 extension/curl machine). All extension strength values were standardized to account for differences in body weight (N/kg).

6.3.2 Measures

Western Ontario and McMaster Universities Osteoarthritis Index. The WOMAC is a 24-item self-administered questionnaire, divided into subscales for pain (5 items), joint stiffness (2 items), and physical function (17 items) (Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988). It is rated on a 5-point Likert scale (0-4), with lower scores indicating lower symptom or disability levels. The instrument is scored by summating each subscale to a maximum score of 20, 8, or 68, respectively, or by computing a global score (the sum of all three subscale scores). Cronbach's alphas for the subscales range from 0.86-0.97, and test-retest reliability of the global score ranges from 0.77-0.83 (McConnell, Kolopack, & Davis, 2001; Soderman & Malchau, 2000).

Arthritis Self-Efficacy Scale. The ASE is a measure of perceived efficacy to cope with arthritis (Lorig, Chastain, Ung, Shoor, & Holman, 1989). It consists of 20 items that are scored on a scale of 0-100, where higher scores indicate greater self-efficacy. The scale has three subscales to measure pain (5 items), physical function (9 items), and other symptoms (6 items). These subscales have demonstrated good reliability, with Cronbach's alpha coefficients of 0.76, 0.89, and 0.87 and test-retest reliabilities of 0.87,

0.85 and 0.90 respectively (Lorig et al., 1989). A total score for the questionnaire is obtained by summating the three subscale scores to a maximum score of 200.

Medical Outcomes Study Short Form 36. The SF-36 is a commonly used measure of general health and related quality of life (Ware & Sherbourne, 1992). It consists of eight subscales (bodily pain, physical function, general health, mental health, social functioning, vitality, role-physical, and role-emotional), with Cronbach's alpha coefficients ranging from 0.78-0.93 (Ware & Sherbourne, 1992). Each of the subscales is transformed into a 0-100 scale for scoring. Two summary scores can be derived from the questionnaire: the physical component summary (PCS), and the mental component summary (MCS).

Life Orientation Test. The Life Orientation Test is a scale used to measure dispositional optimism (Scheier & Carver, 1985). It consists of eight test items, plus four filler items, scored on a 5-point Likert scale. The scale is summed to a maximum of 32, with higher scores reflecting greater optimism. The reliability of the scale is good (Cronbach's alpha = 0.76), and test-retest reliability has been reported as 0.79 over a four-week interval (Scheier & Carver, 1985).

Flat Surface Walking Test. Participants were asked to walk a distance of 50 feet, from a standing start, in a straight, quiet corridor outside of the Exercise & Health Psychology Laboratory. Those who used a walking aide for regular ambulation were permitted to use it during this test. Participants were timed using two stopwatches (accurate to $1/100^{th}$ of a second), and the average of the two times was recorded for the trial. Each participant performed two trials, separated by three minutes. The fastest time from the two trials was used in the analysis.

Stair Ascent/Descent. This test consisted of a stair climb, followed by a stair descent. Participants began from a standing start, and were instructed to climb on flight (13 steps) of standard stairs, using the railing for balance if necessary. At the top of the stairs, they immediately reversed direction and descended the same stair case. Again, the test was timed using two stopwatches (accurate to $1/100^{th}$ of a second), and the average of the two times was recorded for the trial. If participants felt that they could perform a second trial

safely, they were encouraged to do so. The fastest (or only) time from the trials was used in the analysis.

Isometric Strength Assessment. Participants were seated in the HUR leg extension machine, and their thighs were strapped down using inelastic straps with Velcro closures to ensure quadriceps isolation. The lever arm of the machine was set to 75° (Stevens, Mizner, & Snyder-Mackler, 2003) and the pad was placed just above the foot of the surgical limb. Participants were then instructed to contract their quadriceps as forcefully as possible, pushing their leg against the pad of the lever arm. A force meter attached to the lever arm recorded the force output in Newtons (N), and the trial was stopped at the participants' peak force output. A second trial was performed after a rest period of three minutes, and the highest force output from the two trials was used in the analysis.

6.3.3 Intervention

Following baseline testing, participants were randomized to either the lower body strength training intervention condition or the placebo control condition. Participants were block-randomized by gender, using sealed, opaque envelopes. Participants in the intervention group were prescribed a personalized training program that consisted of a 10-minute aerobic warm-up (participant's choice of using a treadmill, cycling ergometer, rowing ergometer, or recumbent stepper), followed by a circuit of bilateral lower body exercises (standing calf raise, seated leg press, hamstring curl, and quadriceps extension). Participants performed two sets of eight repetitions of each exercise, beginning at 60% of their one repetition maximum and increasing, as tolerated, over the course of the six-week intervention.

Similarly, those randomized to the control group were prescribed a personalized training program that consisted of the same 10-minute aerobic warm-up, followed by a circuit of bilateral upper body exercises (seated lat pull, chest press, biceps curl, triceps press). Again, participants performed two sets of eight repetitions of each exercise, beginning at 60% of their one repetition maximum and increasing, as tolerated, over the course of the six-week intervention.

Participants in both conditions were prescribed three exercise sessions per week for six weeks, with each session approximately 30 minutes in length. Exercises were performed on HUR fitness equipment (HUR, Finland), and all participants had one-on-one supervision by a trained kinesiologist during each of their sessions to ensure proper technique and to provide equal individualized contact time between conditions.

Participants completed their training program within three days of surgery. One surgeon performed all TKAs, and post-operative rehabilitation was standardized (usual care) for all participants.

6.3.4 Follow-up Testing

Participants again completed the questionnaire battery and physical testing at the end of the six-week intervention, as well as six and 12 weeks following their surgery.
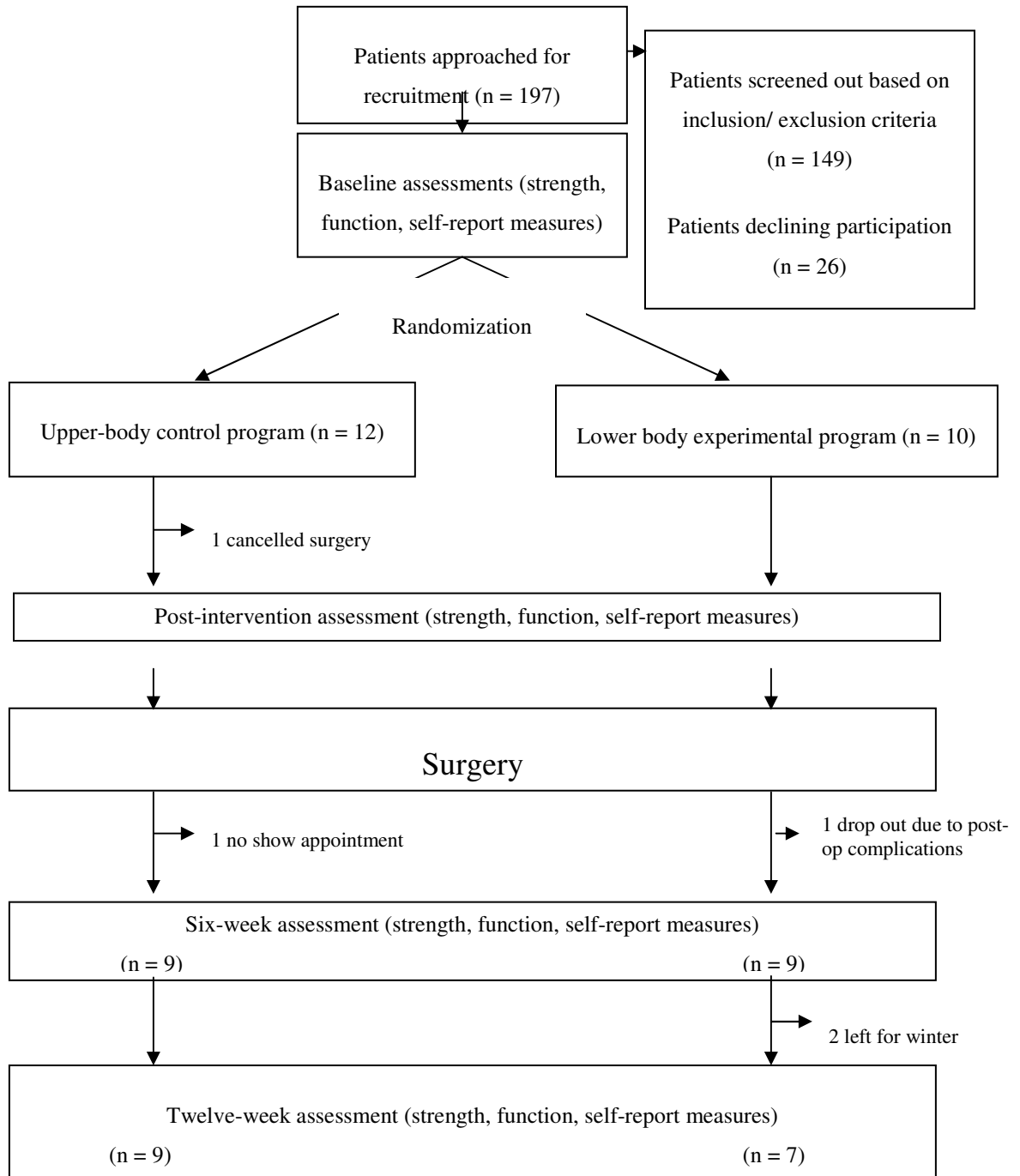
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┌─────────────────────────┐        ┌──────────────────────────┐
│  Patients approached for │───────▶│ Patients screened out    │
│  recruitment (n = 197)   │        │ based on inclusion/      │
└─────────────────────────┘        │ exclusion criteria       │
            │                       │ (n = 149)                │
            ▼                       │                          │
┌─────────────────────────┐        │ Patients declining       │
│ Baseline assessments     │        │ participation            │
│ (strength, function,     │        │ (n = 26)                 │
│ self-report measures)    │        └──────────────────────────┘
└─────────────────────────┘
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Randomization

┌─────────────────────────────┐   ┌─────────────────────────────────┐
│ Upper-body control program │   │ Lower body experimental program │
│ (n = 12)   │   │ (n = 10)   │
└─────────────────────────────┘   └─────────────────────────────────┘

→ 1 cancelled surgery

┌──┐
│ Post-intervention assessment (strength, function, self-report measures)   │
└──┘

┌──┐
│   Surgery   │
└──┘

→ 1 no show appointment   → 1 drop out due to post-
                                                        op complications

┌──┐
│ Six-week assessment (strength, function, self-report measures)   │
│ (n = 9)   (n = 9)   │
└──┘

                                                     → 2 left for winter

┌──┐
│ Twelve-week assessment (strength, function, self-report measures)   │
│ (n = 9)   (n = 7)   │
└──┘

Figure 6. Participant flow through the trial.

6.3.5 Power calculation

Based on the a-priori decision that a 20% difference in quadriceps strength between groups would be clinically meaningful, and previously reported strength values (Maly, Costigan, & Olney, 2005), it was calculated that a sample size of 72 would be necessary to achieve a power of 80% at an alpha level of 0.05.

6.3.6 Analysis

Data from this study were entered into a Microsoft Excel database at the host institution's lab and then extracted into SPSS (version 18) for analysis. All computers at the Exercise and Health Psychology Laboratory are linked with the host institution's IT department's LEGATO backup system for data security.

All results were based on an intent-to-treat analysis strategy. A series of repeated-measures ANOVAs were conducted to investigate the effect of prehabilitation on post-operative outcomes (quadriceps strength, walking and stair ascent/descent tests, WOMAC scores, the SF-36 PCS and MCS, and arthritis self efficacy). Significant interactions were then further examined using an ANCOVA to examine effects at each time point, controlling for baseline values. The level of significance was accepted at $p <$ .05 for all statistical tests (Tabachnick & Fidell, 1996). In accordance with Cohen (1988), 0.01 constitutes a small effect size, 0.06 constitutes a moderate effect size and 0.14 constitutes a large effect size (η^2).

Optimism was then investigated as a potential moderator variable in the relationship between prehabilitation and quadriceps strength using the method prescribed by Kraemer and colleagues (2002). The assumption of this approach is that the potential moderator must be uncorrelated with the treatment. If this condition is met, a hierarchical regression model is fitted with strength as the dependent variable, and treatment entered in step 1, optimism in step 2, then the product term (treatment x optimism) in step 3. This method allows for examination of the unique increment of variance explained by optimism after partialling out the variance explained by the treatment. Any additional variance explained by the interaction term is then interpreted as evidence of moderation (Kraemer, Wilson, Fairburn, & Agras, 2002).

The difference between self-report function (WOMAC-PF) and objectively measured function (strength, walking and stair tests), and the relationship between arthritis self-efficacy and all functional outcomes were assessed using the Pearson correlation coefficient.

6.4 Results

A total of 22 participants were recruited and randomized. Their baseline characteristics are summarized in Table 6. Overall, participants were over 60 years of age, and were classified as obese by body mass index (BMI). There were no significant differences between the two groups in terms of participant characteristics or baseline scores on any of the outcome measures (see Table 7).

	Control Group (n=12)	Intervention Group (n=10)
Gender	66.67% female	50.00% female
Mean age (SD)	60.58 (8.05)	63.50 (4.93)
Mean BMI (SD)	33.78 (7.05)	35.03 (6.13)
Number using walking aide	3	2
Number with bilateral OA	9	10

Table 6. Randomized participant characteristics.

		Baseline	Post-intervention	6 weeks post-op	12 weeks post-op
Optimism	Control	21.75 (3.52)	-	-	-
	Prehab	23.00 (5.31)	-	-	-
Quadriceps strength (N/kg)	Control	0.84 (0.52)	0.81 (0.52)	0.57 (0.29)	0.74 (0.35)
	Prehab	0.96 (0.58)	1.03 (0.57)	0.60 (0.39)	0.77 (0.56)
50 ft. walk (sec.)	Control	14.21 (5.36)	12.63 (3.51)	13.11 (3.30)	11.82 (2.97)
	Prehab	16.88 (16.14)	11.38 (5.95)	14.23 (7.55)	11.80 (5.66)
Stair test (sec.)	Control	33.31 (27.42)	23.28 (11.70)	26.72 (12.05)	22.18 (10.98)
	Prehab	34.53 (29.51)	26.86 (24.89)	30.53 (24.85)	26.99 (26.73)
WOMAC pain	Control	11.92 (3.58)	9.00 (4.41)	4.92 (4.50)	3.58 (4.40)
	Prehab	10.80 (2.20)	8.70 (3.77)	5.60 (2.72)	4.40 (3.20)
WOMAC function	Control	40.25 (4.99)	30.50 (13.68)	19.17 (15.01)	14.33 (15.42)
	Prehab	33.70 (11.80)	28.50 (12.57)	18.10 (11.85)	13.10 (11.56)
SF-36 PCS	Control	24.24 (4.52)	25.61 (5.77)	29.80 (6.71)	34.83 (9.78)
	Prehab	26.85 (7.01)	29.66 (7.99)	31.79 (8.25)	41.25 (10.06)
SF-36 MCS	Control	46.72 (16.49)	42.28 (15.28)	46.68 (15.97)	51.46 (16.37)
	Prehab	52.14 (11.75)	52.76 (7.79)	49.35 (10.47)	48.02 (17.45)
Self-efficacy	Control	139.25 (33.91)	141.08 (33.84)	158.08 (25.54)	166.58 (25.99)
	Prehab	139.90 (28.91)	141.70 (26.31)	159.20 (31.82)	178.10 (19.60)

Table 7. Means (SD) of outcome measures between groups across assessment time points.

Quadriceps strength

There was a significant time effect on the primary outcome of quadriceps strength, $F(3,18) = 5.56$, p < 0.01, $\eta^2 = 0.48$ but there was no significant time x treatment interaction, $F(3,18) = 0.89$, p = 0.47, $\eta^2 = 0.13$ (Figure 7).
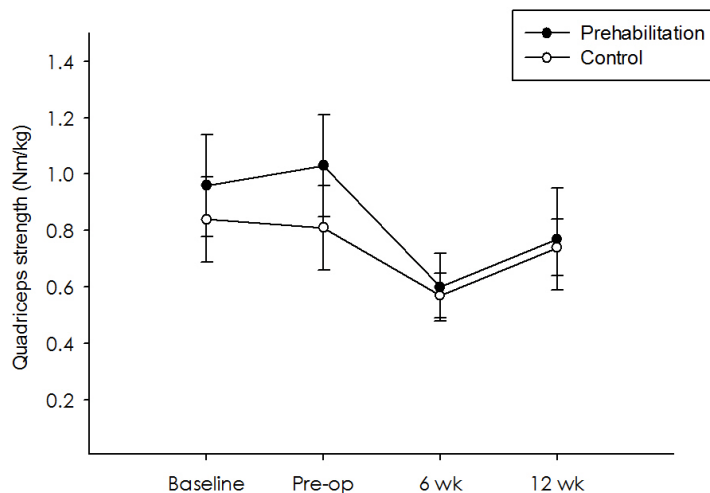

Figure 7. Quadriceps strength between groups [mean (SD)] .

Mobility

The results of the mobility assessments are presented in Figure 8. There was a significant time effect on the 50-ft flat surface walking test, $F(3,18) = 6.79$, p = 0.03, $\eta^2 = 0.53$, but there was no significant time x treatment interaction, $F(3,18) = 1.47$, p = 0.26, $\eta^2 = 0.20$. There was no significant effect of time [$F(3,18) = 2.64$, p = 0.79, $\eta^2 = 0.32$] nor a time x treatment interaction [$F(3,18) = 0.04$, p = 0.99 $\eta^2 = 0.01$] for the stair ascent/descent test.
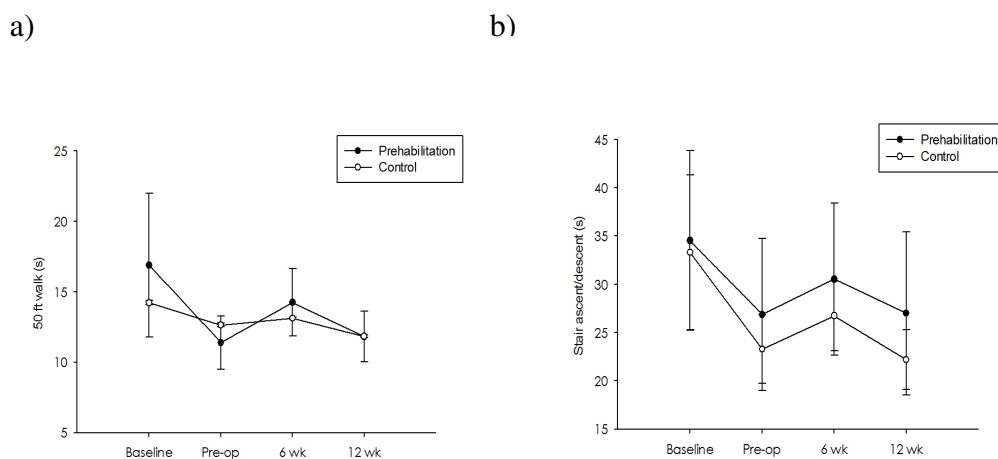
a)   b)

Figure 8. (a) 50 ft walk times: and (b) stair ascent/descent times between groups [mean (SD)].

Pain and self-reported function

Based on scores from the WOMAC (Figure 9), there was a significant time effect for pain $F(3,18) = 20.32$, p < 0.01, $\eta^2 = 0.77$, and self reported function, $F(3,18) = 22.78$, p < 0.01, $\eta^2 = 0.79$, but no time x treatment interaction for either [pain: $F(3,18) = .35$, p = 0.54, $\eta^2 = .054$; function: $F(3,18) = .52$, p = 0.67, $\eta^2 = 0.08$].

a)   b)
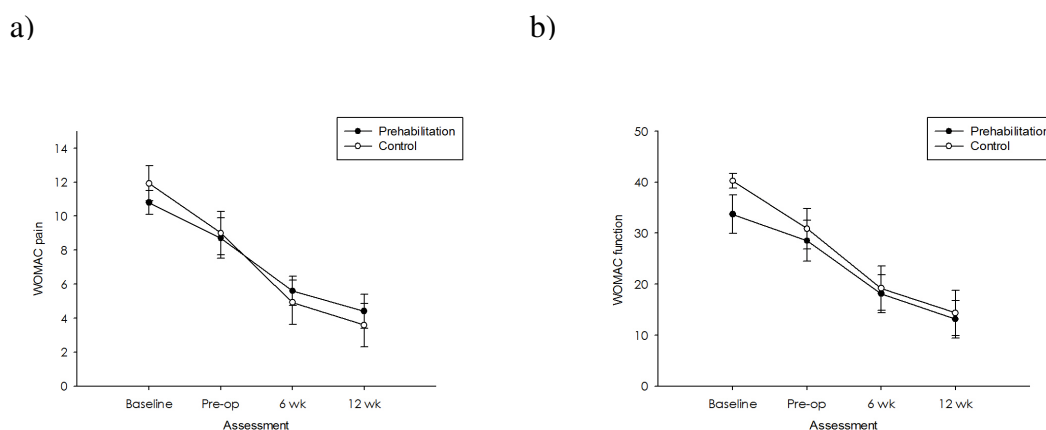
Figure 9. (a) Scores on the WOMAC pain scale; and (b) scores on the WOMAC physical function scale [mean (SD)].

Health-related quality of life

There was a significant time effect on the PCS of the SF-36, $F(3,18) = 9.94$, p < 0.01, η^2 = 0.62, but there was no time x treatment interaction, $F(3,18) = .10$, p = 0.58, $\eta^2 = 0.10$ (Figure 10).
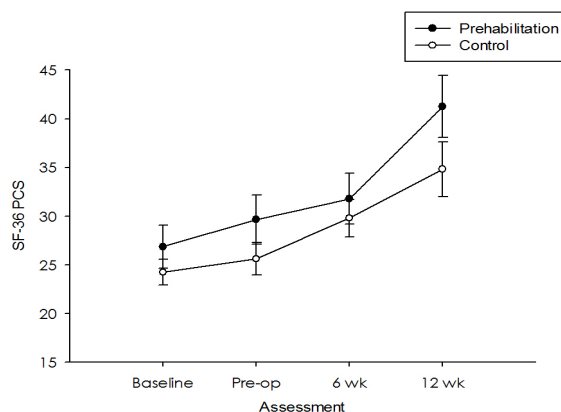

Figure 10. SF-36 PCS scores between groups [mean (SD)].

The MCS, however, showed no time effect, $F(3,18) = 0.07$, p = 0.07, $\eta^2 = 0.07$, but there was a significant time x group interaction, $F(3,18) = 0.41$, p = 0.02, $\eta^2 = .41$ (Figure 11). To explore this significant interaction further, an ANCOVA was conducted to examine effects at each time point, controlling for baseline values. At the post-intervention assessment, there was a trend effect in favour of prehabilitation treatment, $F(1,19) = 3.55$, p = 0.08, $\eta^2 = .16$. No difference between groups were found at the six-week post-operative assessment, $F(1,19) = 0.02$, p = 0.89, $\eta^2 = .001$, or the twelve-week post-operative assessment, $F(1,19) = 1.06$, p = 0.32, $\eta^2 = .05$.
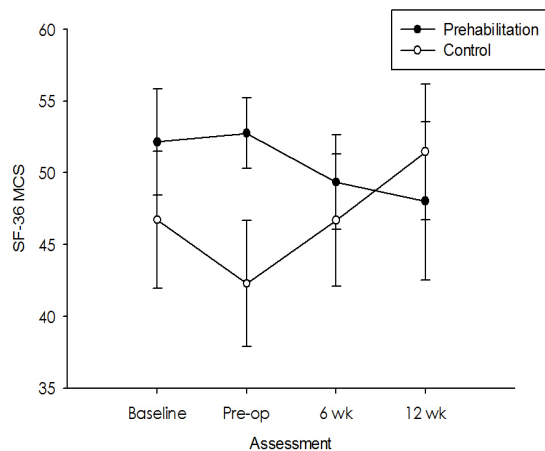
Figure 11. SF-36 MCS scores between groups [mean (SD)].

Arthritis self-efficacy

There was a significant time effect on self-efficacy, $F(3,18) = 9.09$, p = 0.01, $\eta^2 = 0.60$, but there was no significant time x treatment interaction, $F(3,18) = .51$, p = 0.08, $\eta^2 = 0.08$ (Figure 12).
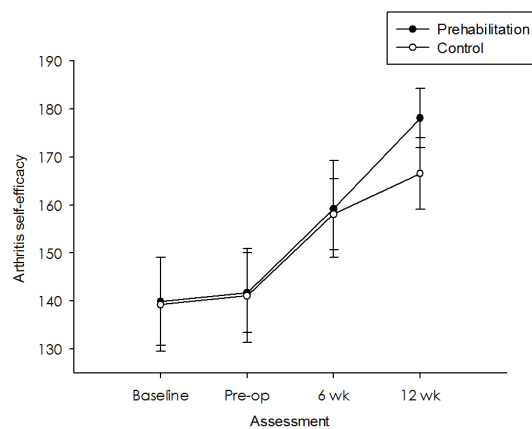

Figure 12. Arthritis self-efficacy between groups [mean (SD)].

Moderation by optimism

After controlling for prehabilitation (step 1), the introduction of dispositional optimism (step 2) did not make a significant contribution to the prediction of quadriceps strength scores, $F(2,19) = 0.43$, p = 0.66. When the interaction term (prehabilitation x optimism) was added (step 3), the change in R^2 was not significant, $F(3,18) = 0.67$, p = 0.58.

Subsequent analysis of the relationship between prehabilitation and all other outcome variables also demonstrated no evidence of moderation by optimism.

Correlational analyses

There were no significant correlations between self-reported and objective measures of function (Table 8). Arthritis self-efficacy at all time points was significantly correlated with pre-operative quadriceps strength. Baseline self-efficacy was related to baseline self-reported function, while self-efficacy at the 12-week follow-up was associated with self-reported function at baseline, and both post-operative follow-ups (Table 9).

		WOMAC-PF			
		Baseline	Pre-operative	6 weeks	12 weeks
Quadriceps strength	Baseline	-.14	-.22	.02	.05
	Pre-operative	-.14	-.21	.01	-.01
	6 weeks	-.16	-.37	-.21	-.18
	12 weeks	-.26	-.33	-.21	-.24
50 ft walk	Baseline	.28	.10	.19	.39
	Pre-operative	-.04	.06	-.15	.09
	6 weeks	-.40	-.23	-.07	.12
	12 weeks	-.29	-.22	.03	.25
Stair ascent / descent	Baseline	.03	-.01	.06	.09
	Pre-operative	-.33	-.11	-.21	-.05
	6 weeks	-.38	-.15	-.16	.01
	12 weeks	-.34	-.14	-.13	.08

Table 8. Correlations between subjective and objective measures of function.

		Arthritis self-efficacy			
		Baseline	Pre-operative	6 weeks	12 weeks
Quadriceps strength	Baseline	.16	.27	.22	.43*
	Pre-operative	.43*	.49*	.46*	.47*
	6 weeks	-.06	.07	-.01	.20
	12 weeks	-.28	-.19	-.08	.04
50 ft walk	Baseline	-.34	-.12	-.03	-.12
	Pre-operative	-.22	-.28	-.23	-.20
	6 weeks	-.14	.18	-.01	-.05
	12 weeks	.25	.27	.05	.03
Stair ascent / descent	Baseline	.13	.11	.04	-.13
	Pre-operative	.15	-.25	-.31	-.31
	6 weeks	.23	.25	.05	-.06
	12 weeks	.30	.35	.16	.12
WOMAC-PF	Baseline	-.46*	-.15	-.30	-.50*
	Pre-operative	-.18	-.24	-.04	-.04
	6 weeks	-.10	.08	-.40	-.44*
	12 weeks	-.11	.26	-.40	-.50*

Table 9. Correlations between arthritis self-efficacy and functional outcomes.
* denotes statistical significance at the $p < 0.01$ level

6.5 Discussion

Quadriceps strength

The significant time effect associated with quadriceps strength is consistent with the hypothesis. Participants exhibited a marked decrease in strength immediately after surgery, then showed a rebounding trend toward baseline values. Strength decreases of up to 60% have been found in post-TKA patients, and although it has largely been attributed to neuromuscular activation failure, (Berth, Urbach, & Awiszus, 2002; Hurley, 1997; Mizner et al., 2003; Mizner, Petterson, Stevens, Vandenborne, & Snyder-Mackler, 2005; Stevens, Mizner, & Snyder-Mackler, 2003) some strength deficits may be due to muscle atrophy (Stevens et al., 2003). Prehabilitation based on strength training would be expected to help prevent such muscle loss. The participants in this study should therefore have had a small, but measurable, advantage in post-operative strength, yet this was not the case. It is possible that the intervention was not of sufficient length or intensity to yield post-operative benefits, or perhaps the neuromuscular deficits following surgery are of a large enough magnitude to override the comparatively small effect of prehabilitation.

Despite a non-significant interaction between time and treatment condition, the large effect size of 0.13 suggests that the intervention did improve pre-operative strength to a clinically meaningful degree. Thus, not only is it possible for patients with severe knee OA to achieve strength gains within six weeks, this improvement can occur during a time that is typically characterized by worsening symptoms (Desmeules et al., 2010). Indeed, quadriceps strength in the control group in this study slightly decreased during the pre-operative period. Though this evidence supports the use of strength training as an intervention modality, the benefits are short-lived, indicating that it may not be adequate in a stand-alone capacity for prehabilitation purposes.

Secondary outcomes

The significant main effect of time on the flat-surface walking test also followed the expected trend. While the decrease in performance following surgery and subsequent rebound, regardless of group, reflects the effect of the operation itself, it was surprising that both groups improved during the pre-operative period. This may simply be the result of patients beginning to be more active as they engage in either the lower body or the placebo exercise program. The simple act of warming up before exercising three times a week, which most participants did by walking on a treadmill, may have been enough to improve their walking speed.

The very large effect size associated with the time x group interaction ($\eta^2 = 0.20$) indicates that the magnitude of change in walking speed for the prehabilitation group may be greater than for the control group through the six-week follow-up time point. It appears that the differences between groups disappeared by the 12-week follow-up, suggesting that any gains made before surgery have only short-term effects.

There was no significant time or interaction effect associated with the stair ascent/descent test, although the effect size of time was quite large ($\eta^2 = 0.32$). It was expected that the prehabilitation group would perform better following surgery, but this hypothesis was not supported. Navigating stairs requires proprioception, and balance, both of which are impaired in individuals with OA (Hall, Mackett, & Doherty, 2005). If the participants in this study had similar deficits, it may account for the similarities at all time points, irrespective of strength differences in the pre-operative period.

Again, the significant time effect associated with pain was expected. TKA provides a great deal of pain relief for most patients (Arden, Arden, & Hunter, 2008), so it is unsurprising that both groups demonstrated a steady downward trend. The reason that the control group improved in the pre-operative period, however, is not as clear. Exercise has been found to reduce pain for OA patients (Petrella, 2000), and perhaps this effect is not dependent upon the type of exercise. It could be that simply engaging in some form of physical activity was enough to trigger this response, indicating that any type of exercise-based intervention would provide benefit.

Subjectively, the TKA procedure imparted similar functional improvements to participants in both groups. Interestingly, the nearly identical trajectory of self-reported function in both groups does not reflect the differences in walking speed or quadriceps strength between them. While the improvements at the post-operative assessments were expected, the magnitude of the pre-operative change in the control group was not. This supports the notion that perceived functional ability has an inverse relationship to pain, which may be a stronger association than that between perceived and objectively measured function in this patient group.

The results concerning the physical component of health-related quality of life once again follow the expected pattern. The mental component scores, however, demonstrate a time x group interaction. It appears that participants in the control condition experience worsening psychological health leading up to surgery, then rapidly improve alongside reductions in OA symptoms after TKA. Those in the prehabilitation condition have a small increase in psychological health with the intervention, but experience a large setback after surgery. This may be because prehabilitation patients have greater outcome expectations associated with TKA, and when these are not met they react negatively, whereas patients in the control group may have their expectations met or exceeded, and thereby react more positively. Additional research is recommended in order to test this hypothesis.

The improvements in arthritis self-efficacy in this study were clearly tied to reductions in symptoms. While both groups showed a small improvement before surgery, which is likely due to pain reduction, the largest gains happened post-operatively. This is consistent with self-efficacy theory, which states that personal experiences and changes in physiological and affective states are sources of efficacy beliefs (Bandura, 1977).

Moderation by dispositional optimism

Although optimism has consistently been found to equate to less long-term postoperative pain (Rosenberger, Kerns, Jokl, & Ickovics, 2009), and better quality of life (Allison, Guichard, & Gilain, 2000; Fitzgerald 1993) for surgical patients, it was not associated with any outcomes in the present study. Moreover, the hypothesis that optimism would

moderate the relationships between prehabilitation and the study outcomes was not supported. Participants in this study scored relatively high on the optimism measure and the small amount of variability in their responses may have prevented the detection of an effect associated with low levels of optimism. Before optimism can be ruled out as a moderator, it is recommended that it be studied in a larger, more diverse sample.

Correlational analyses

The absence of any correlation between self-reported and objectively measured function does not support the hypothesis that these outcomes would be related. This highlights a fundamental clinical problem, as treatment efficacy is often assessed using only one approach, and subsequent medical decisions may differ greatly depending on the measure used. Although there were no outcome differences in the present study when considering subjective versus objective function, this poor relationship should be accounted for in future trials examining the effects of prehabilitation.

Functional self-efficacy has previously been found to account for 45% or more of performance measures for those with OA (Maly et al., 2005), yet in this sample it was only associated with quadriceps strength and self-reported function. Part of this may be attributable to the tasks included in the Arthritis Self-efficacy Scale, as it focuses on a number of general daily living tasks as opposed to walking and stair climbing only. This does not, however, account for the observed relationship between self-efficacy and quadriceps strength. While self-efficacy is domain-specific, arthritis self-efficacy affects any task that the patient believes will be impacted by his or her symptoms (Schiaffino & Revenson, 1992; Schiaffino, Revenson, & Gibofsky, 1991). Efficacy beliefs about personal ability to overcome pain and stiffness to perform well on a strength test may explain the findings of the present study.

The pattern of correlations between self-efficacy and functional outcomes was also inconsistent with previous research. While it has been shown that self-efficacy predicts function at subsequent time points (van den Akker-Scheek et al., 2007), the present study indicates that 12-week self-efficacy was related to baseline and post-operative self-reported function. It is possible that perceptions of increased function at baseline and the

post-operative follow-up provided a boost to self-efficacy, perhaps through mastery experience or physiological factors that manifested at the 12-week assessment. It is also possible that self-efficacy at earlier assessment points did relate to subsequent function, but this study may have been underpowered to detect it.

6.5.1 Limitations

A major limitation of this study is its low sample size. While the effect of the prehabilitation intervention was associated with a large effect size in many of the relationships investigated, there was insufficient power to detect statistically significant differences between groups. It also may have contributed to the amount of variability in a lot of these data that further impacted the detection of significant differences.

Another limitation of this study is the timing of the follow-up assessments. It is possible that the effects of the prehabilitation intervention were more pronounced earlier after surgery, but they had begun to wash out by the six-week measurement time point. It would also be useful to have a longer follow-up period to identify when strength levels returned, or indeed surpassed, baseline levels. This would allow for a much more global understanding of the effects of prehabilitation for TKA patients.

Finally, the results of this study may not be generalizable to other surgical populations. Considering the relationship between muscle strength and disability for those with knee OA in particular, it is possible that those with OA of other joints may not respond as favourably to strength training. Additionally, the waiting period before TKA is typically long enough to allow for strength gains, whereas the wait time for other surgeries may not afford this opportunity. Although there is some evidence that total hip arthroplasty patients may benefit from a similar intervention to this one, more research evidence is needed before these results can be extended to other groups.

6.5.2 Future Directions

Although this intervention positively influenced strength, function, and psychological health before surgery, the effect of the TKA itself appeared to override these benefits to the point that they washed out in the follow-up period. It is possible that the dose or

length of the present intervention was insufficient to convey lasting benefits to patients, so future studies might aim to manipulate the intervention content to increase the magnitude of the pre-operative effect.

This study also showed a direct effect of lower limb strength training prehabilitation on mental health. This relationship needs to be further investigated in order to determine which aspect of the intervention (strength training or simply contact with the experimenters) was responsible for this effect, and how it may impact long-term psychological functioning. Additionally, the differential relationship between TKA and MCS scores for prehabilitation versus control patients must be examined to ensure that boosting mental health before surgery does not have negative consequences in terms of physical recovery.

The disconnect between subjective and objective measures of function should also be further investigated, as it has direct implications for clinical practice. Additionally, a retrospective examination of previous prehabilitation research may provide a clearer picture of intervention efficacy when the measurement approach is taken into account.

6.5.3 Conclusions

The strength training prehabilitation intervention examined in this study was effective at increasing quadriceps strength and walking speed before TKA. It did not, however, impart lasting benefits to patients above and beyond what was conveyed by the surgery itself. The large non-significant effect sizes associated with the time x group interaction for many of the outcomes examined suggest that the study was underpowered due to its small sample size. Further research is advised before clinical recommendations are made about including strength training prehabilitation in everyday practice.

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Chapter 7

7 Examining the implementation context of prehabilitation for total knee arthroplasty patients using the Health Action Process Approach (HAPA) model

7.1 Background

There is a widely recognized gap between best-practice guidelines for osteoarthritis (OA) management and the care that patients generally receive (Porcheret, Healey, & Dziedzic, 2011). Although this is typically attributed to health care practitioner behaviour (et al.,Bartholomew, Cushman, Cutler, Davis, Dawson, Einhorn et al., 2009; Porcheret et al., 2011), patient beliefs and attitudes toward certain therapeutic modalities may account for much of this discrepancy. For example, despite increasing promotion of exercise for arthritis symptom management, adoption and maintenance of exercise programs is low (Brittain & Gyurcsik, 2009; Boutaugh, 2003). Commonly cited barriers to patient uptake include low self-efficacy, lack of awareness about the benefits of exercise, lack of time, and lack of social support (Gecht, Connell, Sinacore, & Prohaska, 1996; Neuberger, Kasal, Smith, Hassanein, & Deviney, 1994). Such obstacles are important to consider when designing interventions for this population, particularly as they illustrate the influence of implementation context on treatment effectiveness.

Implementation context is seen as a lens through which findings from large-scale public health trials should be interpreted (Hawe, Shiell, Riley, & Gold, 2004). Thus, there has been a call for intervention trials to include a process evaluation component in order to help understand which patients will benefit most from the intervention, and under what circumstances (Glasgow, Vogt, & Boles, 1999; Oakley, Strange, Bonell, Allen, & Stephenson, 2006). In response, the focus in the literature has largely been on the multilevel processes that affect intervention delivery (such as administration, institutional policies, and resources) (Armstrong, Waters, Moore, Riggs, Cuervo, Lumbiganon et al., 2008; Rutten, Gelius, & Abu-Omar, 2010); however, this approach fails to account for patient-level factors that might ultimately dictate which interventions are readily adopted and maintained by the target population. Particularly with OA treatments, a catalogue of

potential motivations or barriers to patient uptake may be useful when assessing whether or not these treatments are practicable in real-world settings (Finch, 2006; Gecht et al., 1996; Glasgow et al., 1999; Neuberger et al., 1994 et al.,).

The current conception of implementation context also discounts the value that such information may have for informing intervention design. If researchers could gain an understanding of context early in the development process, it would allow for the manipulation of program content in order to promote maximum uptake. One intervention for OA patients that is in this developmental phase is prehabilitation, or pre-surgical therapy to promote better post-surgical outcomes. To date, most of the existing research has aimed to determine the efficacy of prehabilitation for OA patients undergoing total knee arthroplasty (TKA), but there has thus far been little regard for implementation issues. A recent health policy study by Landry and colleagues reported that clinicians and hospital administrators expressed beliefs that prehabilitation programs would be useful for arthroplasty patients, and would help to decrease demand on already overburdened rehabilitative resources after surgery (Landry, Jaglal, Wodchis, Cooper, & Cott, 2007). Yet, there has been no evaluation of patient beliefs regarding prehabilitation, which limits our understanding of its effectiveness and sustainability at the public health level.

Turning to a theoretical basis of intervention adoption may provide the necessary framework for pursuing this type of evaluation. The Health Action Process Approach (HAPA) was conceived as a model of the adoption and maintenance of health behaviours, and has successfully predicted behavioural intention in a number of settings (Scholz, Nagy, Gohner, Luszczynska, & Kliegel, 2009; Scholz, Sniehotta, & Schwarzer, 2005; Schwarzer, 2009). According to the theory, patients' intentions of participating in a new treatment, such as prehabilitation, can be predicted by their self-efficacy for engaging in the treatment, their outcome expectancies, and their risk perceptions (Figure 13) (Schwarzer, 2009). Using the HAPA model will therefore direct the search for uptake determinants that are most salient to TKA patients, enabling researchers to address those factors that exert the greatest influence over prehabilitation adoption. Moreover, determining patients' intentions to participate in various prehabilitation programs will ideally inform the development of targeted interventions for this population.
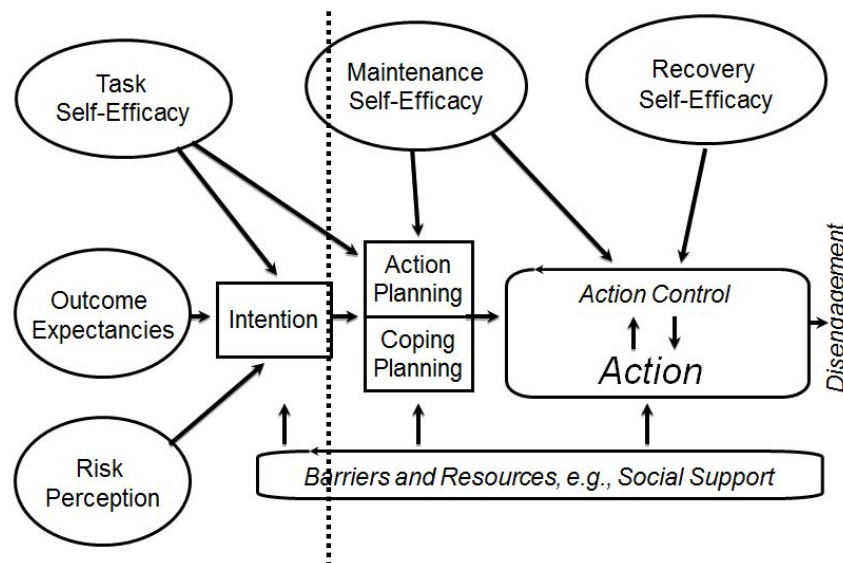
Figure 13. The Health Action Process Approach (HAPA) model (adapted from Schwarzer, 2009).

Dashed line indicates the extent of the present study

The purpose of the current study was to gain insight into the implementation context of prehabilitation for those awaiting TKA. Based on HAPA constructs, patients were asked about their self-efficacy for engaging in prehabilitation activities, as well as their outcome expectancies and perceptions of the risks and benefits associated with those activities. Their willingness to participate in various modes of prehabilitation, including cardiovascular exercise, strength training, and education sessions, was also addressed, providing an initial, descriptive assessment of the demand for prehabilitation in this population.

7.2 Methods

7.2.1 Participants

Participants were recruited from rheumatology clinics and community-based seniors' centres in London, Ontario, Canada. To be eligible, volunteers had to be able to read and write in English, and have considered or already scheduled a total knee arthroplasty

(TKA) as treatment for osteoarthritis (OA). All participants provided informed consent, as per the Office of Research Ethics at the University of Western Ontario.

As this study was exploratory and descriptive in nature, no formal sample size calculation was performed.

7.2.2 Measures

Prehabilitation Uptake Questionnaire. This self-administered questionnaire was designed for the purpose of this study. It has 35 items, chosen to represent the HAPA constructs of outcome expectations (ie: "Do you think that this type of activity has benefit to you while waiting for surgery?"), self-efficacy (ie: "How confident are you that you could engage in this type of activity?"), risk perceptions (ie: "Do you believe that infection at the surgery site is likely to occur?"), and intentions to participate in prehabilitation activities (ie: "Do you intend to participate in this activity at least twice a week leading up to your surgery?"). Items are scored on a 5-point Likert scale, with higher values indicating stronger beliefs or intentions. In addition to the questions based on HAPA constructs, the questionnaire also included items about scheduling and barrier self-efficacy. Although these factors do not predict intention in the HAPA model, there is evidence that they account for some variability in behavioural intention and maintenance (Millen & Bray, 2008; DuCharme & Brawley, 1995). The responses to these questions were therefore examined descriptively, but were not included in any evaluation of the HAPA model.

Questionnaire items were selected by the researcher based on their face validity. The questionnaire was not assessed for its psychometric properties, as the purpose of the study was to simply gather descriptive data.

7.2.3 Procedures

Participation in the study entailed a one-time completion of the Prehabilitation Uptake Questionnaire, which took approximately 25 minutes.

7.2.4 Analysis

Descriptive assessments were made using proportions or means with standard deviations (SD) where appropriate. As an exploratory analysis, correlations between the HAPA constructs were examined to determine if there were relationships between any of the postulated predictors (task self-efficacy, outcome expectancies, risk perceptions) and intention. A stepwise linear regression was then conducted to determine how much variability in intention could be explained by the HAPA constructs. Task self-efficacy was entered at step 1, followed by outcome expectancies (step 2), and risk perceptions (step3).

7.3   Results

A total of 28 participants were recruited for this study, and their characteristics are presented in Table 10. Overall, most participants were receiving some treatment for their OA symptoms while awaiting surgery, and only one in three had heard the term "prehabilitation" before.

Characteristic	N (%) or Mean (SD)
Gender	
Male	13 (46.4%)
Female	15 (53.6%)
Age	62.50 (7.38)
Had previous surgery for OA	8 (28.6%)
Currently receiving treatment for knee OA	**17 (60.7%)**
Painkillers	12 (42.9%)
NSAIDs	6 (21.4%)
Injections	3 (10.7%)
Physiotherapy	2 (7.1%)
Exercise	2 (7.1%)
Natural remedies	1 (3.6%)
Number of treatments/person	
1	8 (28.6%)
2	8 (28.6%)
3	1 (10.7%)
Heard of prehabilitation before	**9 (32.1%)**
From doctor	7 (25%)
From physiotherapist	4 (14.3%)
Other (Arthritis Society, family/friend, website)	3 (10.8%)

Table 10. Uptake survey participant characteristics.

Outcome expectancies

Participants had positive expectations regarding the potential outcomes of the TKA surgery itself. The majority of participants believed the surgery would result in reduced pain (82.1%), improved range of motion (85.7%), improved mobility (85.7%), more ability to be physically active (89.3%), and a greater feeling of independence (71.4%).

Broadly, participants indicated that they would participate in prehabilitation for its associated health benefits and to improve post-surgical outcomes (Figure 14). Specific outcome expectancies associated with participation in prehabilitation included increases in fitness, decreases in the risk of post-operative complications, and improvements in

general wellbeing (Figure 15). Stratified by prehabilitation type, increased strength, fitness, and range of motion were consistently the top three benefits associated with participation, but respondents believed that cardiovascular exercise provided the least pain relief or protection against post-operative illness.
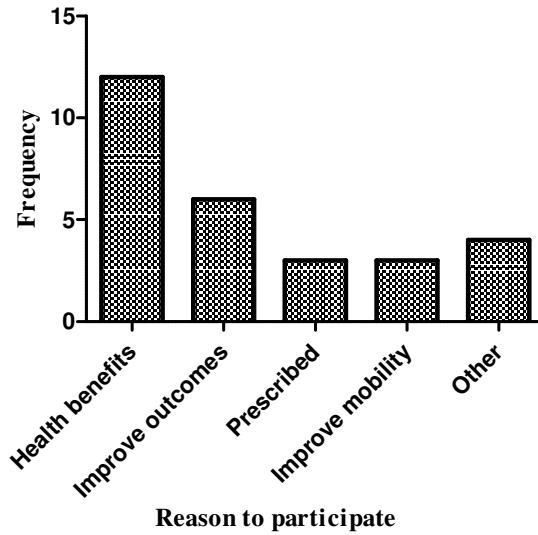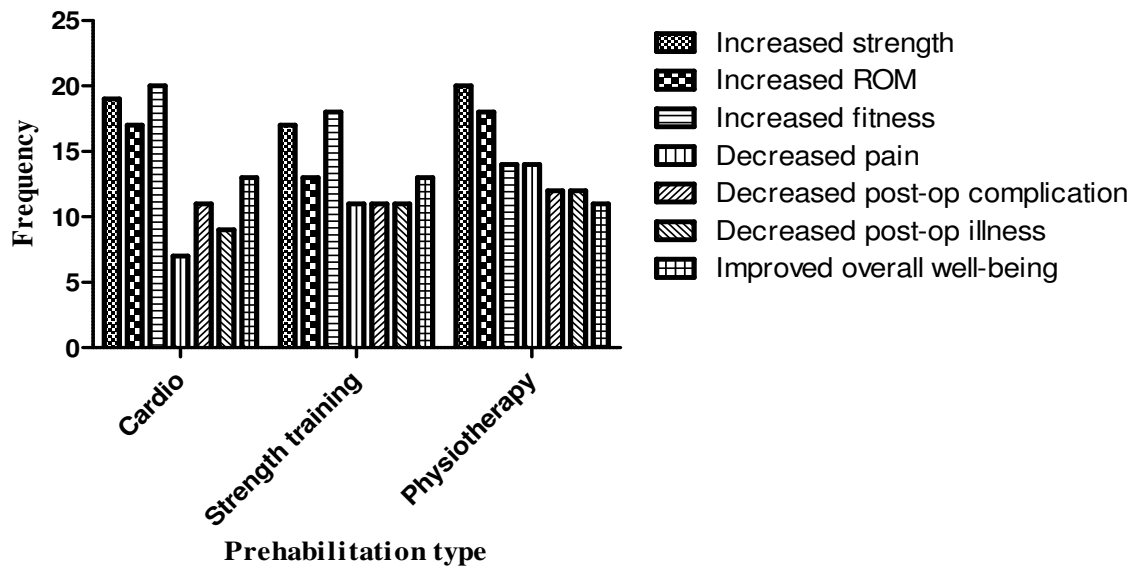

Figure 14. Reasons to participate in prehabilitation.

Figure 15. Perceived benefits of prehabilitation.

Self-efficacy

Task self-efficacy, scheduling self-efficacy, and barrier self-efficacy did not significantly differ between intervention types, but barrier self-efficacy consistently scored the lowest of the three (Figure 16).
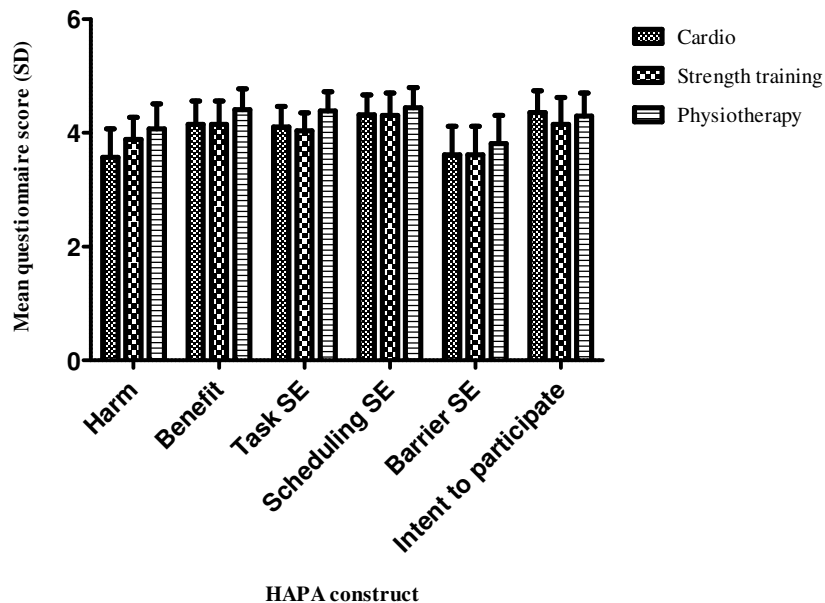
Figure 16. HAPA constructs by prehabilitation type.

Risk perceptions

The TKA surgery itself was not viewed as overly risky. Negative outcomes that participants reported as being likely were post-operative complications that required revision surgery (identified by 21.4% of participants), infection (10.7%), and a fear of "testing" the new knee (32.1%).

Potential risks of participation in a prehabilitation program were identified as joint damage, increased pain, increased stiffness, and an increased chance of post-operative complications (Figure 17). Participants believed that, generally, there were greater risks associated with cardiovascular exercise compared to strength training or physiotherapy, but pain was the greatest perceived risk across intervention types.
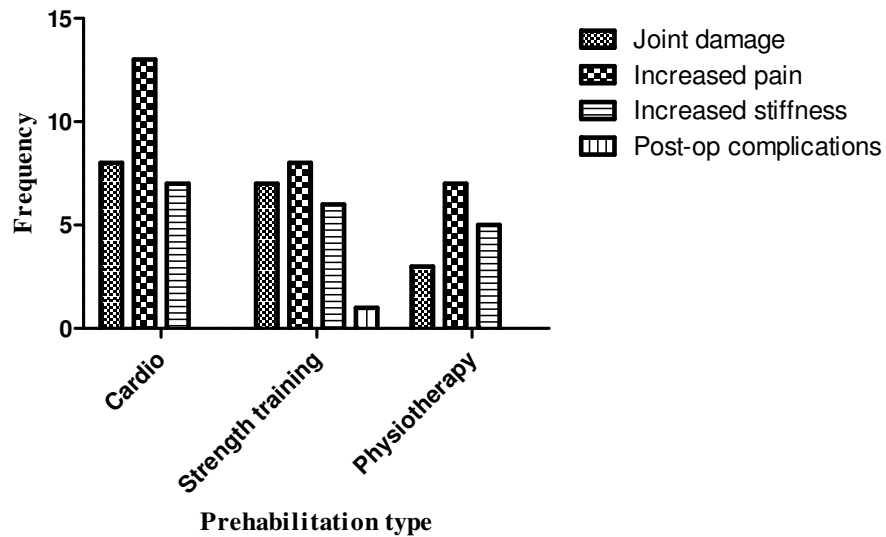
Figure 17. Perceived risks of prehabilitation.

Behavioural intentions

Overall, participants indicated that they were likely to participate in prehabilitation, although the extent to which they intended to participate varied slightly by intervention type (Figure 18). Given the chance to expand on the basic categories of cardiovascular exercise, strength training, and physiotherapy, participants identified home-based physiotherapy, cardiovascular exercise, and strength training as the most favourable options. They also indicated that they would engage in these activities, on average, three or more times per week. Education sessions ranked highly in terms of willingness to participate, but the majority of these individuals would only attend once or twice per week.
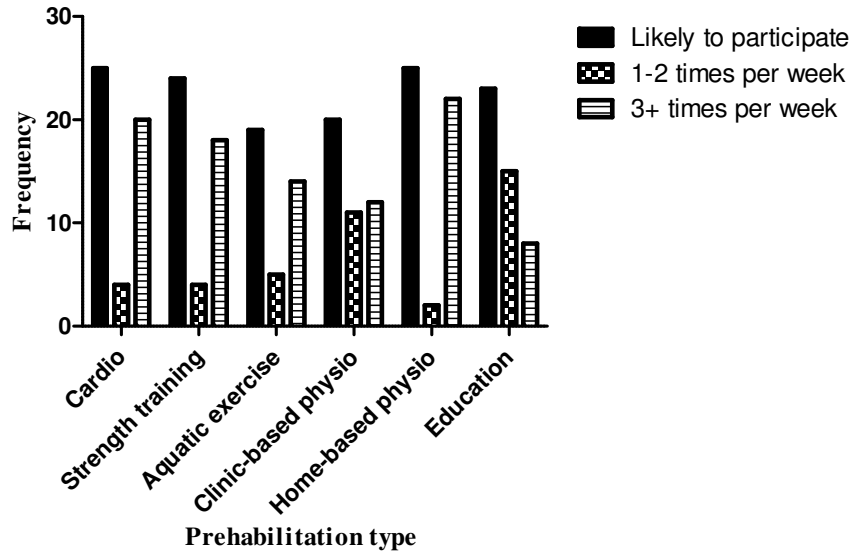
Figure 18. Intentions to participate in prehabilitation.

The most commonly identified barriers to participating in a prehabilitation program, regardless of type, were pain, lack of time, fear of injury, and needing more information about the purpose of the program before committing to attend (Figure 19).
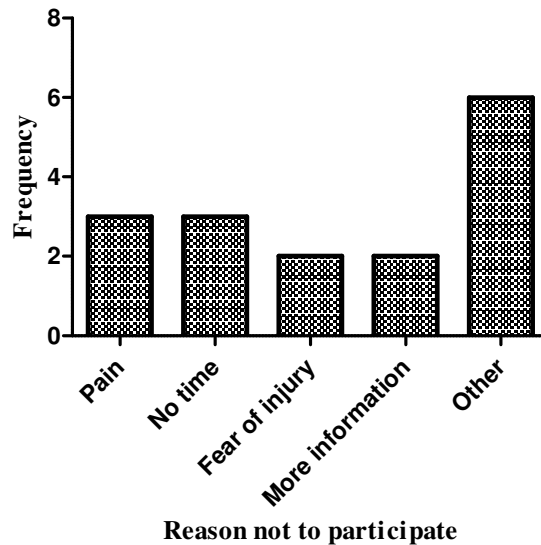

Figure 19. Barriers to participating in prehabilitation.

HAPA constructs across prehabilitation types

Correlations between the HAPA constructs are presented in Table 11. As all predictors exhibited strong relationships with intention, they were included in a stepwise regression model to determine the proportion of intention variance they accounted for. All three models fitted after entering task self-efficacy (step 1), outcome expectancies (step 2), and risk perceptions (step 3) were significant. The final model, with all three predictors, accounted for 64.6% of the variance in intention, $F(3,73) = 44.39$, p <0.001. Task self-efficacy accounted for 54.10% of the variance, while outcome expectancies accounted for an additional 10.3%. Risk perceptions did not provide a unique contribution.

	Task self-efficacy	Outcome expectancies	Risk perceptions	Intentions
Task self-efficacy	-	0.77*	0.60*	0.69*
Outcome expectancies	0.77*	-	0.41*	0.77*
Risk perceptions	0.60*	0.41*	-	0.41*
Intentions	0.69*	0.77*	0.41*	-

Table 11. Correlations between HAPA constructs.
* denotes statistical significance at p < 0.01 level

7.4 Discussion

This study has served as an initial insight into the implementation context of prehabilitation for TKA patients. Using the HAPA model, it has provided a framework for better understanding intervention uptake, and has suggested direction for the future development of prehabilitation programs and implementation strategies for this population.

Based on responses to the Prehabilitation Uptake Questionnaire, outcome expectancies associated with the surgery itself were quite positive. It is not surprising that patients expected reductions in pain and improvements in mobility, because these are typically the benefits that prompt the decision to have a TKA. What was unexpected was the number

of respondents who anticipated a greater ability to be physically active after surgery. This suggests that engaging in leisure-time physical activity may be a target outcome for this population, and an emphasis on enhancing this ability through exercise-based prehabilitation programs might encourage uptake.

Potential negative outcomes after TKA, namely complications resulting in revision, infection, and fear of adapting to the artificial joint, were not expected to happen by the majority of participants. This might be due to the information that patients have received about the population rate of such outcomes, or it may reflect confidence in the surgeon who will perform the procedure. Regardless of the source, however, it does present a problem for prehabilitation promotion based on avoidance of surgical risks. If patients believe they are at low risk, they are not likely to engage in preventive measures (Schwarzer, 2009). This is consistent with previous research illustrating that compliance with medical treatment decreases in tandem with perceived risk for negative outcomes (Mann, Allegrante, Natarajan, Halm, & Charlson, 2007). When implementing prehabilitation interventions, therefore, it is important to focus on other potential benefits associated with participation.

The perceived benefits associated with prehabilitation were somewhat general in nature. Overall health and increases in fitness were the most commonly identified benefits, as opposed to TKA-specific outcomes, suggesting that patients may perceive that the surgery itself will take care of their OA symptoms while prehabilitation will affect broader health factors. The number of respondents citing the impact of prehabilitation on wellbeing also indicates that psychological benefits are important to patients, and that they recognize the potential value of such outcomes. Unfortunately, there is a paucity of information regarding the effect of various prehabilitation modalities on psychological health. It is therefore recommended that future researchers include psychological variables in prehabilitation studies, and that interventions be specifically designed to convey both physical and mental health benefits.

 Increased pain was the chief concern about prehabilitation, which was expected considering that patients awaiting TKA are typically experiencing debilitating pain

already (Hunter & Felson, 2006). The number of respondents citing joint damage as a perceived risk was surprising, however, as most prehabilitation modalities are either education-based (and thereby unrelated to joint structure), or may actually be protective against joint degradation (Sharma, Dunlop, Cahue, Song, & Hayes, 2003). This may reflect a communication failure between physicians and patients about the mechanisms of OA, or it may be the result of insufficient information being available in a format that is accessible to the general public. Whatever the reason, it is important, from an implementation standpoint, to reassure patients that prehabilitation cannot cause additional joint damage, and that there is very little risk of other injury while participating in prescribed interventions.

Self-efficacy was quite high in all three domains (task, scheduling, and barrier). While this may be partially attributable to the single-item scales used to calculate these scores, it does suggest that OA patients believe they are able to undertake prehabilitation activities. Previous researchers have found that, in surgical populations, barrier self-efficacy accounts for a much larger proportion of program adherence variability than does task self-efficacy (Millen & Bray, 2008). An increase in knee pain was highlighted as a potential barrier in the Prehabilitation Uptake Questionnaire because it was thought to represent the most likely impediment to participation in this group. The results from the barrier self-efficacy question support this assumption, as participants not only indicated that pain was the most likely negative consequence of prehabilitation, but also that they had the least confidence in their ability to persevere in the event that it increased. Patients with chronic conditions consistently report physical limitations and pain as barriers to self-management of their symptoms, particularly when the treatment itself causes these symptoms to increase (Jerant, von Friederichs-Fitzwater, & Moore, 2005). Performing prehabilitation tasks with the challenge of worsening symptoms must therefore be accounted for when designing interventions, and boosting self-efficacy to deal with this situation is likely to increase both uptake and maintenance of the program (Millen & Bray, 2008).

In this sample, intention to participate in prehabilitation was high, and the majority of respondents indicated that they would be willing to attend sessions quite frequently.

These results reinforce the notion that many TKA patients prefer to take an active role in their treatment (Arden, Arden, & Hunter, 2008), which is further evidenced by the somewhat lower interest in education sessions. Passive interventions are not likely to convey the same amount of perceived control to the patient, which may make such modalities less attractive.

It is rather incongruous that participants indicated that they were quite likely to engage in pre-surgical cardiovascular exercise, despite the fact that this type of prehabilitation was believed to have the largest risk of pain and the least amount of potential benefit. This may speak to patients' previous experience or level of familiarity with this type of exercise, or it might reflect a desire for simple interventions that require minimal equipment and little travel from home. It is more likely, however, that this reflects a response bias. Participants may have indicated their intent to participate in prehabilitation simply because they believed they should, whereas they actually would not participate when presented with the opportunity. If the questionnaire items had been worded to elicit information about which interventions participants would not engage in, there may have been a more predictable response regarding cardiovascular exercise. It is also possible that such a response bias extended to all positive intentions toward prehabilitation, which is something that should be investigated further in future studies.

From a theoretical perspective, the HAPA model appears to be appropriate for use in this scenario, although this conclusion is based on single-item responses. As task self-efficacy accounted for most of the variability in intention, it can be targeted in interventions as the most salient determinant of behaviour in this population. Future interventions should therefore accommodate patient abilities and emphasize ease of participation to encourage uptake.

7.4.1 Limitations

The largest limitation in this study was sample size. Because of the low number of respondents, it precluded the use of inferential statistics that may have quantified the nature of the relationships between the HAPA constructs. There is also very little variability in the data, which may be preventing the detection of trends in responses.

Furthermore, it is difficult to assess the generalizability of the results, as the participants are relatively similar in personal characteristics and reside in the same geographic area. Perceptions about prehabilitation are likely affected by the dissemination of research regarding its effectiveness, and it is possible that these sample patients had been exposed to more of this information (through their physicians or elsewhere) than patients in other regions; however, a broader, more inclusive sample would be required to examine this effect.

7.4.2 Future directions

Aside from conducting a replication study with a larger sample size, it would also be useful to conduct a confirmatory factor analysis to determine whether the HAPA model is in fact a predictive tool for this population. Moreover, future research should measure actual participation in prehabilitation programs to ascertain the influence of behavioural intention on intervention uptake. This would allow the inclusion of target HAPA constructs in future pehabilitation designs, which may ultimately increase the benefit of such programs for TKA outcomes.

It may also be of interest to determine TKA patients' motives for engaging in prehabilitation. Participants indicated that the likelihood of harm was very similar to the likelihood of benefit for cardiovascular exercise, strength training, and physiotherapy (see Figure 4), yet they were willing to engage in these types of activities. Understanding how patients weigh the potential pros and cons of treatment may provide valuable insight into the implementation context, and is therefore recommended in future research.

7.4.3 Conclusions

Despite a general unawareness of the term "prehabilitation," participants expressed a belief that intervention in the pre-surgical period is beneficial. These results further suggest that developing interventions for TKA patients should focus on general physical and mental health benefits alongside specific TKA outcomes, and should be simple and home- or community-based where possible. Furthermore, clearly informing patients about the risks associated with participation is likely to encourage greater program

uptake. Using the HAPA model may be a useful way to identify constructs to target while promoting prehabilitation, although additional research is required to confirm this.

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Chapter 8

8 Prehabilitation and total knee arthroplasty: The take-home message

The purpose of this series of studies was to investigate the potential role of prehabilitation in post-operative recovery for patients undergoing total knee arthroplasty (TKA) as treatment for osteoarthritis (OA). It aimed to consolidate the body of knowledge regarding prehabilitation for TKA patients, test a simple prehabilitation intervention for use in this population, and provide an initial insight into the implementation context of such an intervention.

This research was undertaken with an understanding that treatment is only one factor that ultimately affects functioning and disability for patients with chronic conditions, and that there are a number of therapeutic and extra-therapeutic influences on functional outcomes following intervention (Tucker & Reed, 2008). Thus, to begin closing the gap between the traditional clinical rehabilitation model and a broader public health disability model, psychological factors and patient preferences were also investigated as determinants of post-operative recovery. Additionally, in response to a call for theory-driven research programs that rely on methodological pluralism to better inform practice (Dunn & Elliott, 2008), these studies were specifically designed to investigate the prehabilitation model in terms of its real-world applicability.

To evaluate each of the studies conducted in this series, their contributions to the overarching goals of the research program must be discussed. In the following sections, the results from each study will be examined with respect to the Translating Research into Injury Prevention Practice (TRIPP) framework (Finch, 2006), as well as their implications for clinical practice.

8.1 Developing an intervention

The third step in the TRIPP model corresponds to the development of an intervention to address the public health concern at hand. In the present program of research, this

concern was the role of prehabilitation in supplementing TKA. In order to guide the design of a prehabilitation intervention, a meta-analysis was undertaken to ascertain the current state of prehabilitation research in the target population, and to highlight gaps in our understanding of the types, durations, and intensities of therapy that are most beneficial. The results of this analysis informed the development of intervention content for the third study in this series, and provided direction regarding the selection of outcome measures.

The findings of the meta-analysis indicated that prehabilitation had no effect on post-operative pain or self-reported function, but did have a small effect on quadriceps strength and a large effect on length of hospital stay. From this, it was determined that prehabilitation targeting quadriceps strength may convey the most benefit to TKA patients. It also indicated that, in light of the inconsistencies in assessment time points and outcome measures, an effort should be made to evaluate intervention efficacy using standardized instruments.

From a practical standpoint, the results of the meta-analysis provide an argument for prehabilitation as a potential means to reduce the costs associated with hospital stays after surgery. The large effect on length of hospitalization, regardless of intervention type, also suggests that simple pre-operative programs may help to free bed space in crowded hospitals, allowing more patients to receive care.

8.2   Measurement issues

In response to the underutilization of standardized OA assessment tools, the second study compared the Lower Limb Tasks Questionnaire (LLTQ) (McNair, Prapavessis, Collier, Bassett, Bryant, & Larmer, 2007) to the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (Bellamy, 2005; Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988b). The purpose of this comparison was twofold: First, it would determine whether or not a tool designed for assessing function in multiple patient groups was also appropriate for use with OA patients, thereby encouraging clinicians to use self-report measures in practice; secondly, it would ensure that the outcome measurements in

the intervention trial were conducted using an instrument that clinicians were likely to use, making the results more clinically applicable.

The findings of this study indicated that there is acceptable agreement between the activities of daily living (ADL) subscale of the LLTQ and both the functional subscale and global score of the WOMAC. This suggests that the LLTQ ADL could be substituted for the WOMAC in practice without sacrificing validity or accuracy. The statistical responsiveness of the WOMAC was far superior to that of the LLTQ ADL subscale, however, meaning that the WOMAC is more appropriate for evaluating treatment effectiveness. In terms of clinical application, it was thus concluded that the LLTQ ADL would be useful for practitioners who would otherwise not use any self-report measure, but those who have an exclusive OA practice would be better served by the WOMAC.

Relating to the TRIPP model, this study did not explicitly fulfill one of the steps, but it did provide the necessary background to selecting an outcome measure for the scientific evaluation of a prehabilitation intervention (step four). Because the WOMAC was more sensitive to change, it was deemed the more appropriate tool for assessing the effect of the intervention over time.

8.3   Scientific evaluation

As mentioned, the fourth step in the TRIPP model corresponds to the evaluation of an intervention under "ideal" conditions. The third study in this series was therefore a randomized controlled trial that aimed to determine the efficacy of a pre-operative strength-training intervention on post-operative outcomes for TKA patients. The primary focus of the intervention was to increase quadriceps strength before surgery in order to affect the primary outcome of post-operative strength, as dictated by the findings of the meta-analysis. Secondary outcomes included objective measures of function (flat surface walking and stair ascent/descent), self-reported function and pain (as measured using the WOMAC), health-related quality of life, and arthritis self-efficacy.

The strength training prehabilitation intervention examined in this study was effective at increasing quadriceps strength and walking speed before TKA. It did not, however,

impart lasting benefits to patients after surgery. While this does support the findings of the meta-analysis, in that prehabilitation had no impact on post-operative mobility, pain, or self-reported function, it contradicts the evidence from the meta-analysis regarding post-operative strength benefits. Although a number of possibilities for the lack of effect have been addressed (see chapter six), it also must be considered that many of the interventions included in the meta-analysis were multi-modal in nature. It is conceivable that the strength benefits attributed to these interventions were not merely the product of the strengthening component of the programs, but perhaps the result of all of the components acting in concert. The results of study three in the present series would serve to support this argument, but does not help to explain the potential physiological mechanism through which such an effect might occur.

It therefore seems premature to offer a clinical recommendation regarding the routine prescription of prehabilitation. From the perspective of post-operative outcomes, there is very little evidence to support strength training as a stand-alone pre-operative intervention. Yet, practitioners must consider the relative weight of objective versus subjective benefits for their patients. Despite the lack of measurable improvements in self-reported outcomes (pain or function), patient satisfaction is important when the goal of treatment is to improve the subjective experience of OA symptoms (Bryant, Schunemann, Brozek, Jaeschke, & Guyatt, 2007). The increases in strength and mobility demonstrated during the pre-operative period in study three might satisfy patient desires to see improvement and experience a small measure of symptom relief before surgery. This may be enough to warrant a recommendation for prehabilitation on a case-by-case basis.

8.4   Describing the implementation context

After (or, as argued, in parallel to) developing an intervention, the fifth step in the TRIPP model advises the cataloguing of potential motivations or barriers to intervention uptake in the target population. By understanding the receptiveness of the audience, the implementation of the intervention in question can be tailored to encourage maximum participation. An uptake survey was therefore conducted as the final study in this research

program in order to ascertain the current demand for prehabilitation programs within the public health care system.

The results of the survey indicated that outcome expectancies associated with prehabilitation were mostly related to general health improvements, while commonly identified risks pertained to the exacerbation of OA symptoms. Most importantly, though, participants expressed a belief that intervention in the pre-surgical period is beneficial, and stated that they were likely to participate in programs if they were offered. This relates to the idea of patient satisfaction raised by the intervention trial, suggesting that, regardless of reported benefits (or lack thereof), patients want to engage in prehabilitation treatment. For clinicians, this provides a strong argument in favour of prescribing prehabilitation, be it structured or simply self-directed activity, for patients awaiting TKA.

8.5   The patient-centred approach

Public health is moving from the traditional medical model toward a more integrative, patient-driven approach to disease management. In this sense, practitioners are treating patients instead of treating medical conditions. Within this model, patients are given an increased role in decision-making, and have the ability to become active agents in their own care. From this perspective, prehabilitation provides an opportunity for those awaiting TKA to proactively engage in targeted treatment that has the potential to improve their post-operative outcomes. This can give patients a sense of control over their symptoms, and can boost self-efficacy for not only managing their OA, but for performing daily living activities as well (Bandura, 1997).

Moreover, developing a number of prehabilitation options will allow the otherwise rote process of TKA to be personalized, with specific attention to the individual preferences, expectations, and needs of each patient. This will ideally improve the overall surgical experience at the individual level, which is ultimately the goal of patient-centred care.

8.6 Limitations

Sample size was a limitation in each of the studies in this series. Recruitment proved to be particularly challenging, and speaks to the general unawareness of the medical community and public at large when it comes to prehabilitation. Altogether, it is probable that the associations between prehabilitation and postsurgical outcomes were underestimated as a result of this shortcoming. It also suggests that the implementation of such interventions may be largely unsuccessful unless careful attention is paid to targeting particular benefits that patients deem important. The results of these studies should therefore be interpreted with caution, as they are likely influenced by a selection bias.

Generalizability is another concern arising from these studies. Because participation was restricted to knee OA patients, it cannot be stated with certainty that the findings would be applicable to other OA groups. Furthermore, the majority of the participants were experiencing end-stage symptoms, so the effect of OA severity has not been adequately addressed. Although knee OA represent a large proportion of the broader OA population, it is unclear what the global public health benefit of prehabilitation might be from the present results.

8.7 Future directions

Having progressed through the first five steps of the TRIPP model with the present series of studies, it is incumbent upon researchers in this area to evaluate the effectiveness of strength-training programs in real-world clinical settings (step six). Now having a preliminary understanding of the implementation context of prehabilitation for TKA patients, it becomes a challenge for future studies to incorporate patient preferences and expectations into these interventions. There is also a need to gain insight into the clinician's beliefs and intentions regarding prehabilitation in order to ensure that the medical community endorses research-supported programs.

Additionally, the present series of studies has identified a need for broader exchange of findings in a structured, standardized format to allow progress to be made in this field. Researchers should adhere to rigorous reporting criteria, use consistent outcome measures, and provide specific protocol details to facilitate the development and implementation of new interventions (Tate, Kalpakjian, & Kwon, 2008).

Finally, despite some evidence that prehabilitation is effective at the individual patient level, its impact on public health remains to be determined. Cost-benefit analyses and "pragmatic clinical trials" (Tate et al., 2008) of various intervention modalities would provide a rationale for introducing prehabilitation on a large scale, and may help to guide implementation strategies in the health care system.

8.8   Conclusions

This program of research has demonstrated that, broadly, prehabilitation has a small effect on post-operative quadriceps strength and can reduce the length of hospital stay after TKA. Although a basic strength training intervention was not sufficient for imparting these benefits on its own, it did result in pre-operative strength and mobility gains. Moreover, the simple act of engaging in pre-operative exercise, regardless of type, served to improve pain and self-reported function before surgery. Considering the positive implementation context for pre-operative intervention among TKA patients, prehabilitation appears to be a safe, effective, and feasible adjunct to TKA, although further research into program content and dosage is recommended.

8.9 References

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Appendix A: Lower-Limb Tasks Questionnaire (LLTQ)

3

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ACTIVITIES OF DAILY LIVING SECTION

Patient: _____   **Date:** _____

INSTRUCTIONS

Please rate your ability to do the following activities in the **past 24 hours** by circling the number below the appropriate response.

If you did not have the opportunity to perform an activity in the **past 24 hours**, please make your *best estimate* on which response would be the most accurate.

Please also rate how important each task is to you in your daily life according to the following scale:

1. = Not important
2. = Mildly important
3. = Moderately important
4. = Very important

Please answer all questions.

		NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE	IMPORTANCE OF TASK			
1.	Walk for 10 minutes	4	3	2	1	0	1	2	3	4
2.	Walk up or down 10 steps (1 flight)	4	3	2	1	0	1	2	3	4
3.	Stand for 10 minutes	4	3	2	1	0	1	2	3	4
4.	Stand for a typical work day	4	3	2	1	0	1	2	3	4
5.	Get on and off a bus	4	3	2	1	0	1	2	3	4
6.	Get up from a lounge chair	4	3	2	1	0	1	2	3	4
7.	Push or pull a heavy trolley	4	3	2	1	0	1	2	3	4
8.	Get in and out of a car	4	3	2	1	0	1	2	3	4
9.	Get out of bed in the morning	4	3	2	1	0	1	2	3	4
10.	Walk across a slope	4	3	2	1	0	1	2	3	4

TOTAL (/40) :____

RECREATIONAL ACTIVITIES SECTION

Patient: _____   **Date:** _____

INSTRUCTIONS

Please rate your ability to do the following activities in the **past 24 hours** by circling the number below the appropriate response.

If you did not have the opportunity to perform an activity in the **past 24 hours**, please make your *best estimate* on which response would be the most accurate.

Please also rate how important each task is to you in your daily life according to the following scale:

1. = Not important
2. = Mildly important
3. = Moderately important
4. = Very important

Please answer all questions.

		NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE	IMPORTANCE OF TASK			
1.	Jog for 10 minutes	4	3	2	1	0	1	2	3	4
2.	Pivot or twist quickly while walking	4	3	2	1	0	1	2	3	4
3.	Jump for distance	4	3	2	1	0	1	2	3	4
4.	Run fast/sprint	4	3	2	1	0	1	2	3	4
5.	Stop and start moving quickly	4	3	2	1	0	1	2	3	4
6.	Jump upwards and land	4	3	2	1	0	1	2	3	4
7.	Kick a ball hard	4	3	2	1	0	1	2	3	4
8.	Pivot or twist quickly while running	4	3	2	1	0	1	2	3	4
9.	Kneel on both knees for 5 minutes	4	3	2	1	0	1	2	3	4
10.	Squat to the ground/floor	4	3	2	1	0	1	2	3	4

TOTAL (/40):___

Appendix B: Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

WOMAC Osteoarthritis Index LK3.1

INSTRUCTIONS TO PATIENTS

In Sections A, B and C, questions will be asked in the following format. You should give your answers by putting an " ✗ " in one of the boxes.

EXAMPLES:

1. If you put your " ✗ " in the left-hand box, i.e.

None	Mild	Moderate	Severe	Extreme
☒	☐	☐	☐	☐

Then you are indicating that you have **no** pain.

2. If you put your " ✗ " in the right-hand box, i.e.

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☒

Then you are indicating that your pain is **extreme.**

3. Please note:

   a) that the further to the right you place your " ✗ " the **more** pain you are experiencing.

   b) that the further to the left you place your " ✗ " the **less** pain you are experiencing.

   c) **please do not** place your " ✗ " **outside the box.**

You will be asked to indicate on this type of scale the amount of pain, stiffness or disability you have experienced in the last 48 hours.

Think about your _____ (study joint) when answering the questionnaire. Indicate the severity of your pain, stiffness and physical disability that you feel is caused by arthritis in your _____ (study joint).

Your study joint has been identified for you by your health care professional. If you are unsure which joint is your study joint, please ask before completing the questionnaire.

Section A

PAIN

Think about the pain you felt in your _____ (study joint) due to your arthritis during the last 48 hours.

(Please mark your answers with an " **X** ".)

QUESTION: **How much pain do you have?**	Study Coordinator Use Only

QUESTION: **How much pain do you have?**

1. Walking on a flat surface.

None	Mild	Moderate	Severe	Extreme
❑	❑	❑	❑	❑

PAIN1 _____

2. Going up or down stairs.

None	Mild	Moderate	Severe	Extreme
❑	❑	❑	❑	❑

PAIN2 _____

3. At night while in bed, i.e., pain that disturbs your sleep.

None	Mild	Moderate	Severe	Extreme
❑	❑	❑	❑	❑

PAIN3 _____

4. Sitting or lying.

None	Mild	Moderate	Severe	Extreme
❑	❑	❑	❑	❑

PAIN4 _____

5. Standing upright.

None	Mild	Moderate	Severe	Extreme
❑	❑	❑	❑	❑

PAIN5 _____

Section B

STIFFNESS

Think about the stiffness (not pain) you felt in your_____ (study joint) due to your arthritis during the <u>last 48 hours</u>.

Stiffness is a sensation of **decreased** ease in moving your joint.

(Please mark your answers with an " ✗ ".)

	Study Coordinator Use Only
6. How **severe** is your stiffness **after first awakening** in the morning? None ❏ Mild ❏ Moderate ❏ Severe ❏ Extreme ❏	STIFF6 _____
7. How **severe** is your stiffness after sitting, lying or resting **later in the day**? None ❏ Mild ❏ Moderate ❏ Severe ❏ Extreme ❏	STIFF7 _____

WOMAC Osteoarthritis Index

Section C

DIFFICULTY PERFORMING DAILY ACTIVITIES

Think about the difficulty you had in doing the following daily physical activities due to arthritis in your _____ (study joint) during the last 48 hours. By this we mean **your ability to move around and to look after yourself**.

(Please mark your answers with an " ✗ ".)

QUESTION: **What degree of difficulty do you have?**					Study Coordinator Use Only
8. Descending stairs.					
None ❏	Mild ❏	Moderate ❏	Severe ❏	Extreme ❏	PFTN8 _____
9. Ascending stairs.					
None ❏	Mild ❏	Moderate ❏	Severe ❏	Extreme ❏	PFTN9 _____
10. Rising from sitting.					
None ❏	Mild ❏	Moderate ❏	Severe ❏	Extreme ❏	PFTN10 _____
11. Standing.					
None ❏	Mild ❏	Moderate ❏	Severe ❏	Extreme ❏	PFTN11 _____
12. Bending to the floor.					
None ❏	Mild ❏	Moderate ❏	Severe ❏	Extreme ❏	PFTN12 _____
13. Walking on a flat surface.					
None ❏	Mild ❏	Moderate ❏	Severe ❏	Extreme ❏	PFTN13 _____

Section C

DIFFICULTY PERFORMING DAILY ACTIVITIES

Think about the difficulty you had in doing the following daily physical activities due to arthritis in your _____ (study joint) during the last 48 hours. By this we mean **your ability to move around and to look after yourself**.

(Please mark your answers with an " ✗ ".)

QUESTION: **What degree of difficulty do you have?**	Study Coordinator Use Only
14. Getting in or out of a car, or getting on or off a bus. None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN14 _____
15. Going shopping. None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN15 _____
16. Putting on your socks or stockings. None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN16 _____
17. Rising from bed. None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN17 _____
18. Taking off your socks or stockings. None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN18 _____
19. Lying in bed. None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN19 _____

Section C

DIFFICULTY PERFORMING DAILY ACTIVITIES

Think about the difficulty you had in doing the following daily physical activities due to arthritis in your _____ (study joint) during the <u>last 48 hours</u>. By this we mean **your ability to move around and to look after yourself**.

(Please mark your answers with an " **X** ".)

QUESTION: **What degree of difficulty do you have?**	Study Coordinator Use Only
20. Getting in or out of the bath.	
None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN20 _____
21. Sitting.	
None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN21 _____
22. Getting on or off the toilet.	
None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN22 _____
23. Performing heavy domestic duties.	
None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN23 _____
24. Performing light domestic duties.	
None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐	PFTN24 _____

Appendix C: Arthritis Self-efficacy Scale

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Arthritis Self-Efficacy

For each of the following questions, please circle the number that corresponds to how certain you are that you can do the following tasks regularly at the present time.

Self-Efficacy Pain Scale (may be combined with Other Symptoms Scale)

1. How certain are you that you can decrease your pain **quite a bit**?

   very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

2. How certain are you that you can continue most of your daily activities?

   very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

3. How certain are you that you can keep arthritis pain from interfering with your sleep?

   very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

4. How certain are you that you can that you can make a **small-to-moderate** reduction in your arthritis pain by using methods other than taking extra medication?

   very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

5. How certain are you that you can make a **large** reduction in your arthritis pain by using methods other than taking extra medication?

   very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

Self-Efficacy Function Scale

1. How certain are you that you can walk 100 feet on flat ground in 20 seconds?

   very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

2. How certain are you that you can that you can walk 10 steps downstairs in 7 seconds?

   very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

3. How certain are you that you can get out of an armless chair quickly, without using your hands for support?

   very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

4. How certain are you that you can

   very ┃ ┃ ┃ ┃ ┃ ┃ ┃ ┃ ┃ ┃ very

button and unbutton 3 medium-size buttons in a row in 12 seconds?   uncertain   1 2 3 4 5 6 7 8 9 10 certain

5. How certain are you that you can cut 2 bite-size pieces of meat with a knife and fork in 8 seconds?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

6. How certain are you that you can turn an outdoor faucet all the way on and all the way off?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

7. How certain are you that you can scratch your upper back with both your right and left hands?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

8. How certain are you that you can get in and out of the passenger side of a car without assistance from another person and without physical aids?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

9. How certain are you that you can put on a long-sleeve front-opening shirt or blouse (without buttoning) in 8 seconds?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

Self-Efficacy Other Symptoms Scale (may be combined with Pain Scale)

1. How certain are you that you can control your fatigue?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

2. How certain are you that you can regulate your activity so as to be active without aggravating your arthritis?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

3. How certain are you that you can do something to help yourself feel better if you are feeling blue?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

4. As compared with other people with arthritis like yours, how certain are you that you can manage arthritis pain during your daily activities?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

5. How certain are you that you can manage your arthritis symptoms so that you can do the things you enjoy doing?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

6. How certain are you that you can deal with the frustration of arthritis?

very | | | | | | | | | | very
uncertain 1 2 3 4 5 6 7 8 9 10 certain

Appendix D: SF-36

SF-36(tm) Health Survey

Instructions for completing the questionnaire: Please answer every question. Some questions may look like others, but each one is different. Please take the time to read and answer each question carefully by filling in the bubble that best represents your response.

Patient Name: _____

SSN#: _____   Date: _____

Person heling to complete this form: _____

1.   In general, would you say your health is:

- ❑   Excellent
- ❑   Very good
- ❑   Good
- ❑   Fair
- ❑   Poor

2.   Compared to one year ago, how would you rate your health in general now?

- ❑   Much better now than a year ago
- ❑   Somewhat better now than a year ago
- ❑   About the same as one year ago
- ❑   Somewhat worse now than one year ago
- ❑   Much worse now than one year ago

3. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

a. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports.
- ❑   Yes, limited a lot.
- ❑   Yes, limited a little.
- ❑   No, not limited at all.

b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf?
- ❑   Yes, limited a lot.
- ❑   Yes, limited a little.
- ❑   No, not limited at all.

c. Lifting or carrying groceries.
- ❑   Yes, limited a lot.
- ❑   Yes, limited a little.
- ❑   No, not limited at all.

d. Climbing several flights of stairs.
- ❑   Yes, limited a lot.
- ❑   Yes, limited a little.
- ❑   No, not limited at all.

e. Climbing one flight of stairs.
- ❑   Yes, limited a lot.
- ❑   Yes, limited a little.
- ❑   No, not limited at all.

f. Bending, kneeling or stooping.
- ❑   Yes, limited a lot.
- ❑   Yes, limited a little.
- ❑   No, not limited at all.

g. Walking more than one mile.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

h. Walking several blocks.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

i. Walking one block.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

j. Bathing or dressing yourself.
- ❑ Yes, limited a lot.
- ❑ Yes, limited a little.
- ❑ No, not limited at all.

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

a. Cut down the amount of time you spent on work or other activities?
   ☐ Yes   ☐ No

b. Accomplished less than you would like?
   ☐ Yes   ☐ No

c. Were limited in the kind of work or other activities
   ☐ Yes   ☐ No

d. Had difficulty performing the work or other activities (for example, it took extra time)
   ☐ Yes   ☐ No

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

a. Cut down the amount of time you spent on work or other activities?
   ☐ Yes   ☐ No

b. Accomplished less than you would like
   ☐ Yes   ☐ No

c. Didn't do work or other activities as carefully as usual
   ☐ Yes   ☐ No

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?
- ❑ Not at all
- ❑ Slightly
- ❑ Moderately
- ❑ Quite a bit
- ❑ Extremely

7. How much bodily pain have you had during the past 4 weeks?
- ❑ Not at all
- ❑ Slightly
- ❑ Moderately
- ❑ Quite a bit
- ❑ Extremely

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

- ❏ Not at all
- ❏ Slightly
- ❏ Moderately
- ❏ Quite a bit
- ❏ Extremely

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks.

a. did you feel full of pep?
- ❏ All of the time
- ❏ Most of the time
- ❏ A good bit of the time
- ❏ Some of the time
- ❏ A little of the time
- ❏ None of the time

b. have you been a very nervous person?
- ❏ All of the time
- ❏ Most of the time
- ❏ A good bit of the time
- ❏ Some of the time
- ❏ A little of the time
- ❏ None of the time

c. have you felt so down in the dumps nothing could cheer you up?
- ❏ All of the time
- ❏ Most of the time
- ❏ A good bit of the time
- ❏ Some of the time
- ❏ A little of the time
- ❏ None of the time

d. have you felt calm and peaceful?
- ❏ All of the time
- ❏ Most of the time
- ❏ A good bit of the time
- ❏ Some of the time
- ❏ A little of the time
- ❏ None of the time

e. did you have a lot of energy?
- ❏ All of the time
- ❏ Most of the time
- ❏ A good bit of the time
- ❏ Some of the time
- ❏ A little of the time
- ❏ None of the time

f. have you felt downhearted and blue?
- ❏ All of the time
- ❏ Most of the time
- ❏ A good bit of the time
- ❏ Some of the time
- ❏ A little of the time
- ❏ None of the time

g. did you feel worn out?
- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

h. have you been a happy person?
- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

i. did you feel tired?
- ❑ All of the time
- ❑ Most of the time
- ❑ A good bit of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?
- ❑ All of the time
- ❑ Most of the time
- ❑ Some of the time
- ❑ A little of the time
- ❑ None of the time

11. How TRUE or FALSE is each of the following statements for you?

a. I seem to get sick a little easier than other people
- ❑ Definitely true
- ❑ Mostly true
- ❑ Don't know
- ❑ Mostly false
- ❑ Definitely false

b. I am as healthy as anybody I know
- ❑ Definitely true
- ❑ Mostly true
- ❑ Don't know
- ❑ Mostly false
- ❑ Definitely false

c. I expect my health to get worse
- ❑ Definitely true
- ❑ Mostly true
- ❑ Don't know
- ❑ Mostly false
- ❑ Definitely false

d. My health is excellent
- ❑ Definitely true
- ❑ Mostly true
- ❑ Don't know
- ❑ Mostly false
- ❑ Definitely false

Appendix E: Prehabilitation Uptake Survey

Thank you for taking the time to complete this questionnaire. All of the questions refer to your upcoming knee replacement surgery, or the types of activities you may or may not engage in while waiting for your surgery. Please read each question carefully, and answer in the spaces provided. Your answers are anonymous. Please DO NOT write your name on the questionnaire.

1. Gender   Male   Female
                              ☐   ☐

2. Age _____

3. Which knee are you waiting to have surgery on?   Right   Left   Both
                                                      ☐   ☐   ☐

4. Have you ever had surgery for osteoarthritis before?   Yes   No
    If yes, what joint(s) did you have surgery on?   ☐   ☐
                                                  _____

                                                  _____

5. Are you currently undergoing any type of therapy for
   your knee (ie: physio, painkillers, etc.)?   Yes   No
                                                            ☐   ☐

        If yes, what type of treatment?   _____

                                                     _____

6. Of the following list, please indicate which outcomes you feel are most likely to occur
   after your surgery, and which of these outcomes are important to you (please check).

a) Reduced knee pain

Very unlikely to happen	Somewhat unlikely to happen	Unsure	Somewhat likely to happen	Very likely to happen
☐	☐	☐	☐	☐

Unimportant to me	Somewhat unimportant to me	Unsure	Somewhat important to me	Very important to me
☐	☐	☐	☐	☐

b) Improved range of motion

Very unlikely to happen	Somewhat unlikely to happen	Unsure	Somewhat likely to happen	Very likely to happen
☐	☐	☐	☐	☐

Unimportant to me	Somewhat unimportant to me	Unsure	Somewhat important to me	Very important to me
☐	☐	☐	☐	☐

c) Complications resulting in further surgery

Very unlikely to happen	Somewhat unlikely to happen	Unsure	Somewhat likely to happen	Very likely to happen
☐	☐	☐	☐	☐

Unimportant to me	Somewhat unimportant to me	Unsure	Somewhat important to me	Very important to me
☐	☐	☐	☐	☐

d) Increased feeling of independence

Very unlikely to happen	Somewhat unlikely to happen	Unsure	Somewhat likely to happen	Very likely to happen
☐	☐	☐	☐	☐

Unimportant to me	Somewhat unimportant to me	Unsure	Somewhat important to me	Very important to me
☐	☐	☐	☐	☐

e) Fear of 'testing' your new knee

Very unlikely to happen	Somewhat unlikely to happen	Unsure	Somewhat likely to happen	Very likely to happen
☐	☐	☐	☐	☐

Unimportant to me	Somewhat unimportant to me	Unsure	Somewhat important to me	Very important to me
☐	☐	☐	☐	☐

f) Improved mobility (walking, climbing stairs, standing or sitting)

Very unlikely to happen	Somewhat unlikely to happen	Unsure	Somewhat likely to happen	Very likely to happen
☐	☐	☐	☐	☐

Unimportant to me	Somewhat unimportant to me	Unsure	Somewhat important to me	Very important to me
☐	☐	☐	☐	☐

g) Infection at the surgery site

Very unlikely to happen	Somewhat unlikely to happen	Unsure	Somewhat likely to happen	Very likely to happen
☐	☐	☐	☐	☐

Unimportant to me	Somewhat unimportant to me	Unsure	Somewhat important to me	Very important to me
☐	☐	☐	☐	☐

h) Greater ability to be physically active

Very unlikely to happen	Somewhat unlikely to happen	Unsure	Somewhat likely to happen	Very likely to happen
☐	☐	☐	☐	☐

Unimportant to me	Somewhat unimportant to me	Unsure	Somewhat important to me	Very important to me
☐	☐	☐	☐	☐

7. Have you heard the term 'Prehabilitation' before?   Yes ☐   No ☐

If yes, where did you hear it?

Doctor ☐
Physio / occupational therapist ☐
Newspaper or magazine ☐
Website or internet article ☐
Family or friend ☐
I've done prehabilitation before ☐
Describe: _____
Other: _____ ☐

'Prehabilitation' is a term used to describe therapy engaged in **before surgery**, which is intended to improve recovery after surgery, or to prevent complications associated with surgery. It refers to many different kinds of therapy, including but not limited to: exercises, physical therapy, education sessions, and diet change.

8. If the following prehabilitation activities were to be made available to you in the **6-8 weeks before your knee replacement surgery**, please indicate how likely it is that you would participate in them, and how frequently you would be willing to participate (please check your responses).

a) Cardiovascular exercise (walking, cycling)

Very unlikely to participate	Somewhat unlikely to participate	Unsure	Somewhat likely to participate	Very likely to participate
☐	☐	☐	☐	☐

Never	1-2 times per week	3 or more times per week
☐	☐	☐

b) Strength training (lifting weights, using therapy bands, body weight exercises)

Very unlikely to participate	Somewhat unlikely to participate	Unsure	Somewhat likely to participate	Very likely to participate
☐	☐	☐	☐	☐

Never	1-2 times per week	3 or more times per week
☐	☐	☐

c) Aquatic exercise (moving in shallow water)

Very unlikely to participate	Somewhat unlikely to participate	Unsure	Somewhat likely to participate	Very likely to participate
☐	☐	☐	☐	☐

Never	1-2 times per week	3 or more times per week
☐	☐	☐

d) Physical therapy (seeing a therapist in a clinic)

Very unlikely to participate	Somewhat unlikely to participate	Unsure	Somewhat likely to participate	Very likely to participate
☐	☐	☐	☐	☐

Never	1-2 times per week	3 or more times per week
☐	☐	☐

e) Home-based physical therapy (doing exercises prescribed by a therapist at home)

Very unlikely to participate	Somewhat unlikely to participate	Unsure	Somewhat likely to participate	Very likely to participate
☐	☐	☐	☐	☐

Never	1-2 times per week	3 or more times per week
☐	☐	☐

f) Education sessions (getting information about your surgery, and what to expect)

Very unlikely to participate	Somewhat unlikely to participate	Unsure	Somewhat likely to participate	Very likely to participate
☐	☐	☐	☐	☐

Never	1-2 times per week	3 or more times per week
☐	☐	☐

9. For the activities you are likely to participate in, please describe why you would participate in them:

_____

10. For the activities you are not likely to participate in, please describe why you would not participate in them:

_____

11. Consider pre-surgical cardiovascular exercise (walking, cycling) and answer the following questions:

	Definitely cause harm	Likely cause harm	Unsure	Likely not cause harm	Definitely not cause harm
a) Do you think that this type of activity may cause further harm to your affected knee?	1	2	3	4	5

If you believe it may cause harm, what type of harm would you be most concerned about it causing (please check all that apply)?

☐ More damage to my knee joint   ☐ Greater risk of illness

☐ Increased pain   ☐ Heart problems

☐ Increased joint stiffness   ☐ Other: _____

☐ Greater risk of surgical complications

	Not at all confident	Somewhat unconfident	Unsure	Somewhat confident	Extremely confident
b) How confident are you that you could engage in this type of activity?	1	2	3	4	5

If you are not confident that you could engage in this activity, please explain why:

	Not at all confident	Somewhat unconfident	Unsure	Somewhat confident	Extremely confident
c) How confident are you that you could schedule this activity into your routine at least twice per week?	1	2	3	4	5

	Not at all confident	Somewhat unconfident	Unsure	Somewhat confident	Extremely confident
d) How confident are you that you could continue to participate in this activity if you experienced increased discomfort in your knee?	1	2	3	4	5

	No benefit	Very little benefit	Unsure	Some benefit	Great benefit
e) Do you think this type of activity has benefit to you while waiting for knee replacement surgery?	1	2	3	4	5

If you think this activity may be beneficial, what type of benefits would you hope to get from it (please check all that apply)?

☐ Improved overall fitness   ☐ Less risk of postsurgical illness
☐ Greater knee strength   ☐ Less risk of surgical complications
☐ Less knee pain   ☐ Greater feeling of wellbeing
☐ Better knee range of motion   ☐ Other: _____

	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
f) Do you intend to participate in this activity at least twice per week leading up to your surgery?	1	2	3	4	5

12. Consider a supervised pre-surgical strength training program (lifting weights, using therapy bands, body weight exercises like push-ups) and answer the following questions:

	Definitely cause harm	Likely cause harm	Unsure	Likely not cause harm	Definitely not cause harm
a) Do you think that this type of activity may cause further harm to your affected knee?	1	2	3	4	5

If you believe it may cause harm, what type of harm would you be most concerned about it causing (please check all that apply)?

- ☐ More damage to my knee joint
- ☐ Increased pain
- ☐ Increased joint stiffness
- ☐ Greater risk of surgical complications

- ☐ Greater risk of illness
- ☐ Heart problems
- ☐ Other: _____

	Not at all confident	Somewhat unconfident	Unsure	Somewhat confident	Extremely confident
b) How confident are you that you could engage in this type of activity?	1	2	3	4	5

If you are not confident that you could engage in this activity, please explain why:

_____

	Not at all confident	Somewhat unconfident	Unsure	Somewhat confident	Extremely confident
c) How confident are you that you could schedule this activity into your routine at least twice per week?	1	2	3	4	5

	Not at all confident	Somewhat unconfident	Unsure	Somewhat confident	Extremely confident
d) How confident are you that you could continue to participate in this activity if you experienced increased discomfort in your knee?	1	2	3	4	5

	No benefit	Very little benefit	Unsure	Some benefit	Great benefit
e) Do you think this type of activity has benefit to you while waiting for knee replacement surgery?	1	2	3	4	5

If you think this activity may be beneficial, what type of benefits would you hope to get from it (please check all that apply)?

- ☐ Improved overall fitness
- ☐ Greater knee strength
- ☐ Less knee pain
- ☐ Better knee range of motion

- ☐ Less risk of postsurgical illness
- ☐ Less risk of surgical complications
- ☐ Greater feeling of wellbeing
- ☐ Other: _____

	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
f) Do you intend to participate in this activity at least twice per week leading up to your surgery?	1	2	3	4	5

13. Consider pre-surgical physical therapy (with a therapist) and answer the following questions:

	Definitely cause harm	Likely cause harm	Unsure	Likely not cause harm	Definitely not cause harm
a) Do you think that this type of activity may cause further harm to your affected knee?	1	2	3	4	5

If you believe it may cause harm, what type of harm would you be most concerned about it causing (please check all that apply)?

☐ More damage to my knee joint   ☐ Greater risk of illness

☐ Increased pain   ☐ Heart problems

☐ Increased joint stiffness   ☐ Other: _____

☐ Greater risk of surgical complications

	Not at all confident	Somewhat unconfident	Unsure	Somewhat confident	Extremely confident
b) How confident are you that you could engage in this type of activity?	1	2	3	4	5

If you are not confident that you could engage in this activity, please explain why:

	Not at all confident	Somewhat unconfident	Unsure	Somewhat confident	Extremely confident
c) How confident are you that you could schedule this activity into your routine at least twice per week?	1	2	3	4	5

	Not at all confident	Somewhat unconfident	Unsure	Somewhat confident	Extremely confident
d) How confident are you that you could continue to participate in this activity if you experienced increased discomfort in your knee?	1	2	3	4	5

	No benefit	Very little benefit	Unsure	Some benefit	Great benefit
e) Do you think this type of activity has benefit to you while waiting for knee replacement surgery?	1	2	3	4	5

If you think this activity may be beneficial, what type of benefits would you hope to get from it (please check all that apply)?

☐ Improved overall fitness   ☐ Less risk of postsurgical illness

☐ Greater knee strength   ☐ Less risk of surgical complications

☐ Less knee pain   ☐ Greater feeling of wellbeing

☐ Better knee range of motion   ☐ Other: _____

	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
f) Do you intend to participate in this activity at least twice per week leading up to your surgery?	1	2	3	4	5

14. Please rank the following activities in terms of how risky they are to participate in before knee replacement surgery (1 = most risky, 5 = least risky):

Cardiovascular exercise   ____

Strength training   ____

Aquatic exercise   ____

Physical therapy   ____

Education sessions   ____

15. Please rank the following activities in terms of how beneficial they are to participate in before knee replacement surgery (1 = most beneficial, 5 = least beneficial):

Cardiovascular exercise   ____

Strength training   ____

Aquatic exercise   ____

Physical therapy   ____

Education sessions   ____

Appendix F: Ethics Approval

Office of Research Ethics

The University of Western Ontario
Room 4180 Support Services Building, London, ON, Canada N6A 5C1
Telephone: (519) 661-3036 Fax: (519) 850-2466 Email: ethics@uwo.ca
Website: www.uwo.ca/research/ethics

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. H. Prapavessis	**Review Level:** Expedited
Review Number: 15819	**Revision Number: 1**
Review Date: February 5, 2010	**Approved Local # of Participants:** 120

Protocol Title: Effectiveness of Pre-surgical Strength Training on Post-surgical Function, Pain, and Psychological Health in Osteoarthritis Patients Undergoing Complete Knee Arthroplasty

Department and Institution: Kinesiology, University of Western Ontario

Sponsor:

Ethics Approval Date: February 5, 2010 **Expiry Date:** August 31, 2011

Documents Reviewed and Approved: Revised Study End Date

Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:

    a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
    b) all adverse and unexpected experiences or events that are both serious and unexpected;
    c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

Chair of HSREB: Dr. Joseph Gilbert
FDA Ref. #: IRB 00000940

Ethics Officer to Contact for Further Information			
☑ Janice Sutherland (jsutherl@uwo.ca)	☐ Elizabeth Wambolt (ewambolt@uwo.ca)	☐ Grace Kelly (grace.kelly@uwo.ca)	☐ Denise Grafton (dgrafton@uwo.ca)

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UWO HSREB Ethics Approval - Revision
V.2008-07-01 (rptApprovalNoticeHSREB_REV)   15819   Page 1 of 1

Office of Research Ethics

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Telephone: (519) 661-3036 Fax: (519) 850-2466 Email: ethics@uwo.ca
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Use of Human Subjects - Ethics Approval Notice

Western

Principal Investigator: Dr. H. Prapavessis	
Review Number: 16626E	**Review Level:** Expedited
Review Date: November 25, 2009	**Approved Local # of Participants:** 323
Protocol Title: Investigating perceptions of prehabilitation among knee arthroplasty patients and surgeons, using the Health Action Process Approach (HAPA) model.	
Department and Institution: Kinesiology, University of Western Ontario	
Sponsor:	
Ethics Approval Date: December 15, 2009	**Expiry Date:** December 31, 2010
Documents Reviewed and Approved: UWO Protocol. Poster, Recruitment Email.	

Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced study on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

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    a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
    b) all adverse and unexpected experiences or events that are both serious and unexpected;
    c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

      Chair of HSREB: Dr. Joseph Gilbert
      FDA Ref. #: IRB 00000940

Ethics Officer to Contact for Further Information			
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Appendix G. Reprint Permission

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	1151 Richmond St
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The University of Calgary
Calgary, Alberta, Canada
2006-2008 MSc

The University of Calgary
Calgary, Alberta, Canada
2001-2006 BKin

Honours and Awards:

Meritorious Student Submission – Society of Behavioral Medicine Annual Conference (co-author Dr. Harry Prapavessis)
April 2011

Citation Award – Society of Behavioral Medicine Annual Conference (co-author Dr. Harry Prapavessis)
April 2011

Dr. Tom Pashby Award- Canadian Academy of Sports Medicine (co-authors Dr. Carolyn Emery, Dr. Tavis Campbell, Dr. Alexis Peters)
April 2007

Social Sciences and Humanities Research Council of Canada (SSHRC) Doctoral Fellowship
2008-2011

Faculty of Health Sciences Entrance Award (UWO)
2008

Alberta Graduate Scholarship (Province of Alberta)
2008

Social Sciences and Humanities Research Council of Canada (SSHRC) Masters Scholarship
2007-2008

Faculty of Kinesiology Open Scholarship (U of C)
2006

Jason Lang Scholarship (Province of Alberta)
2004, 2005

Louise McKinney Scholarship (Province of Alberta)
2003

Alexander Rutherford Scholarship (Province of Alberta)
2001

Related Work Experience

Laboratory Manager
Exercise & Health Psychology Laboratory, UWO
2009-2011

Invited lecturer
Kinesiology 3474b (Psychological interventions in sport and exercise), UWO
2011

Teaching Assistant
UWO
2009-2011

Research Assistant
Sport Medicine Centre, University of Calgary
2006-2008

Service:

Kinesiology Graduate Board President
University of Western Ontario
2010-2011

Kinesiology Graduate Affairs Committee – Executive Member
University of Western Ontario
2010-2011

Kinesiology Student Affairs Committee – Executive Member
University of Western Ontario
2010-2011

Kinesiology Education Management Committee – Executive
Member
University of Western Ontario
2010-2011

Faculty of Health Sciences Council – Student Member
University of Western Ontario
2010-2011

Society of Graduate Students – Councilor
University of Western Ontario
2009-2010

Publications:

Emery C, Hagel, B., Decloe, M., & **McKay, C.** (2010). Risk factors for injury and severe injury in youth ice hockey: A systematic review of the literature. *Injury Prevention, 16,* 113-118.

Emery C, **McKay C,** Campbell T, Peters A. (2009). Examining attitudes toward body-checking, levels of emotional empathy, and levels of aggression in body checking and non-body checking youth hockey leagues. *Clinical Journal of Sport Medicine, 19*(3), 207-215.

Abstracts presented:

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McKay C, Emery CA, Campbell T, Meeuwisse W. *The effect of premature return to play on re-injury risk in elite adolescent ice hockey.* Canadian Academy of Sport Medicine, Vancouver, Canada, June 4-6th, 2009.

McKay C, Emery CA, Campbell T, Peters A. *Examining attitudes toward body-checking, levels of emotional empathy and levels of aggression in body-checking and non-body-checking youth hockey leagues.* 2nd World Congress of Sports Injury Prevention, Tromsø, Norway, June 26th-28th, 2008.

McKay C, Emery CA, Campbell T, Meeuwisse W. *The effect of premature return to play on re-injury risk in elite adolescent ice hockey, and associated psychosocial predictors.* 2nd World Congress of Sports Injury Prevention, Tromsø, Norway, June 26th-28th, 2008.

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McKay C, Emery CA, Campbell T, Peters A. *Examining attitudes toward body-checking, levels of emotional empathy and levels of aggression in minor hockey. A comparison between players in a league that allows body-checking and players in a league that does not allow body-checking.* Canadian Academy of Sport Medicine, Quebec City, April 2007. Winner of Dr. Tom Pashby Award for best scientific paper addressing issues related to the epidemiology and prevention of catastrophic injury in sport.